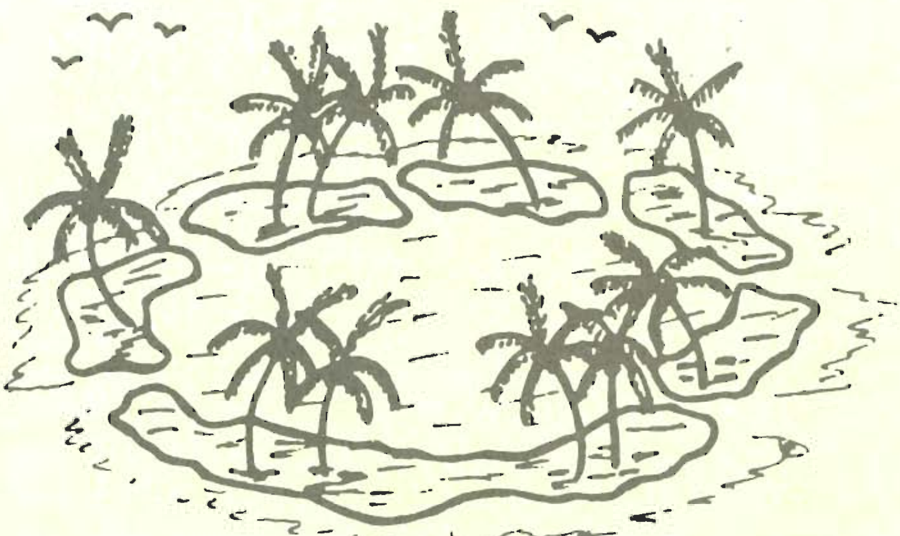
NO. 240

ATOLL RESEARCH BULLETIN

240. ***Man and the Variable Vulnerability of Island Life.***
A Study of Recent Vegetation Change in the Bahamas
by Roger Byrne



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ACKNOWLEDGEMENT

The Atoll Research Bulletin is issued by the Smithsonian Institution, as a part of its activity in tropical biology, to place on record information on the biota of tropical islands and reefs, and on the environment that supports the biota. The Bulletin is supported by the National Museum of Natural History and is produced and distributed by the Smithsonian Press. The editing is done by members of the Museum staff and by Dr. D. R. Stoddart.

The Bulletin was founded and the first 117 numbers issued by the Pacific Science Board, National Academy of Sciences, with financial support from the Office of Naval Research. Its pages were largely devoted to reports resulting from the Pacific Science Board's Coral Atoll Program.

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MAN AND THE VARIABLE VULNERABILITY OF ISLAND LIFE. A STUDY OF RECENT VEGETATION CHANGE IN THE BAHAMAS

by Roger Byrne[1]

I. INTRODUCTION

A question of increasing concern to scientists and laymen alike is to what extent plant and animal communities can withstand disturbance by man. In this context the historical biogeography of small islands is especially relevant. Island life has proved to be particularly vulnerable to human disturbance. In the brief period of human settlement faunal extinction rates have been proportionally much higher on islands than on the continents. For plants the situation is less clear. Few island studies have dealt in detail with the consequences of man's impact and as a result the vulnerability of insular plant communities is poorly understood. It was with this general problem in mind that the present study was undertaken.

More specifically, an attempt was made to determine the extent to which man has modified the vegetation of Cat Island, a small island in the Bahamas. Originally, it was intended to deal with the vegetation of the island as a whole, but for several reasons the detailed analysis was limited to the mixed evergreen-deciduous woodland, or "coppice" as it is locally known. The woodland covers more than 90 percent of the island and has been intensively disturbed by man. On a theoretical level the question was considered as to whether or not the vegetation of offshore islands such as Cat is vulnerable in the same way as that of the Hawaiian Islands or the Galapagos. The choice of Cat Island was to a certain extent fortuitous. As a low-limestone island it provided a comparatively simple setting, it was reasonably

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(Manuscript received November 1978--Eds.)

accessible, and like the Bahamas as a whole its vegetation was virtually unexplored.

Field work was carried out during three visits: July to October 1967, June to August, 1968 and June to September 1970. In addition short visits were made to three other Bahamian islands: Bimini, Mayaguana, and New Providence. Historical evidence was gathered in London during the spring of 1968. Particular attention was paid to the manuscript collections at the Public Records Office, the British Museum, the British Museum of Natural History, and the Royal Botanical Gardens at Kew. This text represents a revised version of a doctoral dissertation submitted to the University of Wisconsin in 1972 (Byrne, 1972).

II. THE THEME: MAN AND THE VULNERABILITY OF ISLAND LIFE

The idea that island life is inherently vulnerable to disturbance by man was first proposed by Charles Darwin as supporting evidence for his theory of natural selection. Since Darwin's time, however, the whole question of insular vulnerability has been variously interpreted and as yet there is no consensus.

Early Interpretations

During his voyage on the Beagle (1831-1836), Darwin was particularly impressed by the extent to which man had disturbed the plant and animal life of so many remote islands. On St. Helena, for example, the woodland had been virtually removed by the combined effects of selective cutting and grazing, and the native plants had been apparently replaced by introduced species.

> The many imported species must have destroyed some of the native kinds; and it is only on the highest and steepest ridges that the indigenous flora is now predominant (Darwin, 1839: 485).

In his account of the voyage, Darwin made no attempt to explain why the plants and animals of remote islands should have been so vulnerable to disturbance. His explanation was to come twenty years later in <u>The Origin of Species</u>. Here he suggested that continental species have a competitive advantage over insular species because the struggle for existence is more severe on continents than on islands. Islands, because of their small size and inaccessibility, have fewer species and consequently the competition among those present is less vigorous. To support this idea he pointed out how relict floras and faunas had survived on islands long after they had become extinct on the mainland.

> On a small island the race for life will have been less severe, and there will have been less modification and less extermination. Hence, we can understand how it is that the flora of Madeira...resembles to a certain extent the extinct tertiary flora of Europe (Darwin, 1859: 108).

This view of islands as natural museums in which plants and animals are preserved by isolation was generally accepted by the great nineteenth century naturalists.

Wallace, for example, agreed with Darwin that species from continental areas, particularly Europe, were more aggressive than insular types. Like Darwin, he noted how the native flora and fauna of St. Helena had been drastically changed during the few hundred years of European settlement.

> When first visited by civilized man it was in all probability richly stocked with plants and animals, forming a kind of natural museum or vivarium in which ancient types, perhaps dating back to the Miocene period, or even earlier, have been saved from destruction which has overtaken their allies on the great continents (Wallace, 1902: 308, 309).

Darwin's close friend Joseph Dalton Hooker was also impressed by the vulnerability of island life. He wrote at length on the success of European weeds on oceanic islands, and like Darwin attributed it to their supposedly superior competitive ability (Hooker, 1860, 1865, 1867a, 1867b).

In general terms, Darwin, Wallace, and Hooker were all agreed that island life was inherently vulnerable. What was not clear was the detailed nature of this vulnerability and to what extent it was due to man. The nineteenth-century naturalists were limited in their thinking by the typological species concept, and because of this they reduced the intricacies of competition to a battle in which the length of species lists assumed an inordinate importance. This is not to say that they were entirely unaware of the significance of man's role. Wallace (1902: 306), for example, emphasized that European weeds could not have successfully invaded New Zealand had man not disturbed the native vegetation first.[1]

Before reviewing more recent views of the vulnerability of island life, mention should be made of the important role oceanic islands played in the development of the theory of natural selection. In <u>The Origin of Species</u> Darwin argued strongly against the then popular land-bridge theory that had been used to account for the origin of insular floras and faunas. Oceanic islands, he maintained, had never been connected to the continents and consequently were poor in species of both plants and animals; furthermore, many important taxa were not represented at all. This impoverishment, he argued, was further evidence against the doctrine of independent creation.

1. Allan (1936), in his critique of the hypothesis of insular vulnerability, failed to give Wallace credit for this observation.

> He who admits the doctrine of the creation of each separate species, will have to admit that a sufficient number of the best adapted plants and animals were not created for oceanic islands; for man has unintentionally stocked them far more fully and perfectly than did nature (Darwin, 1859: 370).

This argument reinforces his earlier conclusion that the inhabitants of oceanic islands are inherently vulnerable to disturbance. Both Hooker and Wallace emphasized the difference between continental and oceanic islands; the former having at some time been connected by land bridges to the continents, whereas the latter had always been isolated. Wallace elaborated on the distinction and defined oceanic islands as follows:

> Islands of volcanic or coralline formation, usually far from continents and always separated from them by very deep sea, entirely without indigenous land mammalia or amphibia, but with a fair number of birds and insects, and usually with some reptiles (Wallace, 1902: 243).

Recent Views

In the present century the broad approach of the natural scientist has generally been abandoned in favor of narrow specialization.

Botanists have been divided on the question as to whether or not insular plants are inherently vulnerable to disturbance. One school of thought has held that Darwin's interpretation was basically incorrect. Allan (1936), for example, argued that continental plants are not inherently more aggressive than insular types. According to Allan, in New Zealand the introduced species owe their success to prior disturbance of the natural vegetation by man and his domesticated animals. Much the same conclusion was reached by Egler in his review of the status of alien plants in Hawaii.

> In the absence of anthropic influences, the evidence strongly favors the view that most of the aliens will be destroyed by the indigenes, such aliens surviving only in greatly reduced numbers and as very subordinate members of the resulting ecosystem (Egler, 1942: 23).

At the same time, Egler argued against the need for any general theory to account for the processes involved, and suggested that the history of each alien species should be looked at individually.

A somewhat different view of insular vulnerability has been presented by Fosberg (1936, 1965, 1972). Fosberg has argued that the ecosystem concept provides an especially useful means of evaluating the significance of man's impact on island life. In essence, he has restated the Darwinian hypothesis in modern terms. In his introduction to the symposium Man's Place in the Island Ecosystem, he characterizes the island ecosystem as follows:

> Limitation in organic diversity; reduced inter-species competition; protection from outside competition and consequent preservation of archaic, bizarre, or possibly ill-adapted forms; tendency toward climatic equability; extreme vulnerability, or tendency toward great instability when isolation is broken down (Fosberg, 1965: 5).

In another paper on this theme, Fosberg emphasized the contrast between old continental ecosystems and young island ecosystems. The former, he suggests, are floristically and faunistically diverse, well-balanced, rarely invaded by aliens, and quick to recover after disturbance. The latter are poor in species, often imbalanced, often invaded, and slow to recover after disturbance (Fosberg, 1963: 557-561). The ecosystem concept has been of considerable value in guarding against too narrow a view of man's impact on island life.

Another botanist who has emphasized the idea that island life is inherently vulnerable is Carlquist (1965, 1970). Like Darwin and Wallace, Carlquist has suggested that islands have been refugia for species that have become extinct on the continents. In his recent book on the natural history of Hawaii, he devoted a chapter to a consideration of the loss of competitiveness in native plants, (Carlquist, 1970: 173-179). He notes that the flora is especially poor in poisonous, strongly-aromatic, or spiny plants and concludes that this reflects the lack of any grazing pressure from mammals. He also points out that few Hawaiian plants are weedy and that most species are less competitive than their continental counterparts. These factors, together with inbreeding, small population sizes, and highly specialized habitat requirements, have made the Hawaiian species especially vulnerable to disturbance. Unfortunately, Carlquist avoids the subject of man's impact. His main concern is the fate of the rare endemics, and introduced species are dismissed as uninteresting weeds, whose story could "only have been a catalogue of sorts" (Carlquist, 1970: viii). This attitude has been characteristic of many island botanists. Rare endemics and remote virgin forests have attracted much more attention than cosmopolitan weeds and secondary woodland.

Unlike botanists, zoologists have rarely questioned the idea that island life is inherently vulnerable to disturbance. Simpson and Mayr, for example, have accepted the vulnerability thesis and have tried to place it in the framework of modern evolutionary theory.

Simpson (1953: 306) suggested that islands, particularly small, strongly isolated islands, are "evolutionary traps," in which the possibilities of further evolution are extremely restricted. The organisms reaching such islands become specifically adapted to a small number of niches, and thereafter a rather static, closed ecological situation persists. Populations are likely to be small, with little genetic variability available for change. If invasion occurs, the native organisms are particularly subject to rapid extinction. On the other hand, he rejects the idea that islands are ephemeral features and therefore unlikely to be very old.

Mayr (1963: 74-76) has likewise noted that insular faunas are particularly vulnerable to competition from introduced species. In general terms he accepts the idea that species from large areas have a competitive advantage over species from small areas.[2] At the same time he cautions against the acceptance of any sweeping generalizations and points out that there are many exceptions to the rule.

Another zoologist who has been concerned with the consequences of the invasion of islands by alien species is Wilson (1965). From a statistical analysis of Hawaiian bird faunas he concluded that there was no evidence to suggest that continental species were intrinsically superior to insular species. His approach, however, involving as it did only faunal lists, could hardly be expected to provide any conclusive answers.

A broader approach to the whole problem of insular vulnerability has been advocated by Elton. In *The Ecology of Invasions by Animals and Plants* he devoted a whole chapter to a consideration of "The Fate of Remote Islands" (1958:

2. Mayr expressed the same idea in his concluding remarks to the symposium on *The Genetics of Colonizing Species* (Baker and Stebbins, 1965: 559).

77-93). Having documented the drastic changes on islands such as Juan Fernandez and Hawaii, he repeats the argument that insular plant and animal communities are vulnerable to invasion because of their comparative simplicity.

> Natural habitats on small islands seem to be more vulnerable to invasion than those on the continents. This is especially so on oceanic islands which have rather few indigenous species (Elton, 1958: 147).

The idea that species diversity can be directly correlated with stability has since become a canon of the conservation movement. In essence it is a restatement of the Darwinian hypothesis put forward nearly a hundred years earlier. Unfortunately, Elton does not explain on just why small islands are so vulnerable or, more particularly, to what extent man is responsible for this vulnerability. As Elton himself admits, this is a poorly-researched topic and ecologists have in general avoided such complicated questions.

Geographers who have explored this theme have rarely been intimidated by the complexities of island life. In most cases they have taken an holistic approach which has included plants, animals, and man. A pioneer study of this kind is Clark's The Invasion of New Zealand by People, Plants, and Animals (1949). Here, however, the main concern was with the invaders, particularly man, and the changes in the native flora and fauna are only briefly described.

More recently, Harris (1965) has explored a similar theme in his Plants, Animals, and Man in the Outer Leeward Islands. This study involved a detailed review of the historical evidence for man's impact on the plant and animal communities of Antigua, Barbuda, and Anguilla. Harris's conclusions were much the same as Elton's, namely, that small oceanic islands are particularly vulnerable to invasion by alien plants and animals, especially man. The plant and animal communities of the Outer Leewards are highly vulnerable because they lack the "ecological resistance" of more complex communities, and although the number of species that have become extinct since man first settled the islands is not known, it is thought to be large (Harris, 1965: 141).

In another publication, Harris (1962) reviewed Darwin's hypothesis in the light of his research in the Outer Leewards. Like Allen and Egler, he emphasized the point that without prior disturbance by man, alien plants would make up only a small proportion of the total plant cover. In other words, alien plants are not inherently more aggressive than the native species. A very similar conclusion was reached by Watts (1966, 1970) in his study of man and vegetation change in Barbados. Having shown that alien species had not been able to invade areas of comparatively undisturbed vegetation, Watts concluded that alien species were dependent for their success on prior disturbance by man.

In a similar study Kimber (1969) analysed the history of recent vegetation change in Martinique, a small volcanic island in the Lesser Antilles. Although her approach was primarily historical, it was strongly influenced by the ecosystem concept. The question of insular vulnerability was not considered as such, but the evidence presented clearly shows that the vegetation of the island has been disturbed drastically by man. In her conclusion she states that the island ecosystem of Martinique is out of balance and that the plant cover has been degraded and simplified by man's interference (Kimber, 1969: 599).

A somewhat different approach to the problem has been taken by J.D. Sauer (1960, 1967). Unlike Clark, Harris, Watts, and Kimber, Sauer combined the historical approach with detailed analyses of the contemporary vegetation. His research on the coastal vegetation of Mauritius and the Seychelles is especially relevant to the present study insofar as it shows that the native species were inherently well-adapted to withstand the impact of disturbance by man. These findings do not necessarily mean that Darwin's hypothesis should be rejected. They do mean that coastal species with their cosmopolitan distributions are not typically insular. Significantly, the inland vegetation on both Mauritius and the Seychelles has been extensively modified by man.

Unresolved Issues

In general terms Darwin's hypothesis has withstood the test of empirical research rather well, although it must be admitted that few biologists or geographers have concerned themselves with a detailed analysis of insular vulnerability. In some cases vulnerability is easily understood. Flightless birds without fear of predators are obvious candidated for extinction. For plant populations the situation is less clear.

With a few notable exceptions, such as Egler, Fosberg, and J.D. Sauer, botanists have tended to ignore the subject, and have concerned themselves with systematic studies or with the analysis of undisturbed vegetation. Several biogeographers have explored the theme but for the most part have restricted themselves to the historical approach. Unfortunately, the historical record alone is rarely detailed enough to allow for anything more than a very qualitative reconstruction of vegetation change. For some islands it has been possible to establish the chronology of introductions and extinctions, but these in a sense represent only the first and last chapters of the story. The complex processes of vegetation change that have been started by man on small oceanic islands are still only poorly understood.

On a different level, the question as to what extent islands vary in their vulnerability remains unanswered. Theoretically, one would expect that the vegetation of inaccessible islands such as the Hawaiian Islands or the Galapagos would be more vulnerable to disturbance than that of off-shore islands such as the Bahamas. The former are inhabited by rare endemics, the latter by wide-ranging species. Somewhat unexpected, therefore, are the conclusions reached by Harris (1965), Watts (1966), and Kimber (1969), which suggest that the plant and animal life of the Lesser Antilles is vulnerable in much the same way as that of the Hawaiian Islands. If this is indeed the case, the plant and animal life of the Bahamas might also be expected to be vulnerable.

With these questions in mind, it was decided to study in some detail man's impact on the vegetation of one small island in the Bahamas, Cat Island. More specifically, the study attempts to determine to what extent cutting, burning, browsing, and the introduction of alien plants and animals have brought about changes in the native vegetation.

Although Cat Island is an oceanic island in the sense that it has never been joined to the continent, it is clearly less isolated than remote islands such as Hawaii or the Galapagos. As an offshore island with a lesser degree of insularity, it provides an interesting test for the hypothesis of insular vulnerability.

III. THE SETTING: A LOW LIMESTONE ISLAND

In spite of their early discovery, the Bahamas are still in many respects unknown. Wallace (1902:5), in his introduction to Island Life, briefly commented on the remarkable contrasts in flora and fauna between peninsular Florida and the Bahamas, only 50 miles to the east (Figure 1). The differences, he argued, could not be explained by existing conditions, as the climate and soil of the two areas were the same. The Bahamas were different, he implied, because they were islands. Unfortunately, although he went on to discuss, with the aid of many examples, "the complex causes of insular floras and faunas," the Bahamas were not referred to again. Then, as now, very little was known about them. Unlike the formerly prosperous sugar islands to the south, the Bahamian environment has attracted little attention from scientists.[1]

This has been particularly true for remote "Out Islands"[2] such as Cat Island (Figure 2). Apart from some botanical exploration at the beginning of the present century (Britton, 1907) and a study of land snails in the 1930s (Clench, 1938), virtually no scientific research of any kind had been carried out on Cat Island before the present study was started in the summer of 1966. Lind's study of coastal landforms began shortly afterwards and his findings have since been published (1969).

Cat Island provides a comparatively simple setting for a study of man and vegetation change. It is only 250 square kilometers in area and has a subdued relief, the highest elevation being just over 60 meters. Because of its small size and low elevation it is climatically more or less uniform. The differences that do exist are due to differences in exposure; the eastern and southern coasts face the trade winds, while the western coast is comparatively sheltered. As far as bedrock geology is concerned, again there is little variation; the entire island is composed of virtually pure calcium carbonate. There is, however, some local variation in lithology which in large part reflects the degree to which the limestone has become indurated by exposure to the atmosphere. Also, there is considerable local variation

1. This is not strictly true in certain areas of biology and geology, as a lengthy bibliography compiled by Gillis et al. (1976) indicates.
2. The term "Out Island" in the Bahamas refers to islands other than New Providence, the seat of the capital, Nassau.

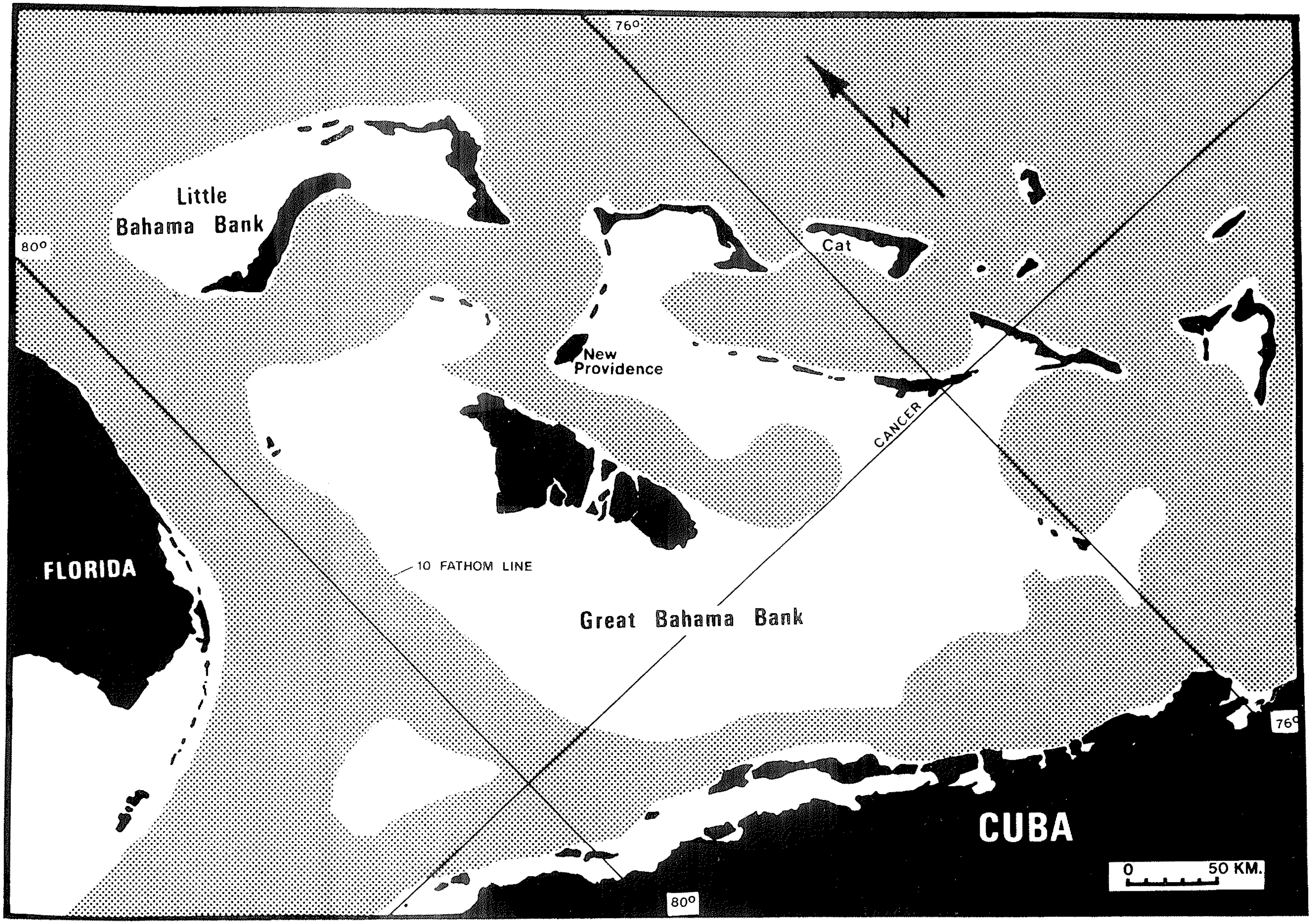

Figure 1. Map of the Bahama Islands

in the degree to which the limestone surface has been dissected by solution. In some areas there are numerous potholes, in others the surface is still more or less intact. These local differences in lithology and relief have an important influence on the composition and structure of the vegetation.

Insularity

Cat Island is located in the east central part of the Bahamian archipelago, less than a hundred miles north of the Tropic of Cancer (Figure 1). Like most Bahamian islands it fringes the windward margin of a shallowly submerged bank. Together the island and the bank form an easterly arm of the Great Bahama Bank which projects out into the deep water of the Atlantic. Off the northern, eastern and southern coasts precipitous slopes descend to depths of more than 2,500 fathoms. To the west ten miles of bank lie between the island and the comparatively shallow Exuma Sound, only 1000 fathoms deep. To the northwest a narrow submarine ridge connects Cat Island with Eleuthera and the Great Bahama Bank. There is, however, no evidence of any geologically recent land connection between the Great Bahama Bank and either Florida or Cuba, so in this sense, Cat Island is an oceanic island.

On the other hand, the sea level fluctuations of the Pleistocene drastically changed the relative areas of land and sea. A fall in sea level of only 10 fathoms, such as occurred several times during the Pleistocene, would double the present land area of the island and make it a peninsula of the Great Bahama Bank (Figure 1). For the Bahamas as a whole it would increase the land area from 5,400 to 60,000 square miles and would make the minimum salt water distance to Cuba only 10 miles and to Florida 50 miles. Clearly, Cat Island's insularity has varied significantly in the recent geological past; even today this is not an oceanic island to the same degree as remote islands such as the Hawaiian islands or the Galapagos. Cat Island's insularity is also qualified by the proximity of other islands in the archipelago.

Geology and Geomorphology

The shallow water of the Bahama banks provides an ideal environment for the accumulation of a great variety of carbonate sediments, and borehole data indicate that similar sediments have been accumulating in the area since at least the Early Cretaceous and possibly the Palaeozoic (Lynts,

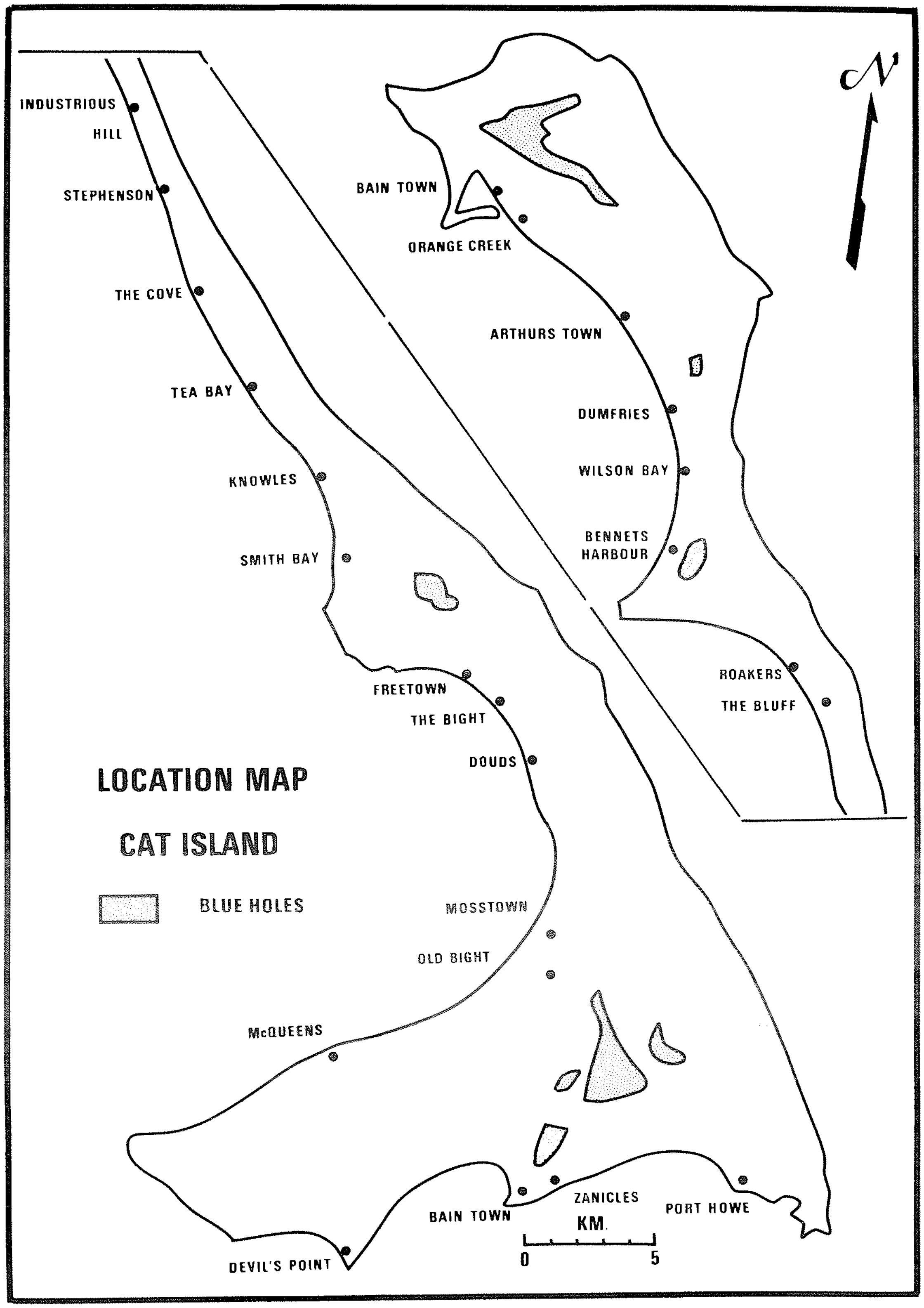

Figure 2. Location Map of Cat Island

1970: 1227). This accumulation has been made possible by a long-continued subsidence, and indicates that the Bahamian environment has in the long term been a remarkably stable one (Newell and Rigby, 1957).

Even so, the present Bahamian islands are in a geological sense very young. The surface rocks are aeolianites and shallow- water marine sediments of late Pleistocene or Holocene age. On Cat at least three age-surfaces can be identified. They are easily recognized in the field by the degree to which the limestone has been indurated and potholed. Because of the homogeneous nature of the bedrock, differences in surface characteristics are important in determining the character of the vegetation. For this and other reasons that will be discussed later it was decided to use landform types as a framework within which to analyse vegetation change. Although some of the details of the origins of Bahamian landforms are still unclear, the general pattern seems plain; furthermore, it is a pattern that repeats itself on all the larger islands.[3] What follows here is a brief account of the sequence of landform types observed on Cat Island. Figure 3 represents a geomorphological cross-section of the island and Figure 4 shows the distribution of the more important habitat-types.

Dune Ridges.

On the windward side of the island three discontinuous dune systems run sub-parallel to the present coast. The oldest lies furthest inland and is usually higher than the other two, reaching just over 60 meters in places. The aeolianite is indurated to an unknown depth, and its surface is pockmarked with potholes. Although no dates are available for the age of these dunes, they may have been formed during the Yarmouth or early Sangamon interglacial. That they were partly submerged prior to the present sea level rise is shown by a wave-cut bench at about 1 meter above the present high tide mark. Fossil coral was occasionally observed at about the same elevation, although nowhere was it as common as on other Bahamian islands, such as Andros and Mayaguana. Isotope dates for presumably synchronous corals on the Florida Keys range between 80,000 and 150,000 years (Broecker and Thurber, 1965; Newell, 1965).

A mile or so to the east of the older dunes is a dune system of intermediate age.[4] These dunes are generally

3. Doran (1955) has provided a useful account of the landforms of the southeastern Bahamas.
4. In some areas, as for example behind the northern coast of the island, the intermediate-age dunes have overridden the older dunes.

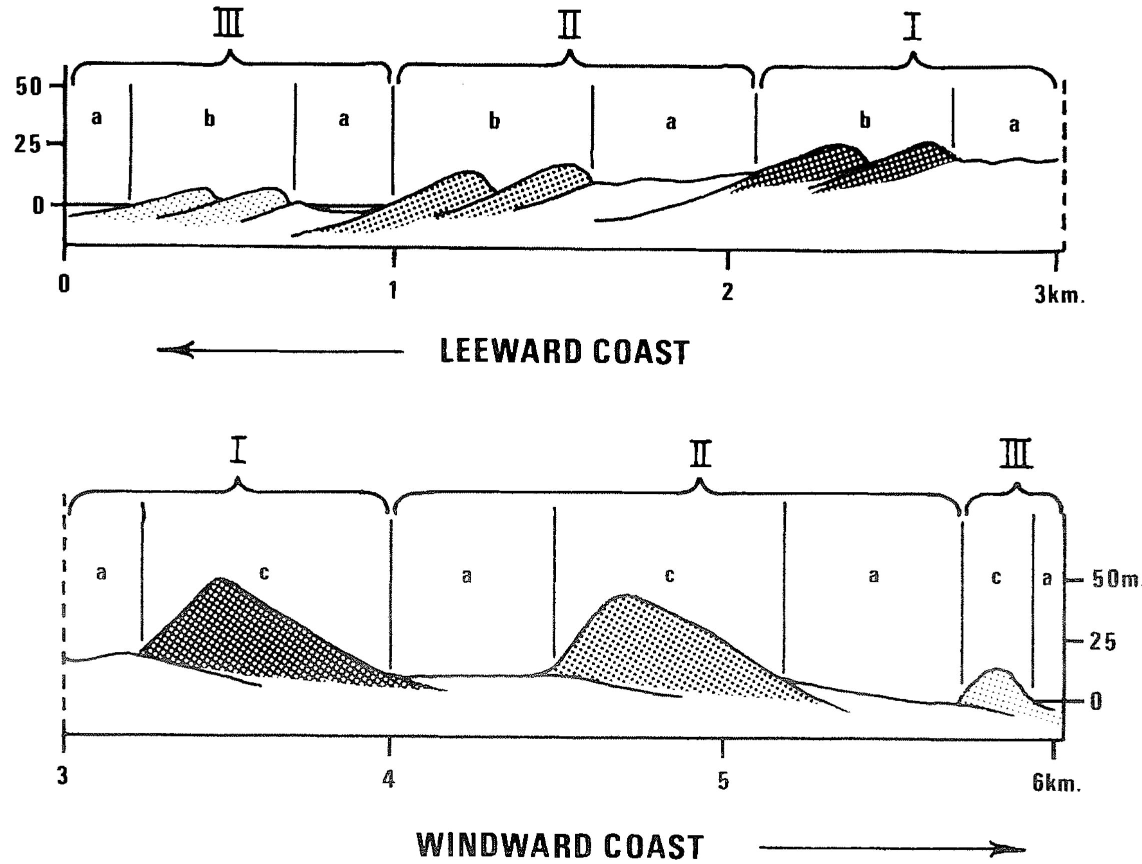

Figure 3
A Geomorphological cross-section of Cat Island

	AGE	LANDFORM TYPE	HABITAT TYPE
III	Holocene	a Marine Beds b Beach Ridges c Dune Ridges	Offshore Whiteland Whiteland
II	Young Pleistocene	a Marine Plains b Beach Ridges c Dune Ridges	Flatland Blackland Blackland
I	Old Pleistocene	a Marine Plains b Beach Ridges c Dune Ridges	Flatland Blackland Blackland

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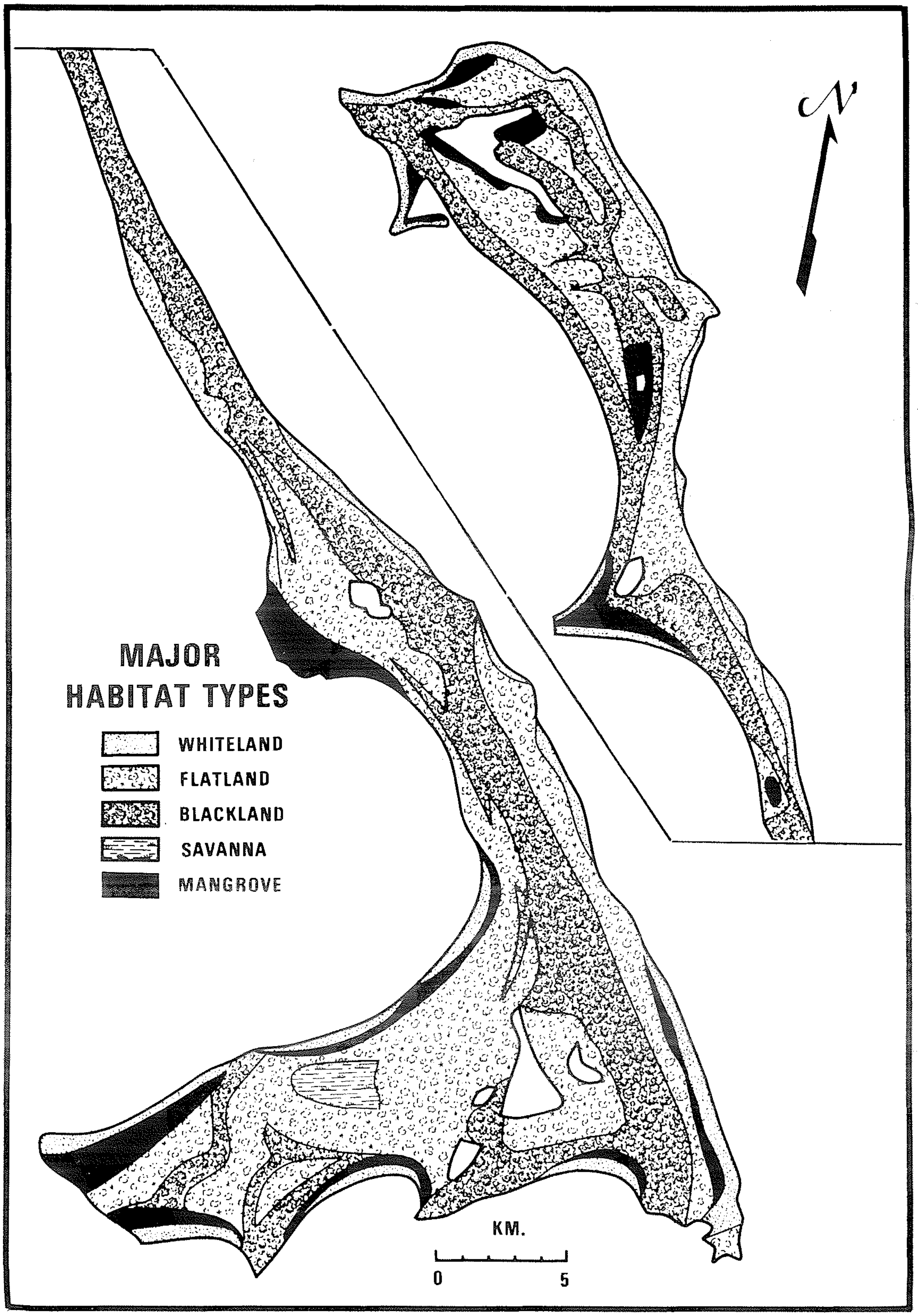


Figure 4. Map of Cat Island showing Major Habitat Types

between 15 and 30 meters high. Their surfaces are also indurated, but lack the numerous potholes of the older dunes. In localized areas the limestone is loosely consolidated and breaks down to produce a sandy soil. On the ground, the intermediate dune system has a comparatively fresh appearance, with steep lee slopes and gentle dip slopes easily distinguished. Also Pleistocene in age, they do not show any evidence of marine erosion apart from that which has accompanied the recent rise in sea level. Directly behind the windward coast is the youngest dune system. These dunes rarely reach more than 15 meters in height and are usually around 6 meters high. The lime sand has been only shallowly indurated and is easily kept loose by cultivation. Like the two older dune systems, the younger dunes are fossil landforms, and erosion rather than dune formation characterizes the present coast. These Holocene dunes were studied in detail by Lind, who obtained dates for them of between 4,000 and 500 years (Lind, 1969: 126).

Casual inspection with a hand lens suggested, all three dune systems are composed of similar carbonate sediments. Oolites are particularly important, with fragments of shell, coral, and calcareous algae also being common. Fossils are not abundant, although in certain layers shells of the land snails *Cerion* and *Cepolis* can be found. The differences in the surface characteristics of the three dune systems are important as far as the cultivation of crops is concerned and as a consequence they are recognized locally as distinctive habitat-types. The two Pleistocene dune systems are known collectively as "the blackland," while the Holocene dunes are called "the whiteland".

Beach Ridges.

On the leeward side of the island, water has been a more important depositional agent than wind, and here beach ridges are the most prominent land form. They curve round in multiple series independent of whatever was the prevailing wind direction at the time they were being formed. Their distribution has apparently been influenced by the movement of currents in the lee of the dunes.

Again three age surfaces can be distinguished, each one corresponding to a dune system on the windward side of the island (Figure 3). Collectively they differ from the dunes both in their lower elevation and in the symmetry of their cross profiles. In terms of surface characteristics, each beach ridge system is much the same as its equivalent dune system, and to this extent offers similar opportunities for plant life. This is true of cultivated as well as wild plants, and as a result the local people make the same distinction between the younger, older, and intermediate-aged surfaces as they do on the dunes. The former is known as "the whiteland," the other two "the blackland".

Lagoonal Plains.

Between the dunes, and between the dunes and beach ridges, are two comparatively level surfaces. Their origin is indicated by the marine shells they contain, including the conch Strombus. Apparently they are of different ages. The higher surface at about 6 meters above sea level is riddled with potholes, whereas the lower one, only a few meters above sea level, is comparatively intact. The higher surface is probably the same in age as the oldest dune/beach-ridge system while the lower surface corresponds to the intermediate dune/beach-ridge system. A third surface, corresponding to the youngest dune/beach-ridge system, can be seen below present sea level at an average depth of about 3 fathoms.

Unlike the cross-bedded aeolianite that makes up the dunes, these marine sediments have bedding planes that are close to horizontal and as a result the land surface tends to be much smoother. Especially level areas are known locally as "platey land" and, as will be shown later, have a distinctive vegetation cover. The plains are not entirely flat, being characterized by low undulations with wavelengths in the order of 1 x 10 meters. The proximity of the water table in low-lying areas means that slight changes in elevation can produce sharp changes in vegetation.

Soils

The soils of the island are thin and discontinuous. For the most part they vary according to the age of the land surface and the extent to which it has been disturbed by man. Mooney (1905), in the only comprehensive account of Bahamian soils yet available, lists four soil types as being present on Cat: (1) Coral sand, (2) Bahama Black Loam, and (3) Bahama Red Loam, (4) Bahama Marl.

The coral sand type refers to the soil found on the Holocene sand dunes and ridges, or in local terms, the whiteland. The term "coral sand" is a misnomer since coral fragments form only a very small percentage of these sediments. The whiteland soil type is immature in the sense that there is little profile development. The A1 horizon is very thin, rarely more than a few inches thick if it is present at all. In most parts of the island, cultivation has disturbed whatever profile had developed in the pre-agricultural period.[5] According to Mooney (1905: 157), this soil is quite rich in potash, phosphates, and nitrates. However, a more recent government report states that the whiteland soil is poor in nutrients and too droughty for successful agriculture (Anonymous, 1960).

The Bahama Black Loam is the most widespread soil type on the island. It covers all but a few areas of the indurated Pleistocene surfaces. Like the whiteland soil it has been severely disturbed by cultivation and is rarely more than a few inches thick. During cultivation it collects in pockets and crevices in the limstone surface, leaving large areas of bare rock exposed. According to Mooney (1905: 158), it is a residual soil derived from the underlying limestone by weathering. An alternative explanation would be that it consists of broken-down organic matter. Because of the capillary rise of water through the underlying limestone, this soil type is less droughty than the whiteland soils (Anonymous, 1960: 2). It is recognized as the most productive soil type on the island and is therefore frequently cultivated.

The Bahama Red Loam has a restricted distribution on Cat Island. It is found on the older dune and beach ridge systems and in the land-locked depressions between them. This red soil is almost certainly a fossil soil that formed under different weathering conditions during the Pleistocene. Similar fossil soils have been described in several areas of the West Indies (Ruhe et al., 1961; Kaye, 1959). It is a lateritic soil rich in iron and aluminum and has been derived from the underlying limestone by weathering. Although it appears to be a loam in the field, particle size analysis has shown it to be a clay (Ahmad and Jones, 1969). This is also indicated by the way in which it floods after rain and becomes hard and compacted when dry. According to Mooney (1905: 166), it is rich in nutrients, particularly phosphates, nitrates, and potash, It has a slightly lower pH than the Bahama Black Loam (7.0-7.5 cf7.5-8.0) and probably because of this has been especially favored for pineapple cultivation (Anonymous, 1960: 2).

Mooney's fourth soil type, the Bahama Marl has a very restricted distribution on Cat Island, being found only in small areas of low ground east of McQueens settlement (Mooney, 1905: plate XXXI). Basically it is a freshwater marl overlying decayed organic material. Its proximity to the water table makes cultivation precarious, and as a result it has only been used for grazing in recent years.

5. Lind (1969) failed to take this into account in his study of the coastal landforms of the island.

The importance of soil differences as far as the composition of the wild vegetation is concerned is not clear. The whiteland is a distinctive habitat-type, but not because of its soil characteristics. The boundary between the Black Soil and Red Soil is usually distinct, but as Mooney reported (1905: 165), it does not appear to have any significance as far as wild vegetation is concerned. The Bahama Marl is too localized to be of major importance. For the island as a whole it is probably a safe assumption that soil differences *per se* are not an important cause of variation in the structure and composition of wild vegetation.

Climate

As might be expected from its location, Cat Island has a seasonally wet and dry sub-tropical climate (Table 1).

TABLE 1

CLIMATIC DATA 1952-1962
THE BIGHT, CAT ISLAND
Bahamas Dept. of Agriculture, cited in Lind (1969: 10)

	Temperature		Rainfall	
	F	C	inches	mm.
Jan	72	22.2	1.2	30.5
Feb	74	23.3	1.2	30.5
Mar	73	22.8	1.6	40.6
Apr	75	23.9	4.5	114.3
May	78	25.6	3.9	99.1
Jun	81	27.2	1.9	48.3
Jul	82	27.8	3.8	96.5
Aug	83	28.3	5.0	127.0
Sep	82	27.8	9.1	231.1
Oct	80	26.7	9.1	231.1
Nov	76	24.4	3.6	91.4
Dec	77	25.0	2.1	53.3
Total			39.2	995.7
Mean	78	25.6		

The basic climatic control is the north Atlantic subtropical high pressure cell. In winter the cell moves south and intensifies, limiting convection and reducing rainfall. Occasional outbreaks of modified polar air bring cloudy weather from the north and temperatures fall as low as the 60s, but for the most part the sky is clear and temperatures average in the 70s. In summer the high pressure cell moves north, convection is stronger, and trade wind cumulus clouds may tower as high as 50,000 feet. This is the rainy season, during which sporadic convectional showers provide most of the total precipitation. Afternoon temperature may reach the low 90s in July and August, although the comparatively cool trade winds keep the averages in the 80s.

As far as plants are concerned, perhaps the most important aspect of Cat Island's climate is its mildness. Separated from the continent by the warm waters of the Gulf Stream and under the influence of the trades for most of the year, the island has a truly oceanic climate. Wallace (1902: 5) underestimated this oceanicity when he argued that differences in plant and animal life between Florida and the Bahamas could not be explained by climate. Frost is virtually unknown in the islands, and because of this many plants are able to grow that could never survive for long on the mainland. To the northerner Bahamian vegetation is very definitely tropical.

In a negative sense rainfall is a more important climatic variable than temperature. Although the data presented in Table 1 do not show it, summer droughts are a common occurrence in the Bahamas. In some years no rain may fall for several months and at such a time plant life is dependent upon either the formation of dew or the upward movement of water through the limestone by capillary action. A visitor to Cat Island from the West Indies or Central America would see few plant species that were new to him, but he would probably be surprised by the generally stunted nature of the vegetation. Early students of the Bahamas flora were especially impressed by the many morphological adaptations to drought shown by Bahamian plants, for example, hairiness and small leathery leaves (Coker, 1905: 215). Deciduousness is also a response to the seasonally-dry climate, and during the "winter" many trees and nearly all the shallow-rooted bushes lose their leaves.

A phenomenon closely related to the occurrence of drought is fire. Unfortunately, the significance of natural fires as far as Cat Island vegetation is concerned is difficult to assess. According to local informants, no lightning fires were known to have occurred within living memory. Even so, the possibility remains that they could occur, especially in the seasonally-flooded savannah. The evergreen woodland could also burn naturally if there were enough dry fuel available on the ground. This is rarely the case today, although it may have been more common in the past. The significance of natural fires in the Everglades area of South Florida has been recently emphasised by Craighead (1971) and Robertson (1962).

Another important aperiodic climatic variable is the frequency of hurricane strength winds. In 186 years, 12 hurricane eyes have passed over the island, an average of one every 16 years (Lind, 1969: 132). Although no studies have been done on the effects of hurricanes on Bahamian vegetation, the conclusions drawn from studies in similar areas elsewhere are probably applicable (Craighead, 1962, 1964; Stoddart, 1965; Sauer, 1962; Wadsworth and Englerth, 1959). Native species are usually quick to recover after the storm. Flexible trunks and branches, bushy habits, photosynthetic bark, and deep root systems are characteristic of many Bahamian species.

Hydrology

The porosity of the limestone exaggerates the droughtiness of the surface, but on the other hand it means that rainfall is not quickly lost as run-off. In the indurated Pleistocene dunes, the water table may be at a considerable depth below the surface. At the Devils Point settlement, for example, deep wells are required to reach fresh water. In the summer of 1970 the water table was 12 meters below the ground surface and only 3 meters above sea level. Plant life on these hills must therefore rely upon water from the unsaturated zone. In the loosely-consolidated younger dunes and beach ridges the water table is very close to sea level.

Although there are no permanent fresh water streams on the island, several low-lying, land-locked depressions are flooded after heavy rains in the summer and autumn. This flooding makes tree growth impossible and means that slight changes in elevation can cause sharp changes in vegetation. In these areas the location of the water table has an important influence on the character of the vegetation.

The Environment as a Whole

A low, limestone island such as Cat appears to provide a rather difficult environment for plant life. Droughts, hurricanes, and an apparently infertile limestone surface all combine to place limitations on plant growth, and at first acquaintance it is somewhat surprising that anything can grow here, wild or cultivated. Yet, paradoxically, the island is floristically rich. In an area of only 250 square kilometers, probably a thousand species of vascular plants are present.[6] In large part this diversity must reflect the fact that the low, limestone island is an ancient environment. In the area that is now the Bahamas, islands similar to Cat have probably been discontinuously present since at least the early Cretaceous. Plants and animals have therefore had a long time to adapt to this sort of setting. It is interesting to note here that of 60 genera identified in the Wilcox Flora of the Southeastern United States, which dates to the early Eocene (Berry, 1930), roughly 40 percent are living in the Bahamas today. This is not to suggest as the nineteenth-century authorities might have done, that Bahamian vegetation has survived undisturbed since the early Tertiary. The Bahama islands as they are today are geologically young. Furthermore, the sea level oscillations of the Pleistocene must have caused drastic changes in hydrological conditions and corresponding changes in vegetation independent of any changes in regional climate. On a shorter time scale, natural disturbance, in the form of dune formation and erosion, flooding by salt and fresh water, hurricanes, and lightning fires, has undoubtedly played an important role in the development of Bahamaian vegetation. How this vegetation has been able to withstand the new types of disturbance introduced by man is the main concern of the present study.

6. This estimate is based on the Bahama Flora (Britton and Millspaugh, 1920:vii), which lists 995 spermatophytes and 33 pteridophytes for the archipelago as a whole. These totals, however, only include cultivated species such as have shown "a strong tendency to become spontaneous."

IV. THE PRESENT VEGETATION: A GENERAL VIEW

Ideally, a study of man and vegetation change would begin with the vegetation as it was before man arrived and then trace the changes that have occurred as a result of his presence. In practice, even for recently settled islands, this is rarely possible. The problem, of course, is that there are so few accurate accounts of aboriginal vegetation. Certainly for Cat Island there is nothing. The Arawaks left no written record, and the early European accounts are disappointingly vague. An alternative approach was therefore called for. The one that is followed here is similar to that used by Harris in his study of the Outer Leeward Islands (1965). The present vegetation is described first in general terms. This general account then provides the basis for the later, detailed analysis of man's impact.

In most respects, the vegetation of Cat Island is similar to that of the rest of the Bahamas and indeed to that of similar environments in the New World subtropics as a whole.[1] A low, largely evergreen woodland covers all but the lowest ground, where it gives way to either salt-tolerant vegetation or seasonally-flooded savanna. Because of the island's small size and low relief, climate is not an important cause of variation in the composition or structure of the vegetation. The differences that do exist can largely be attributed to disturbance by man or to differences in topography, lithology and drainage. For purposes of general description, therefore, the vegetation was classified indirectly on the basis of landform or habitat- types. The resulting classification is shown in Table 2. It has the advantage that it avoids the arbitrary problem of classifying vegetation itself and at the same time provides a coherent framework within which to study the processes of vegetation change.

The Original intention, was to study man's impact on the vegetation of the entire island. However, it soon became clear that such a broad approach would have to be of limited depth and it was therefore decided to restrict the study to an analysis of man's modification of the evergreen woodland, or "coppice" as it is locally known. Unlike the vegetation of salt water habitats and seasonally-flooded

1. It differs from several Bahamian Islands (New Providence, Abaco, Andros, Grand Bahama, Caicos) in that the Caribbean pine (Pinus caribaea) is not present. There is no obvious explanation for the anomalous distribution of pine in the Bahamas.

TABLE 2
VEGETATION AND HABITAT TYPES
A. SALT WATER HABITATS

ASPECT	COASTAL		INLAND	
HABITAT TYPE	Holocene dunes and beach ridges	Pleistocene dunes and beach ridges	Holocene marine sands	Pleistocene marine limestones
LOCAL NAMES	Strand	Scrub	Tidal Flats	Lagoons
VEGETATION	Strand	Scrub	Mangrove	Mangrove

B. FRESH WATER HABITATS

DRAINAGE	SEASONALLY-FLOODED		WELL-DRAINED		
HABITAT TYPE	Holocene marls	Pleistocene marine limestones	Holocene dunes and beach ridges	Pleistocene dunes and beach ridges	Pleistocene marine limestones
LOCAL NAMES	Marsh	Savanna	Whiteland	Blackland	Flatland
VEGETATION	Marsh	Savanna	Woodland		

areas, the woodland occupies ground on which cultivated crops can be grown, and as a result it has been drastically disturbed by man. In the general account that follows, the comparatively undisturbed vegetation of the uncultivated areas is described first, since it provides the background for the later discussion of the woodland.[2] Figures 5 through 15 illustrate the general aspect of the vegetation of the uncultivated areas.

Salt Water Habitats

Salt water is never far from the surface in the Bahamas. No part of Cat Island is more than 3 kilometers from the sea, and the fresh water lens at its deepest is probably not more than 30 meters thick. All the larger lakes are saline and tidal. Around the margins of these lakes there is a transitional zone of brackish water, the width of which varies from a few meters to over a kilometer. Its extent largely a function of topography and bedrock characteristics.

The vegetation of the salt-water habitats is distinctive, few of the salt-tolerant species are adapted to life in a fresh-water environment. None of the species present is peculiar to Cat Island and most of them are widely distributed throughout the New World sub- tropics. The differences in vegetation within the salt-water habitats are largely to differences in parent material and exposure. The latter is most important, and accounts for the contrast between the vegetation of the coast and that of the tidal flats and lagoon margins.

Coastal Environments

The coastal environment presents problems that few species have been able to overcome. The plants that live here are adapted to periodic flooding by salt water, salt spray, high evaporation rates, and geomorphic instability. Soils are thin or non-existent and the species present are capable of growing in a raw sand or bare rock substrate. The nature of the substrate is the main determinant of local

2. Most of the species listed in this account were collected in the field. A voucher collection including some 600 specimens has been deposited in the University of Wisconsin herbarium, and an almost complete duplicate set in the herbarium of the Arnold Arboretum, Harvard University. A systematic list of the species encountered is given as Appendix I, and a list of local names and their scientific equivalents as Appendix II.

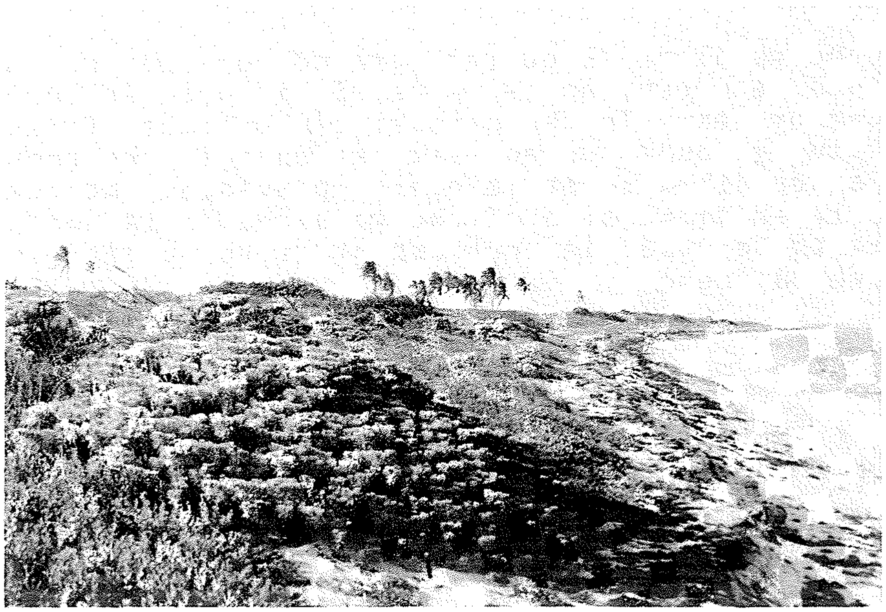
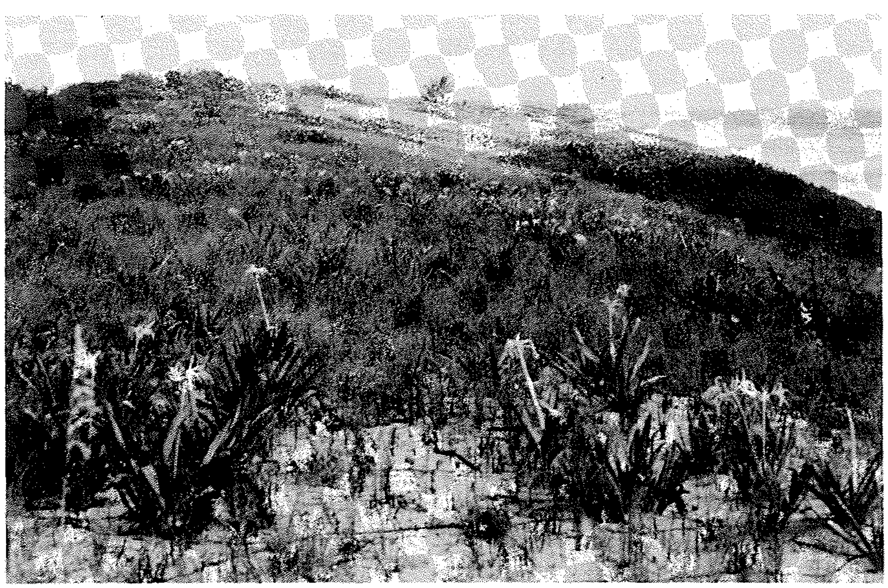


Figure 5. Holocene beach-ridges at North Bird Point. Mallatonia gnaphaloides is in the central foreground, Suriana maritima in the lower left. Herbaceous cover consists of Uniola paniculata and Iva imbricata. The coconuts in the background are planted.

Figure 6. Holocene dune coast east of Stevenson. Large thickets are primarily Coccoloba uvifera. In the foreground is Hymenocallis declinata together with Uniola paniculata and Ipomoea pes caprae.



variation in floristic composition.

Holocene Dunes and Beach Ridges. Most of the dunes and beach ridges that fringe the coast were formed during the postglacial rise in sea level. They are composed of a variety of carbonate sediments that are as yet poorly consolidated and are in fact being constantly eroded and redeposited, especially along the exposed east coast. This is a particularly unstable habitat and as one would expect, herbs, vines, and shrubs are especially important.

The zonation of species that characterizes so many tropical coasts is not always evident on Cat Island. Disturbance by waves, wind, and man usually prevents the establishment of any stable pattern. In several exposed areas along the eastern and northern coasts the sand is virtually bare of shrubs. Here sea oats (Uniola paniculata) and the sea lily (Hymenocallis declinata) are common. The sand is usually crisscrossed by trailing vines, Ipomoea pes-caprae, Cassytha filiformis, Canavalia maritima, and the bay marigold (Ambrosia hispida). several grasses (Paspalum vaginatum, Cenchrus tribuloides, Distichlis spicata) and succulents (Sesuvium portulacastrum, Iva imbricata, Chamaesyce mesembrianthemifolia, Cakile lanceolata). Not all of these species are likely to be found in any one locality, but all are common along the coast. In other areas a thicket of evergreen shrubs reaches down to the edge of the beach. Probably the two most common species here are the sea grape (Coccoloba uvifera) and bay cedar (Suriana maritima). Also characteristic of the coastal thickets are Scaevola plumieri, Mallatonia gnaphaloides and Guilandina bonduc.

In some areas along the comparatively quiet western coast the Holocene sands have become partially indurated. The harder surface offers different opportunities for plant life and is characterized by different species combinations. This transitional type of habitat can in fact be included in the next sub-heading.

Pleistocene Dunes and Beach Ridges. The indurated Pleistocene surfaces offer a more stable habitat for plant life and, the vines and stoloniferous grasses are less common here. Fleshy beach plants such as Sesuvium portulacastrum are occasionally seen but for the most part low xerophytic shrubs provide the only cover. Two very common species are Strumpfia maritima and Rachicallis americana. Suriana maritima is sometimes present as also are Antirrhea myrtifolia, Erithalis fruticosa, Ernodea littoralis, Eugenia longpipes, Jaquinia keyensis and Bumelia retusa. The limestone surface is very droughty and even on sheltered sites the shrubs are rarely more than 2 meters tall.

Tidal Flats and Lagoon Margins.

Along the exposed eastern coast no plants can survive for long in the inter-tidal zone. However, this is not the case along the more sheltered leeward coast. Here is an extensive area of tidal flat most of which occupied by mangroves. All four New World mangrove species are native to Cat Island, the red mangrove (Rhizophora mangle), the black mangrove (Avicennia germinans), the white mangrove (Laguncularia racemosa), and buttonwood (Conocarpus erecta). Rhizophora is by far the most common of the four, ranging from the high tide mark to the edges of the tidal channels. On the flats it rarely reaches more than a meter in height, whereas along the tidal channels it may reach 2 to 3 meters. Avicennia, more tree-like in habit and lacking the prop roots, appears to prefer a more stable substrate than lime mud. Characteristically, it is seen fairly close to the high tide mark or in an area where the limestone bedrock is close to the surface. Laguncularia is the rarest of the four and appears similar in habitat preferences to Avicennia. Conocarpus is very definitely restricted to a narrow zone just above the high tide mark. Also, salt-tolerant herbs such as Batis maritima, Salicornia perennis and Borrichia arborescens are frequently found just above the high tide mark.

Along the central axis of the island and behind the coastal dune barriers are several salt water lagoons, some narrowly connected to the sea, others completely landlocked.[3] For reasons that are not immediately apparent the lagoons vary considerably in their physical and biological characteristics. Some are comparatively clear while others have the consistency of thick soup due to the accumulation of algae. The vegetation around their margins, however, is similar to that found along the coast or on the tidal flats. and floristic differences can be largely attributed to differences in substrate.

Unconsolidated sediments, such as cover a wide area around the Orange Creek Blue Hole (Figure 2), are usually characterized by Rhizophora and other typical tidal flat species. On the other hand, salt-tolerant shrubs such as Rachicallis, Strumpfia, and Conocarpus are more common where the shoreline is rocky.
This generalization does not always hold true, as for example along the rocky shoreline of the Blue Hole east of Dumfries, where there is a forest of pure Rhizophora, with

3. Several of the deeper lagoons are known as "blue holes." Some are thought to be inhabited by sea monsters and are therefore avoided by the local people.

Figure 7. Leeward limestone coast at Wilson Bay. Species present are Conocarpus erecta, aevola plumierii, Coccoloba uvifera, Reynosia septentrionalis, Borrichia arborescens, and Strumpfia maritima.

Figure 8. Exposed limestone coast south of north Bird Point. Suriana maritima showing the effects of exposure to the trade winds.

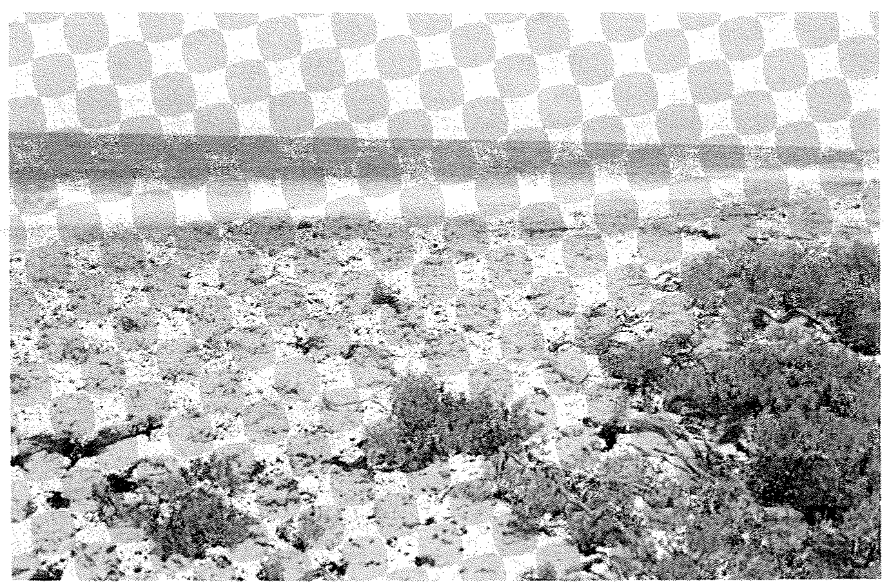


Figure 9. *Rhizophora mangle* at the Dumfries Blue Hole. Epiphytic bromeliads are the only other vascular plants present here.

Figure 10. Margin of a tidal channel south of Dumfries. *Avicennia nitida* dominates the foreground, its pneumatophores are growing in a meter of peat and marl. The most common species in the background is *Conocarpus erecta*.

trees as high as 8 meters, growing on peat that was measured to be at least 6 meters thick in places. Samples were taken from this peat for pollen analysis, but unfortunately they proved to be barren.

Man's Impact on the Vegetation of Salt-Water Habitats.

For the most part the vegetation of salt-water habitats has not been disturbed by man. Only near the settlements on the sheltered leeward coast has really significant modification taken place. Here mangrove swamps in tidal inlets have been locally cleared or filled to reduce the mosquito problem and generally improve sanitary conditions. *Rhizophora* is cut for charcoal, although not in sufficient quantities to affect its overall distribution. Likewise *Conocarpus* has not become noticeably rare around the settlements even though it is the most popular source of firewood.

A few horses are grazed on the whiteland, although it is doubtful that they have had much of an impact on the coastal vegetation as most of the common species are not really palatable. Fires were occasionally observed to have spread down to the coast from inland fields; however, their effect has probably been small in the long term.

As far as the invasion of alien plants is concerned, only the Australian Pine (*Casuarina equisetifolia*) has been really successful. It was introduced to the island probably less than a hundred and fifty years ago and has since spread along most of the sheltered west coast. It is planted in the settlements as an ornamental and occasionally on the whiteland as a windbreak. From these plantings it has rapidly colonized a narrow zone just above the high tide mark. Characteristically, it carpets the ground with a cover of needles that few species can cope with and has replaced the native plants over a considerable section of the leeward coast. On the windward coast it has been less successful, possibly because erosion is more active there.

Apart from *Casuarina*, the only other exotics that have become established are Spanish Bayonet (*Yucca aloifolia*) and the Mahoe (*Thespesia populnea*), neither of which have spread far outside of the settlements. The coconut (*Cocos nucifera*), although often seen in the beach drift, has for some reason failed to establish itself spontaneously on Cat Island. The same is true of the Indian Almond (*Terminalia catappa*).

In general, the vegetation of salt water habitats has proved remarkably resistant to disturbance by man. Except

Figure 11. Competition between _Casuarina equisetifolia_ and _Gundlachia corymbosa_. The accumulation of _Casuarina_ needles has somehow caused the death of the _Gundlachia_ bushes. Crab holes are evident in the foreground.

on the leeward coast where *Casuarina* has become so important, there is little evidence of man's intervention.

Seasonally-Flooded Freshwater Habitats

Over most of the island fresh water is quickly absorbed at the surface. However, in low-lying areas, particularly land-locked areas, the surface may be flooded to a depth of several feet after heavy summer rains. The water may stand on the ground for several days before being absorbed by the limestone. These floods, together with drought in the dry season, provide a combination that few perennials can withstand. Woody species may survive long enough to become saplings, but in the long-term, tree growth is not possible. The vegetation of these areas is in many respects similar to that of the Florida Everglades and to seasonally- flooded savannas in general.

The largest area of savanna on Cat Island is just to the east of McQueens (Figure 2). To the north and east it is bounded by a Pleistocene dune ridge whose fairly steep slopes provide a sharp limit to the flooded area, whereas to the south and west a gradual rise through a series of low ridges produces a more broken transition. The ridges appear as islands, or "hammocks," of evergreen woodland surrounded by savanna. With increasing elevation the woodland increases in area at the expense of the savanna, until the distribution is reversed and small pockets of savanna survive in depressions surrounded by woodland. These in turn disappear on the higher ground.

In the lower parts of the larger savannas fresh water may be present throughout the year. These marshy areas are characterized by *Eleocharis caribaea*, sawgrass (*Cladium jamaicense*), and cattail (*Typha domingensis*). In seasonal ponds several aquatics were collected, including *Nymphaea ampla* var. *pulchela*, *Potamogeton heterophyllus*, and *Prosperinaca platycarpa*. Around the margins of these ponds *Echinodorus berteroi Jussiaea suffruticosa*, *Centella erecta*, *Lippia stoechadifolia* are commonly encountered, together with the sedges *Albilgaardia monostachya*, *Dichromena colorata* and *Rhynchospora cyperoides*. Around the edges of the smaller, potholes the pond apple (*Annona glabra*) is often found.

In the drier areas several species of herbs are characteristically present; for example, *Pluchea rosea*, *Buchnera elongata*, *Eustoma exaltatum*, *Sabbatia stellaris*, *Eupatorium villosum*, *Walthera indica*, *Cynoctonium mitreola*, and *Linum bahamense*. The savannas are not grasslands in the true

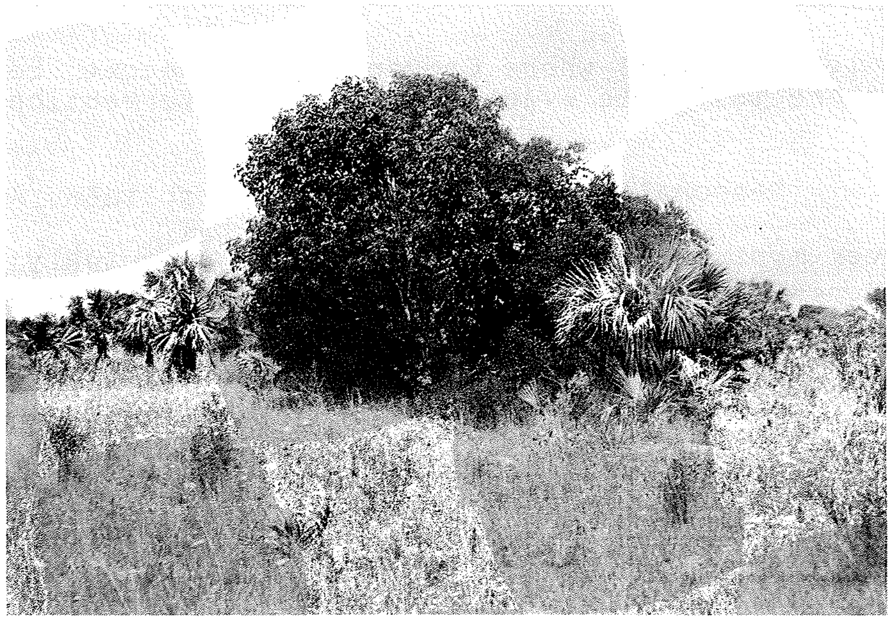
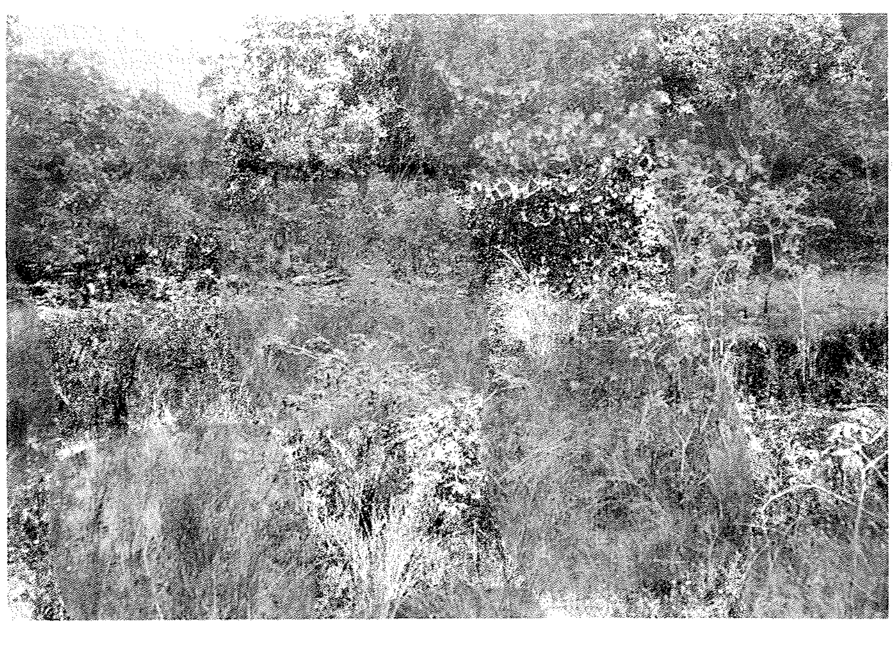


Figure 12. A "hammock" in the McQueen's savanna. A poisonwood (Metopium toxiferum) has become established on a small ridge. On either side are palmettoes (Sabal palmetto); in the foreground Pluchea rosea, Andropogon gracilis, and Aristida ternipes.

Figure 13. A small seasonally-flooded depression just above the McQueen's savanna. The white bracts of Dicromena colorata are visible in the foreground, as are saplings of Tabebuia bahamensis. In the background are Coccoloba uvifera and Metopium toxiferum.



sense of the word, as grasses cover only a small percentage of the total area. *Andropogon gracilis* and *Aristida ternipes* were the only grasses seen, and both were rare.

Around the edges of the savannas, pioneer shrubs and small trees often obtain temporary foothold; especially common are horsebush (*Gundlachia corymbosa*), sweet gale (*Myrica cerifera*), coco plum (*Chrysobalanus icaco*), beefwood (*Torrubia Longifolia*), and five finger (*Tabebuia bahamensis*). Palmettoes (*Sabal palmetto*) mark the upper margins of the flooded ground and in turn give way to evergreen woodland on the well-drained sites.

Man's Impact on the Seasonally-Flooded Freshwater Habitats.

As in the salt-water habitats, the growth of crops is not possible in the seasonally-flooded areas, and consequently the native vegetation has been relatively undisturbed. Fire has probably been the main cause of change.[4] All but the youngest palmettoes show scorch marks on their trunks (Figure 14). According to local information, savanna fires served no useful purpose and were simply the work of children. There were no reports of any lightning fires, but this does not mean they never occur. In the Everglades, for example, they are not uncommon events (Robertson, 1962).

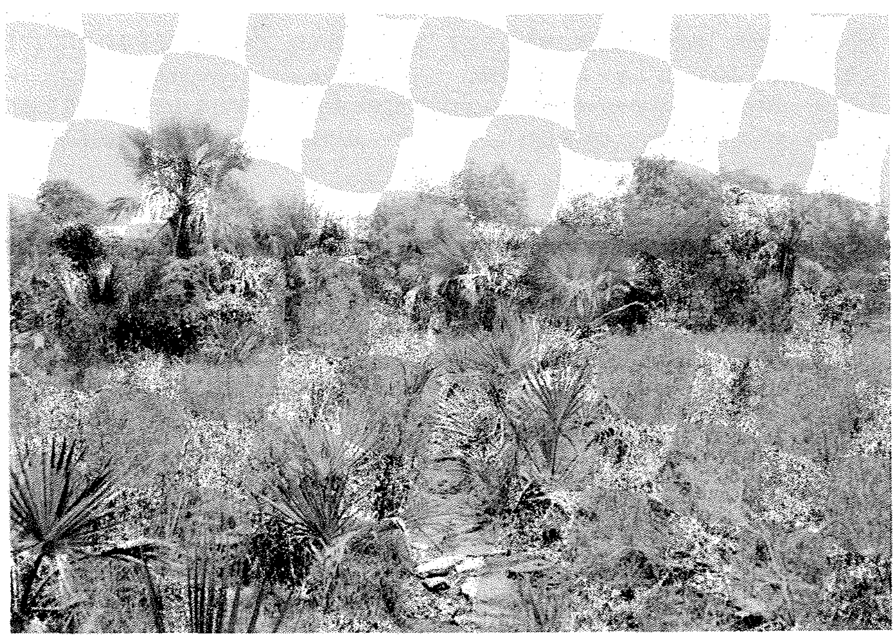
Grazing by horses was observed in the more accessible areas, although what species were affected was not determined. The savannas are generally regarded as poor pasture because they dry out during the winter months.

No alien species appear to have established themselves in the seasonally-flooded areas. *Casuarina*, which has colonized analogous areas in the Everglades (Egler, 1952), is conspicuously absent. On the other hand, the McQueens savanna does provide a good example of man having locally extended the range of a native species. As can be seen from Figure 15, the trail through the savanna passes through an avenue of palmettoes. These have grown from berries dropped during the harvesting of palmetto inflorescences for hog feed. For the most part, however, the seasonally-flooded savannas have been of little value to man, and for this reason they have remained relatively undisturbed.

4. There is no evidence to suggest that the area of savannas has been enlarged by repeated fires. In all cases the woodland comes down to the edge of the seasonally flooded areas.

Figure 14. Palmettoes (Sabal palmetto) recently burned by children. The palmettoes were not killed by the fire and were actually sprouting new leaves at the time the photograph was taken.

Figure 15. "Footpath distribution" of palmettoes near McQueens. The individuals alongside the trail have grown from accidentally dropped fruits, that had been gathered for hog feed.



Well-Drained Freshwater Habitats.

Most of the island is covered by a low, largely evergreen woodland, locally known as "the coppice". And as its local name implies, it has been drastically disturbed by man. Seen from above it has the appearance of a patchwork quilt, the abandoned fields of shifting agriculturalists showing progressively darker shades of green according to their age (Figure 16). On the ground, sharp changes in height and floristic composition give further clues as to the history of disturbance. It was this obviously disturbed aspect of the woodland that made it particularly interesting in the context of the present study

In mature woodland on the more mesic sites, the dominant trees reach a height of 10 meters or so, with the larger trees having diameters at breast height of from 20 to 30 centimeters. On dry sites, where the fresh water lens is thin or the limestone surface is steep, the woodland degenerates into a cactus scrub. Here the shrubby trees are rarely more than 3 meters tall, and the dildo cactus (Cephalocereus millspaughii) adds to the xerophytic character of the vegetation.

As a vegetation type the Cat Island woodland is probably equivalent to Beard's (1955) "Evergreen Bushland" and dry "Evergreen Thicket". This kind of vegetation is frequently encountered in low limestone environments throughout the New World sub-tropics. To the northerner the woodland is definitely tropical. The great majority of species present range south to the Greater Antilles or beyond, and very few are found north of the Florida Keys. Furthermore, it is floristically rich. Coker was certainly correct when he reported that:

> As one passes through a typical Bahamian coppice, different plants are met with at every step. The variety seems interminable and on first acquaintance one is appalled with the difficulty of becoming acquainted with them (Coker, 1905: 232).

In the present study, 120 species of trees and shrubs were encountered during systematic sampling, and herbarium collections were made of 30 more (Appendix I). This floristic diversity is to a large extent masked by a remarkably uniform physiognomy. Most of the woody species have small, entire-margined and leathery leaves. This uniformity provides a classic example of convergent evolution, species having adapted in similar ways to the problems of life on a low limestone island.

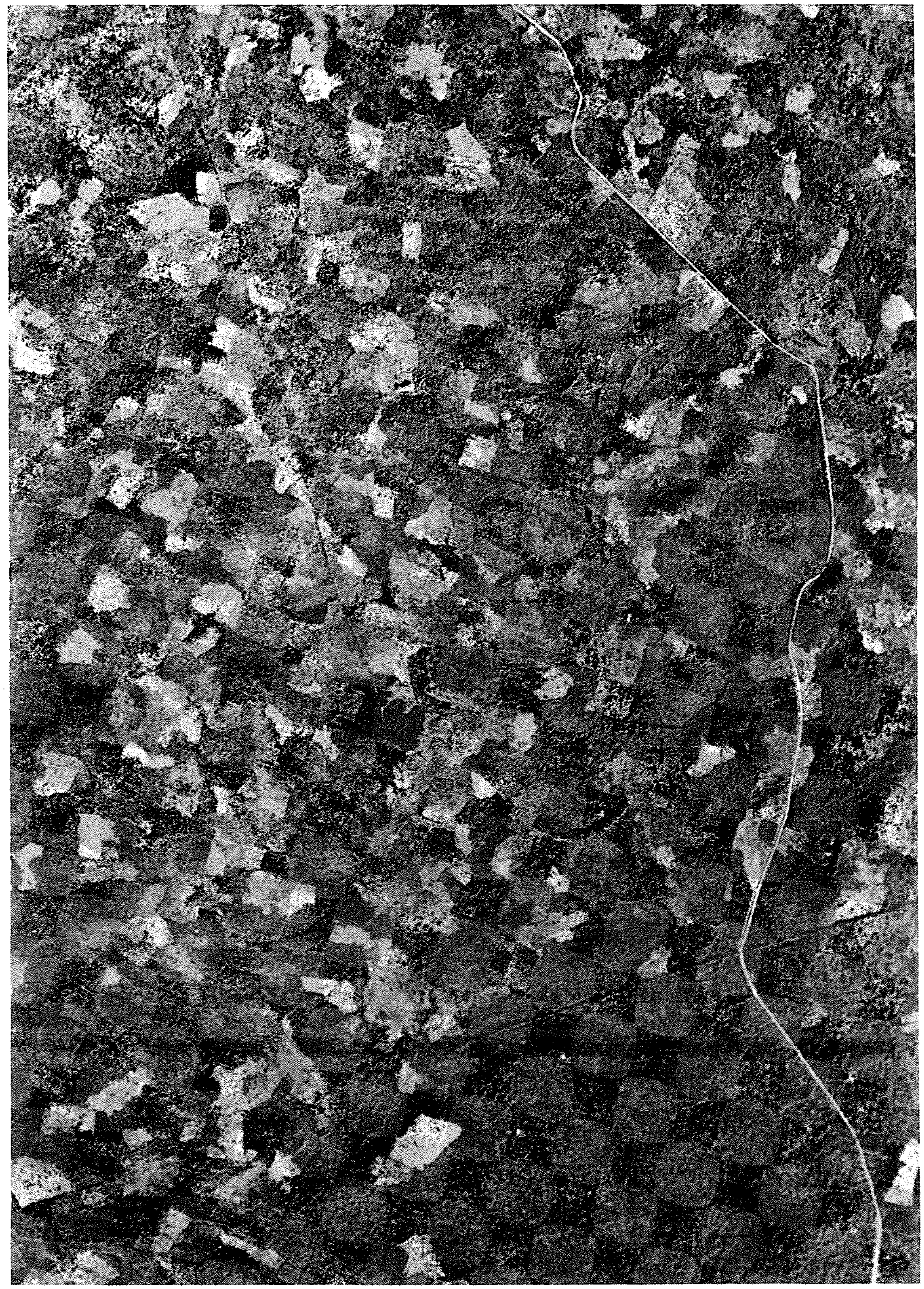


Figure 16. An aerial view of the woodland south of Old Bight. Scale = 1:1,000

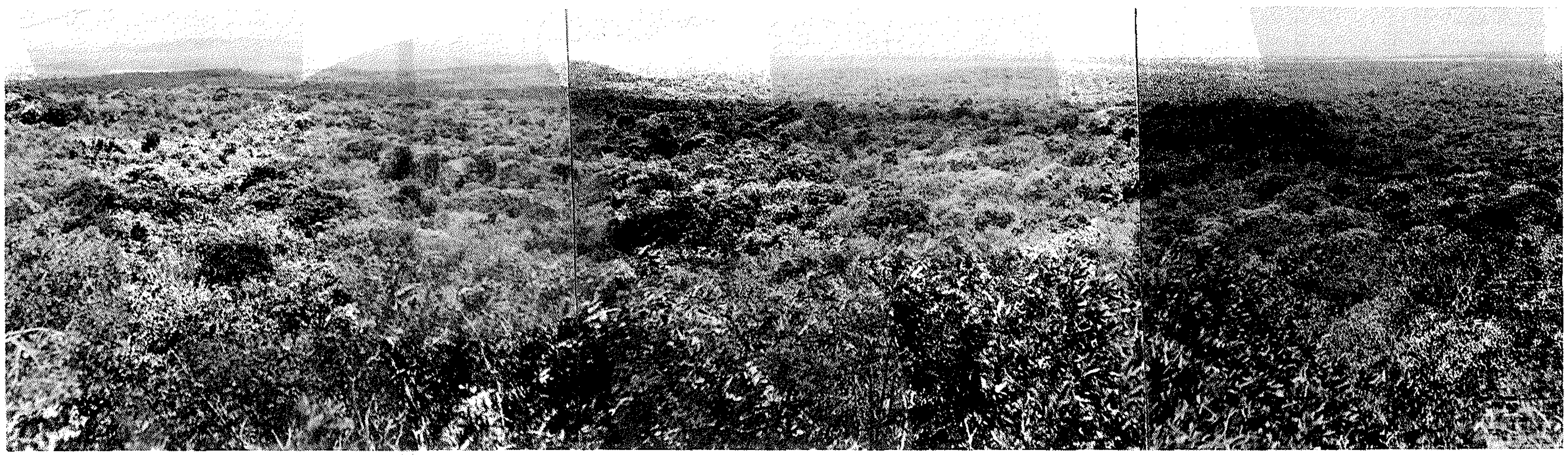


Figure 17. View of the woodland looking east from the Pleistocene dune-ridge north of Freetown. A saltwater lagoon, locally known as Red Pond, is visible to the left.

On the other hand, the woodland is not entirely uniform in structure or floristic composition. As was indicated above, both vary from place to place, largely as a function of the availability of moisture. This in turn is largely determined by the location of the water table and the nature of the substrate. Although the former was difficult to identify in the field the latter was not. Therefore it was decided to simplify the analysis by subdividing the woodland into three types on the basis of landform or "habitat" characteristics (Table 2). More specifically the three types are: (1) Holocene dunes and beach ridges; (2) Pleistocene marine plains; and (3) Pleistocene dunes and beach ridges--or, in local terminology, the whiteland, flatland, and blackland, respectively. As will become clear later, these habitat-types are not floristically distinct, as many species are present in all three. Even so, by subdividing the woodland in this way it was possible to control some of the environmental variability that would otherwise have complicated any analysis of man's impact. Figures 17 to 23 give a visual impression of the three habitat types.

The Whiteland

The largest area of whiteland on the island forms a discontinuous strip along the east coast (Figure 4). On the west coast there are localized areas near Orange Creek, Bennet's Harbour, and McQueens. Not all of the whiteland is covered by evergreen woodland. On its seaward margins it is occupied by the salt-tolerant vegetation of the coast or tidal flats, and inland by the seasonally-flooded savanna, or other varieties of evergreen woodland, depending upon the location of the water table.

The woodland is generally lower on the whiteland than elsewhere. The trees have a characteristically bushy appearance, and are rarely more than 6 meters tall. The number of species present is proportionately lower. There are probably three basic reasons for this impoverishment. First, the loose sand does not have a very high moisture-retention capacity and ground water is not able to rise very easily by capillary action (Anonymous, 1960). Second, the sand provides a rather insecure rooting-medium for trees so often subject to hurricane-strength winds. Third, and perhaps most important, the whiteland has in most areas an exposed location on the coast and evapotranspiration rates are therefore high. This is particularly significant on the southern and eastern coasts, which face the persistent trade winds.

In spite of the impoverished aspect of the whiteland vegetation, a considerable diversity of species is likely to

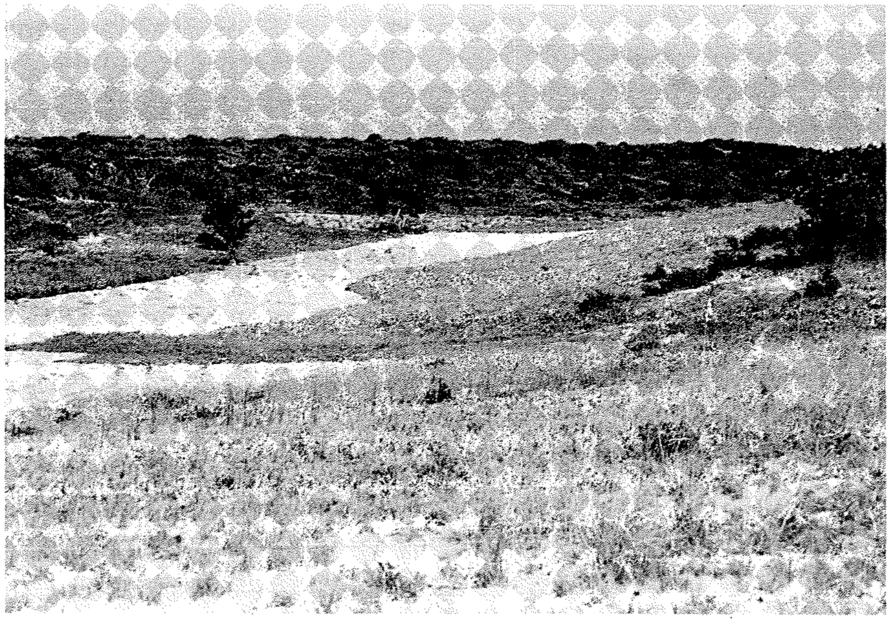
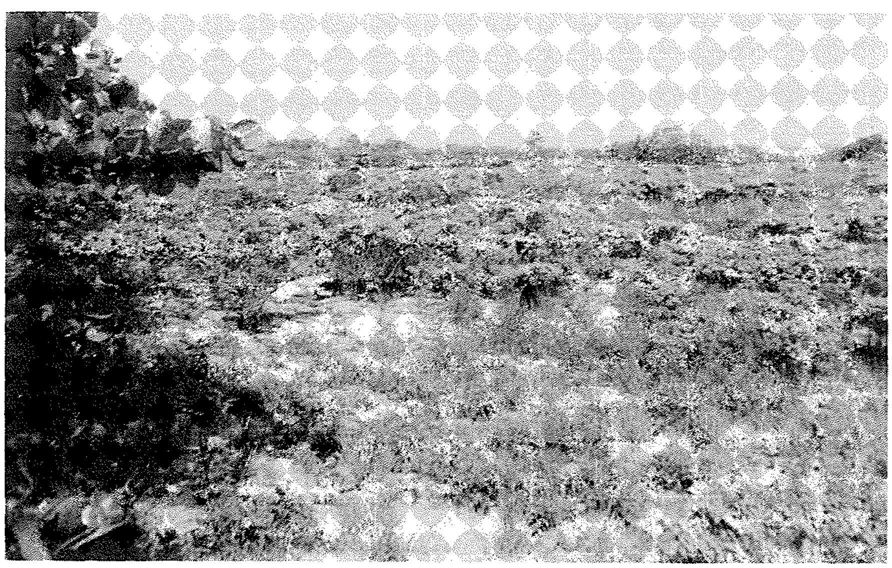


Figure 18. A whiteland field, the light area in the middle distance, is in the process of being cleared. In this case the fallow period has not been long enough to allow shrubs to become established. Uniola paniculata, Chloris petraea, Cenchrus echinatus and Bidens pilosa are common in the foreground.

Figure 19. Corchorus hirsutus dominates this whiteland field The bushes are probably about ten years old Coccoloba uvifera is present in the left foreground and also in the distance.



be encountered at any one locality. Especially common in areas of older woodland are cassina (Acacia choriophylla), ramshorn (Pithecellobium keyense), dollen plum (Reynosia septentrionalis, poisonwood (Metopium toxiferum), milkberry (Bumelia retusa), and beefwood (Torrubia longifolia). On less favorable sites sea grape (Coccoloba uvifera), coco plum (Chrysobalanus icaco), black torch (Erithalis fruticosa), and white torch (Amyris elemifera) may be present.

On exposed sites, the woodland degenerates into a coastal thicket in which the area of bare sand exceeds the area covered by vegetation. Such eas are occasionally washed by salt water and are therefore not cultivated. Apart from a few remote areas, as for example west of McQueens (Figure 2), the whiteland has been repeatedly cleared and burned for agriculture during the past three hundred years. The woodland is in fact secondary vegetation in various stages of recovery after clearing, burning, and grazing.

The Flatland

Between the whiteland and the Pleistocene dunes and beach ridges is the flatland. In total area it accounts for the largest part of the island. On its lower margins it grades into either the whiteland, the seasonally-flooded freshwater areas, or the saline lagoons; on higher ground it is bordered by the Pleistocene dunes and beach ridges.

The woodland is generally higher on the flatland than on the whiteland. In relatively undisturbed areas, trees were seen 10 meters in height with diameters at breast height of 20 to 30 centimeters. In contrast to the almost impenetrable whiteland thickets, individual trees are spaced 2 to 3 meters apart . The more common species are pigeon plum (Coccoloba diversifolia), poisonwood (Metopium toxiferum), wild tamarind (Lysiloma bahamensis), kamalamay (Bursera simaruba), and mastic (Sideroxylon foetidissimum). The ground is covered with a thick accumulation of leaves, which in turn may be covered by a dense growth of terrestrial bromeliads. The trees themselves characteristically support a rich growth of epiphytic orchids and bromeliads. The woodland as a whole has a distinctly tropical appearance.

Such undisturbed areas are comparatively rare, as most of the flatland has been repeatedly cleared and burned for agriculture. Second-growth woodland in various stages of recovery covers most of this habitat-type. Here a great variety of species are present including horsebush (Gundlachia corymbosa), granny bush (Croton linearis), jumbay (Leucaena leucoephala), and soap bush (Corchorus hirsutus). The individual trees and shrubs are closely spaced,

Figure 20. A flatland field close to the edges of the seasonally-flooded savannah. Cultivation is precarious here because of the risk of flooding. Palmetto fronds have been laid out to dry before burning.

Figure 21. Second growth on the flatland south-east of Bennet's Harbour. The bushes are three meters tall and probably about twenty years old. The palmetto is the buffalo top (Thrinax microcarpa).

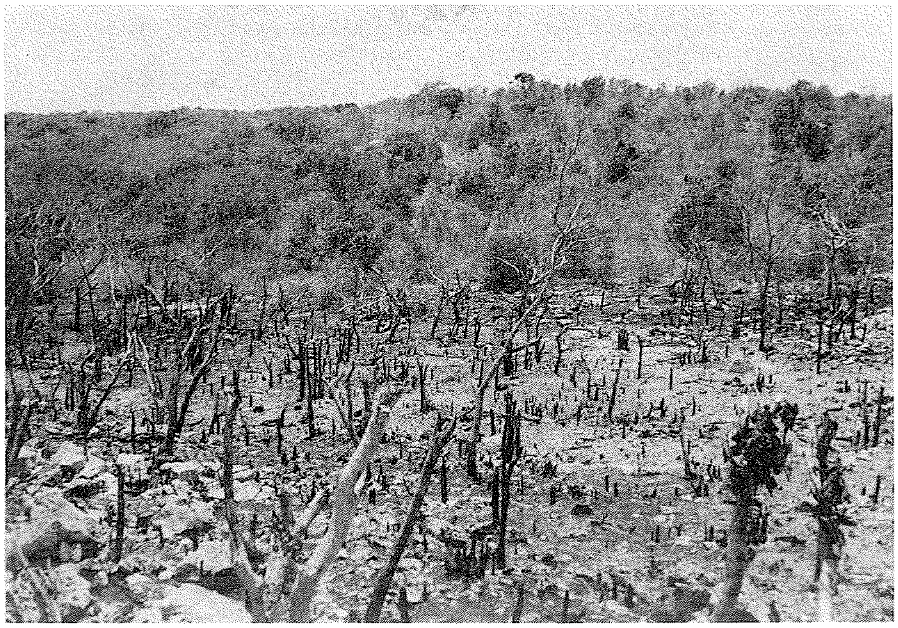
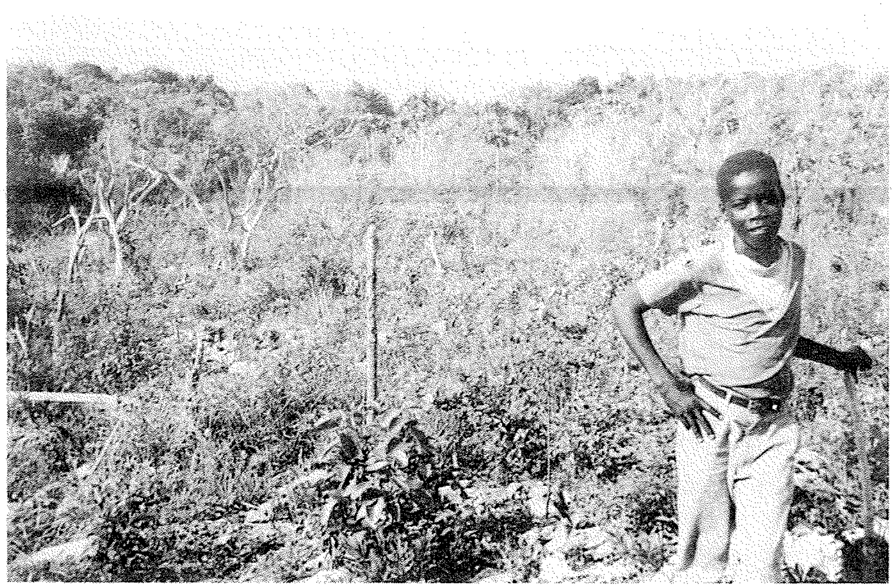


Figure 22. A severely burned blackland field. Note that many of the bushes in the background are still without leaves. The photograph was taken in June 1967 after an unusually dry dwinter.

Figure 23. The same field in 1970, from a slightly different angle. The field had been abandoned in 1969. Recovery is slow probably because of the deep burn. The sprout in the foreground (Coccoloba diversifolia) is one of the few to be seen.



making the woodland almost impossible to penetrate without a machete. The canopy in thinner and as a result a luxuriant growth of epiphytes is not possible. Vines, however, are common, particularly the troublesome _Smilax havanensis_, together with _Jaquemontia cayensis_, and several morning glories (_Ipomoea microdactyla_, _I. acuminata_).

The Blackland

The Pleistocene dunes and beach ridges in a sense form the backbone of the island, and are covered with the highest and floristically most diverse woodland. Except in exposed areas facing the trade winds or in areas where slopes were excessively steep, this is the optimum habitat for tree growth.

As on the flatland, comparatively undisturbed woodland was hard to find because most of the blackland has been intensively used for agriculture. However, in a few areas trees were seen on the order of 12 meters tall with diameters at breast height of around 30 centimeters. This mature woodland has a distinctly tropical appearance not only because of the great number of species present, but also because of the many epiphytic orchids and bromeliads. The dominant tree species are pigeon plum (_Coccoloba diversifolia_), poisonwood (_Metopium toxiferum_), hog cabbage palm (_Pseudophoenix vinifera_), mastic (_Sideroxylon foetidissimum_), and madeira (_Dipholis salicifolia_).

In older woodland the differences between the flatland and blackland are not too obvious. This is not the case in the younger woodland. On the blackland the limestone surface is riddled with potholes and small crevices. These microhabitats play an important role in slowing soil erosion and reducing evaporation. The broken surface also reduces the severity of the fires set by the shifting agriculturalists. As will be shown later, the rate of succession is more rapid on the blackland than on any other habitat-type.

V. CLEARING AND BURNING FOR AGRICULTURE

Cat Island has been discontinuously inhabited for at least a thousand years, during which time the woodland has been repeatedly cleared and burned for agriculture. The history of this disturbance is unfortunately obscure. The impact of agriculture on the woodland is only occasionally referred to in the historical record, and the record itself is understandably thin. What follows here is a brief summary of the evidence that is available. Particular attention is given not so much to the history of agriculture itself as to the way in which agricultural practises have affected the woodland.

The Island Arawak (1000 A.D.-1500 A.D.)

The first known inhabitants of the Bahamas were the Island Arawak. According to the available archaeological evidence, these people probably reached the islands about 1000 A.D., having left the South American mainland at about the time of Christ (Rouse, 1964; Hoffman, 1967; MacLaury, 1970). At the time of European contact, Arawakan-speaking peoples occupied a wide area, including Amazonia, Central America, and the Caribbean, and although detailed population figures are not known, it appears that a very large number of them, several million according to the Spanish accounts, were in the Greater Antilles, Turks and Caicos, and the Bahamas (Rouse, 1964).

The Arawak population of the Bahamas, or the Lucayas as the islands were called, was reported by Peter Martyr to be on the order of forty thousand (Craton, 1968: 39). If this estimate is correct, the number of people living on Cat Island must have been several thousand. Unfortunately, the Spanish accounts are not reliable on this point. What is certain is that less than thirty years after Columbus's landing the whole of the Arawak population had been transported to Hispaniola by Spanish slavers (Sauer, C.O., 1966; Craton, 1968).

The Island Arawak were skilled agriculturalists, with a long inventory of cultivated plants, including cassava, sweet potatoes, corn, beans, squashes, and tobacco (Sturtevant, 1961). They were also expert fishermen and obtained much of their food from the sea. They lived in settled villages ruled by hierarchies of chiefs, made good pottery, and had a relatively elaborate religion centering around the worship of deities known as Zemis (Rouse, 1964: 502).

Evidence of the former presence of the Arawaks is widespread on Cat Island. Pottery fragments and shell middens are commonly encountered, and in virtually every cave human bones have been found. Some reconnaissance archaeological work has been carried out (MacLaury, 1970), but the data uncovered tell little about Arawak subsistence or to what extent the woodland may have been cleared. The historical record is a more fruitful source of information here. Although Cat Island is rarely referred to specifically, it is possible to draw some general conclusions on the basis of accounts of Arawak populations in the Greater Antilles. The Arawak way of life was remarkably similar throughout the Bahamas and the Greater Antilles (Sauer, C.O., 1966).

It seems likely that the Arawaks practiced some form of shifting agriculture. The actual clearing of the woodland was probably done by fire as the thick accumulation of organic matter on the ground could have been easily burned during the dry season. Clearing of mature hardwood trees by felling or even girdling would have been difficult if not impossible for people equipped with only shell tools.

Arawak cultivation in the Greater Antilles involved planting in "conucos," mounds of earth surrounded by stones. After several years of cultivation fields were abandoned because of declining yields and competition from weeds. Just how much of the woodland was cleared in this way is not known. It would seem likely, however, that in five hundred years even a small population of shifting agriculturalists could have cleared a large part if not all of the woodland on a small island such as Cat. That this was in fact the case is suggested in a letter written by a loyalist who settled on Cat Island in 1784. He wrote that he had seen

> rocks piled up in little heaps by the Indians...and it plainly appears by this and other relics daily met with that the inhabitants have been very numerous, as there is none or but very little ground but what has been cleared and cultivated. Great quantities of their bones are to this day found in different cavities of the rocks (Eve, 1784).

There is an indirect suggestion in the historical record that the Arawak population of the islands at the time of contact was dangerously large. The Spanish accounts describe the Arawak as being close to starvation. Ferdinand Columbus, for example, noted that the amount a Spaniard would consume in a day would last the average Arawak a whole week (Craton, 1968: 24). In view of the crops the Arawaks had at their disposal there can be only two explanations for this. Either the population was too large for the amount of cultivable land available, or there had been a recent crop failure due to a drought or hurricane.

Unfortunately Columbus's journal contains little information about Arawak agriculture or the vegetation of the islands. Apart from the Arawaks themselves, the Bahamas contained nothing of value to the Spanish and therefore received little attention. After the Arawaks had been taken to the mines of Hispaniola, the Bahamas were to remain uninhabited for nearly two hundred years. During this time the woodland presumably recovered to something like its natural state.

The English (1703-1834)

Although the English settled Eleuthera and New Providence in 1648 and 1666 respectively, Cat Island was at this time too vulnerable to attack from the French and Spanish to make permanent settlement worthwhile. In 1703, however, New Providence was attacked and 120 of the 150 inhabitants fled to Cat Island (Craton, 1968: 93). The exile was only a temporary one. In 1723 the Governor reported that "the people of Cat Island have lately quitted that remote place having been so often plundered and disturbed" (Phenney, 1723).

It was during this brief period of settlement that Cat Island's reputation as the best agricultural island in the Bahamas was established. In 1730 Governor Rogers reported that settlers without land on St. Christophers were keen to develop sugar plantations on Cat Island, which "all people in general agree is much the best of the Bahama Islands having large valleys of fine land and plenty of water" (Rogers, 1730). Seven years later settlers from Barbados, the Leewards, and the Virgin Islands were also expressing interest in obtaining land on Cat, whose reputation had increased further:

> Cat Island contains at least as much land fit to cultivate sugar cane upon as Barbados, besides a large quantity of ground fit to produce corn, cotton trees, indigo, ginger, and savannahs or low ground fit to raise and fatten cattle upon. The soil they say is much the same with that of Hispaniola or Cuba (Fitzwilliam, 1737).

In 1734 Thomas Coram petitioned the Commissioners for Trade and Plantations, advocating a settlement scheme involving Cat Island and Nova Scotia. He envisioned a trade triangle in which the Bahamas, specifically Exuma, would provide salt for the cod fisheries in Nova Scotia. The settling of Cat Island would provide protection for the salt rakers from the Spaniards at Baracoa and "would otherwise be vastly advantageous to the crown" (Compston, 1918: 73). The Commissioners gave Coram every encouragement, but the settlment never took place, apparently because of the unsettled political situation in the Bahamas.

For the next sixty years the island was again virtually uninhabited. However, in 1783 settlement began in earnest. In that year the loyalists began to arrive to claim the land grants they had been promised in return for their support of the Crown during the American Revolutionary War. In total about two thousand loyalists came to the Bahamas from the former colonies, bringing with them nearly six thousand slaves (Dunmore, 1789). Of these about 60 loyalists and 500 slaves appear to have settled on Cat (McKinnen, 1804: 198). At this time Cat still had the reputation of being the best agricultural island in the Bahamas (Johnson, 1783), and most of the loyalists who settled on the island were experienced planters from the former colonies. Their main hope was to establish successful plantations based on cotton.

With few exceptions, the plantations were established on high ground overlooking the southern and eastern coasts. The blackland and flatland were regarded as the most productive for cotton while the whiteland was used for food crops (Eve, 1784). Very quickly the woodland was cleared and large fields were planted in cotton. By 1788, 2000 acres had been planted on Cat, roughly a quarter of the total Bahamian acreage in cotton (Wylly, 1789). Initial yields were promising, but in 1788 and again in 1791 a large part of the crop was lost because of insect pests, specifically the chenille and red bug (Wylly, 1800). Clearing and planting continued, but the planters were never able to recover their losses. Even before the Emancipation Act of 1834 the loyalists had left the island, leaving their slaves behind (Anonymous, 1840).

The impact of loyalist agriculture on the woodland can only be assessed in general terms. It is interesting to note, however, that the planters themselves attributed a large part of their failure to indiscriminate clearing. According to one contemporary account, the loyalists "went to work in the true American way, cleared immense fields, and laid their lands open to every wind" (Wylly, 1880). This "first and most fatal error" accelerated soil erosion and encouraged the spread of insect pests (Kelsall, 1800). Having learned from their mistakes, the planters later cleared smaller fields, but the damage had already been done. As one Cat Island planter pointed out, by 1800 there was little new land left to cultivate, and that which had been "too much exhausted or burned" was slow to recover (Eve, 1800). It seems clear that within the short period of twenty years virtually the whole of the woodland had been cleared. After the plantations were abandoned the woodland must again have reasserted itself, but this time its recovery was hindered by the activities of a now permanent population of shifting agriculturalists, the abandoned slaves.

The Free Negro (1834-Present)

The loyalists left behind 694 slaves and 55 free negroes (Cameron, 1805), most of whom were given land or allowed to farm the plantation lands on a share-cropping basis. After the passing of the Emancipation Act in 1834, some freed slaves bought land from the Crown in either 20- or 40-acre lots, while others continued to rent or simply occupied the land illegally as squatters. In the 1830s and 1840s settlements were established along the east coast of the island. Some, such as Orange Creek and Bennets Harbour, were located where small boats might anchor. For the rest the availability of Crown Land seems to have been the most important factor in determining their location.

Emancipation did not mean a sudden change in the way of life of the Bahamian negroes, since most of them had been largely independent for twenty or thirty years. According to the report of a magistrate who visited Cat in the year 1836, all the freed slaves were quite satisfied with their lot. Their only complaint was they had no means of sending their surplus produce to Nassau (Stiles, 1836). Later reports from the island seem to indicate that the free negro population had become well-established. The old plantation grounds were being kept as grazing land, and a small supply of stock and corn was being shipped to Nassau (Anonymous, 1840). By this time (1840), the population was still only 750. Four years later the inhabitants of Cat Island, Rum Cay, and Watlings were close to starvation. An unusually long drought in that year led to the failure of crops and had it not been for emergency supplies from Nassau the people would have starved. According to Governor Mathew, the famine was

> partly caused by the very unusual drought, partly by the improvidence of the people, and partly above all by the exhaustion of the scanty soil (Mathew, 1844).

The last point is significant insofar as it implies that a large part of the land had already been cleared. That this was the case is also suggested in the report of an Anglican missionary who visited the island in 1855:

> I found much difficulty in visiting the people. They are very much scattered with poor roads leading to their dwellings. They go out to their fields pretty early in the morning, which being far from their homes they do not return till sunset (Higgs, 1855).

This account suggests that all the accessible land had been already cultivated and that people were being forced to farm in remote areas of the island. A somewhat more optimistic view of life on Cat Island is given in the report of a government surveyor, Thomas Harvey. In his opinion Cat Island was by far the best agricultural island in the Bahamas, "the soil of the island is excellent and produces fine pineapples" (Harvey, 1858: 23).

The negro practice of clearing the woodland and then burning it was almost universally criticized by English and American visitors. A good example of this attitude is contained in Johnston's report on the agricultural capabilities of the islands. He visited Cat Island in September 1867 and reported:

> I was much pleased with my examination of the lands of the Poitier's estate; a portion of this tract is decidely the best land I saw in the out-islands. How this tract has escaped destruction so long I cannot conceive. But, alas! the work has begun in earnest. I saw very many patches recently cleared, burnt, and others burning, as I passed; cruel! cruel! (Johnston, 1867)

The gradual clearing of the woodland in part reflected the necessities of shifting agriculture but was also a response to the needs of a growing population. In 1861 the total number of people on Cat Island was 2,378, while only thirty years later the population had doubled to its highest total ever of just over 5,000 (Sharer, 1955: 92). Unfortunately, the historical record provides little insight into the state of the island at this time.

According to several of the older inhabitants interviewed on the island in 1970, the late nineteenth century was a time of considerable hardship. Not only had the attempt at sisal cultivation failed, but the population of the island was too large to be supported by traditional agricultural methods. All the cultivable land had been cleared at least once and in many areas the fallow period was not long enough to allow an adequate recovery of fertility. The only alternative was emigration, and many of the islanders left Cat for Nassau or the United States. In certain parts of the island, particularly on level ground, the effects of this over-cropping can still be seen. In areas that have not been cultivated for half a century the woodland still has a degraded appearance.

During the present century the population has continued to decline. However,the practice of shifting agriculture has continued largely unchanged. An interesting commentary on conditions in the 1930s was given by the Harvard conchologist Clench (1938: 501-502). He reported that the unfortunate practice of burning the vegetation was resulting in the rapid disappearance of the soil, and predicted that within a few more generations there would be little or no agriculture possible. According to Clench, most of the woodland being cleared at that time was between 10 and 15 years old, and although the resulting fields were productive for only a year, they were usually farmed for two to five years after each burning. In spite of emigration the pressure of population on the land still appears to have been severe. That this was in fact the case was supported by the accounts of several older inhabitants interviewed on the island in 1970.

It has only been within the past twenty years or so that the intensity of shifting cultivation has declined. The development of the tourist industry in Nassau has led to further emigration from Cat and has meant a return flow of money and food to the island. As a result the acreage in cultivation has declined. Even so, shifting agriculture is still practiced in much the same way it has been for the last century and a half. As one farmer expressed it, "I work after the old peoples' dispensations, and I find myself walking in the right track."

Contemporary Agriculture

Agriculture today is probably less intensive than it has been at any time during the past hundred years. The total population in 1971 was about 3,000, most of whom were either older people or young children. Accurate statistics for acreage cultivated are not available, but a figure of four acres for a family of eight is probably a fair estimate.

The four acres would consist of five or six fields scattered across the island. One reason for this is that the chances of drought are lessened if fields are widely spaced; on a small island such as Cat, summer thundershowers can be very localized. Another important reason is that the different habitat- types are adapted to different crops. For example, the blackland, which is regarded as the best farming land is especially well-suited to sweet potatoes, cassava, peanuts, corn, benny seed, and beans. The flatland, at least in lower areas where moisture is available, is recognized as being especially good for tomatoes, melons, onions, and vegetables in general. Cultivation is, however, a precarious proposition here because of the risk of flooding. On the higher flatland areas the problem is drought, and corn and pigeon peas are the most common crops. The whiteland soils are easily worked but also tend to be droughty. Corn and sorghum were the main crops in 1970, although the latter is much less important that it formerly was. The localized areas of red soil are usually planted in pineapples, although cassava, pigeon peas, and peanuts may also be grown. The clay soil is usually too compact for sweet potatoes. The shallow potholes that are so common in certain flatland and blackland areas are commonly planted with bananas, pawpaws, yams, sugar cane, and eddoes. The variety of habitat-types is important insofar as it enables the farmer to diversify his crop combinations.

In any one year most farmers on the island cultivate two crops, a winter crop which is planted in May and June and harvested in December, and a summer crop which is planted in December and harvested in July and August. The winter crop is the most important in terms of yield, as the summer crop often fails because of droughts. A particular field is usually cultivated for two or three years and may therefore produce four or five crops before being abandoned.

The decision as to where to cultivate in any one habitat- type is usually made on the basis of what trees are present in the area. Poisonwood (Metopium toxiferum), pigeon plum (Coccoloba diversifolia), mastic (Mastichodendron foetidissimum), and horseflesh (Lysiloma leucoephala) are all regarded as an indication of good soil. On the other hand, wild tamarind (Lysiloma bahamensis), horsebush (Gundlachia corymobosa), and granny bush (Croton linearis) are all poor soil indicators. Also important is the age of the woodland. As a general rule, the older the trees, the more productive will be the soil after clearing and burning.

Clearing is done with a machete, usually during the cooler months from January to April. Apart from the question of fertility, people preferred to clear older trees because they were more easily cut than younger bushy growth. Most of the single women and older men hired professional bush cutters to clear their fields. Fields cleared in this way are distinctive in their regular, usually square, shape. Fields are initially about a quarter of an acre in size, and are expanded later if yields are good. If a field is a large one, several shade trees will be spared. Characteristically, these are mastic (Mastichodendron foetidissimum) or kamalamay (Bursera simaruba). In nearly all fields several trunks are left standing to provide support for the vines. After clearing, the lighter brush is laid out on the ground to dry, while the heavier trunks are pulled to the side of the field, the reason for this being that the larger pieces of wood burn at a high temperature and reduce the fertility of the soil

Many local farmers take pride in their burning technique. The old tradition has long been criticized by Europeans, but is apparently the best way to make nutrients available to the crops. It removes debris, exposes the soil, and has the advantage of killing crop-eating insect larvae. Burning is usually done one or two days after rain in May or June. If the ground is too dry, the burn will be too hot and the productivity of the soil will be reduced. One experienced farmer claimed that the severity of the burn should be determined by the crop that is to be planted. Sweet potatoes, for example, would benefit from a hot burn, as they need more ash. Corn, on the other hand, needs a lighter burn. A very hot burn was also thought to encourage more weeds. On Cat Island, fires very rarely escaped from a field into the uncleared woodland, because the living trees are not dry enough to burn. The woodland is in fact a green firebreak. The only situation in which a wild fire might start would be where there was a great deal of dry litter on the ground, as for example in an area of older woodland at the end of a severe drought. Frequent clearing and burning prevents the accumulation of litter and therefore reduces the chances of wildfires.

A few days after a field has been burned, fertilizer is added to the ashes. A few days after that, ideally just after a rain, seeds and cuttings are planted. Planting is done with the aid of a simple dibbling stick. As an insurance against crop-eating insects and birds, especially the ground dove, several seeds are dropped in each hole. Nearly all farmers were aware of the advantages of seed selection, but few thought it was worth the effort. For most crops the time of planting is determined by the phases of the moon. During the next few months weeding takes a large part of the farmer's time. In the first year of cultivation sprout-weeding is the main activity, while in the second and third years the control of herbaceous weeds is more important. If there is no drought the winter crop is usually harvested in November or December. Yields are difficult to estimate because of the irregular methods of harvesting and widely-scattered fields. Most farmers, however, produce more than enough for their own needs and ship the surplus to Nassau.

At present a field is rarely cultivated for more than two or three years. The pressure on the land is so low that it is easier to clear a new field and start again than to farm intensively. According to local opinion, the minimum required fallow period for sustained yields is on the order of ten years. However, in recent years younger woodland has rarely been cleared, and the fallow period is normally at least fifteen years.

Conclusion

In conclusion, the three cultural groups, the Arawak, the loyalists, and the negro peasant farmers, have each had an important impact on the evergreen woodland. The consequences of Arawak settlement are unfortunately not well known, but historical evidence suggests they may have been significant. The loyalists in a period of less than twenty years cleared a large part, if not all, of the woodland. The negro population in a hundred and fifty years of shifting agriculture repeatedly cleared and burned the whole of the woodland. At present it is safe to say that all of the woodland has been cleared and burned at least once, and in the accessible areas it has been cleared and burned at least a dozen times. In this sense it is all secondary vegetation. What is not certain is just how the woodland has changed as a result of this clearing and burning, which species have become rare or extinct, and which have become more important.

VI. SELECTIVE CUTTING OF INDIVIDUAL SPECIES

Man's exploitation of individual species has had an important influence on the character of the woodland and indeed on the character of Bahamian vegetation as a whole. From the early part of the seventeenth century until the latter part of the nineteenth century the selective cutting of dyewoods, barks, and timber trees was an important activity in the Bahamas particularly during periods of econmic depression. So intensive was this exploitation that several sensitive species became rare. During the present century there has been a general decline in the demand for dyewoods, barks and native timber and many of the exploited species appear to have recovered. Fortunately, the history of selective cutting is more amenable to analysis than the history of clearing and burning. Usually the species involved can be definitely identified and in some cases there is reliable evidence as to their former distribution and abundance. Unfortunately, there are few specific references to Cat Island, and what follows therefore deals largely with the Bahamas as a whole.

Dyewoods

The most important of the native dywoods was brasiletto, a shrubby legume valued for the red dye obtained from its heartwood. Apparently three species were exported from the Bahamas under this trade name: *Caesalpinia vesicaria*, *C. bahamensis* and *C. reticulata*. All three are small trees generally found on rather dry sites.[1]

Brasiletto was probably first cut by the Spanish in the sixteenth century (Craton, 1968: 58), although on what scale is not known. In the early seventeenth century English woodcutters from Bermuda were cutting Brasiletto in the Bahamas. The sailing orders for a trading voyage from London to Barbados in 1650 illustrate well the scope of these early activities. The captain was instructed to search the Bahamas for basiletto, seal oil, ambergris, and wreck goods and take what he found to Barbados or any of the Leewards from where it could be shipped to England. From Barbados he was to return to the Bahamas two, three, or even four times if necessary to make the enterprise profitable (Lefroy, 1877-79, II: 108).

1. The three names listed here are taken from the *Bahama Flora* (Britton and Millspaugh, 1920: 173).

In 1670 Simon Robinson, a Bermudan ship captain, reported to the Lords Proprietor.[2] that New Providence had only small quantities of brasiletto whereas "Egsuma had much brasiletto wood...and another island discovered last year also full of brasiletto wood" (Robinson, 1670: 473). According to another Bermudan (Carrell 1670: 475), Jamaica was at that time the chief port for the proceeds of "shaloping brasiletto, amber (Ambergris) and turtle shell". The effects of this early exploitation were quickly felt and by the 1670's the dyewood was in short supply. The Lords Proprietor were concerned about unlicensed cutting and in 1676 instructed Governor Chillingforth to prevent it (Albemarle, 1676). Catesby, who visited the islands in 1725, reported that the value of the wood had made it scarce, the biggest trees remaining not being more than 8 to 9 feet tall (1731,II: 51). By the time the loyalists arrived it was still being exported in considerable quantity (Schoepf, 1778:34). However, after the development of synthetic dyes in the 1870's and 1880's the demand for braziletto declined, and by the end of the nineteenth century its export had virtually ceased (Coker, 1905: 201). On Cat Island in 1970 it was very seldom seen in the woodland.

Another valuable dyewood exported from the Bahamas was Logwood (<u>Haematoxylum campechianum</u>), although this species is not native to the islands. Bahamian woodcutters, cut it in Honduras in the late seventeenth and early eighteenth centuries and brought seeds back with them to plant at home. According to Catesby (1731, II: 65), it was introduced from the Bay of Honduras by a Mr. Spatches in 1722. Apparently it became quickly established locally as it was included by Bruce (1782: 422) in his list of valuable dyewoods growing in the Bahamas in the 1740's. However, when Schoepf (1788:35) visited the islands in 1784 it was not yet an important export. In the nineteenth century it was cut in large quantities on Exuma and to a lesser extent on Cat, New Providence, and Long Island. By 1880 it had become scarce and according to the Blue Book of that year the supply was virtually exhausted (Taylor, 1881: 55). At the end of the nineteenth century it was still being exported in considerable quantities to New York, the most important amounts coming from Andros, Exuma and Cat Island (Coker, 1905: 202). In 1970 there was still a demand for chipped logwood in London but the lack of any chipping machinery on the islands prevented its export.[3] On Cat Island in 1970 it was quite common in certain areas at the southern end of the island.

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2. The first English settlement in the Bahamas was administered by a proprietary form of government.
3. Personal communication from Mr. Leonard A Roaker, a Bahamian agent for barks and dyewoods.

Another dyewood mentioned in the early accounts is yellow fustic, also known as yellow wood or satinwood. These names refer to Fagara flava a member of the citrus family. Yellow wood was initially cut as a dyewood but later became more important as a timber tree. Its fine grain made it the most valuable of all the woods exported from the island in the late nineteenth century. Again its value led to its being over-exploited and by the 1880 the supply had been largely exhausted (Taylor, 1881: 55). Yellow wood is certainly a rare species on Cat Island at present. Of all the valuable woods this is probably the most sensitive to cutting.

In 1723 the Governor reported that "Brown ebony of a strong rhodium scent" was being exported from the colony (Phenney, 1723: 54). The species referred to here is probably Dalbergia ecastophyllum, which today does not grow in the Bahamas. Theoretically this is a species that could have become extinct because of over-cutting. However, it is rarely mentioned in the accounts of the islands and on the basis of the available evidence it seems unlikely that ever grew on Cat Island.

There is a puzzling note in Governor Montfort Browne's report on the state of the islands in 1775. According to Browne (1775: 1), green ebony and bark were being exported to Britain. The trade name green ebony usually refers to the leguminous tree Brya ebenus, which is native to Jamaica and Cuba but not the Bahamas (Britton and Millspaugh, 1920: 196). Again the possibility exists that it was exploited to the point of extinction, although it seems more likely the Governor was referring to the re-export of wood imported from Jamaica.

Barks

Sweetwood bark (Croton eluteria) has long been an established Bahamian export. Its uses have been varied, although it seems to have been most important as a basic ingredient in tonic waters. Exploitation probably began in the seventeenth century. According to Stisser it was exported to England as a smoking mixture in 1686 (cited by Bacot 1869: 3). Catesby reported that it was common on most of the islands, although cutting had reduced the size of the trees. He described it as a fine aromatic bitter to be infused with wine or water (1731,II: 46). Throughout the eighteenth and nineteenth centuries sweetwood bark was exported on a fairly regular basis, although what statistics there are suggest cutting was especially important during times of economic difficulty. The preparation of the bark is a rather time consuming operation and is only worthwhile when money is in short supply.

By the end of the nineteenth century supplies were "steadly diminishing" (Morris, 1896). And in the Bahama Flora it is described as "Becoming scarce" (Britton and Millspaugh, 1920: 223). In recent years the demand for the bark has increased and in 1970 it was being actively cut on Cat Island. A total of about 20 tons were exported from the Bahamas in 1970, of which about a third came from Cat and the rest from Acklins. Sweetwood bark reproduces vigorously from sprouts and although it is not a common tree in the woodland it seems unlikely that its importance has been significantly reduced by cutting. The early accounts of it having become rare may simpyly refer to a declime in the size and yield of individual trees rather than an actual reduction in range. On Cat Island there has been some small scale cultivation of sweetwood bark and many families have a "Bark field" close to their homes.

Another tree that has been cut for its bark is wild cinnamon (Canella alba). Like sweetwood bark it was one of the earliest Bahamaian exports and may in fact have been exploited by the Spanish. However, unlike the sweetwood bark, the demand for wild cinnamon was never very high and it was exported only on a small scale (Coker, 1905: 206). At present wild cinnamon is a very rare species on Cat Island. Apparently it has been less able than the sweetwood bark to recover from the effects of cutting. At one time it was thought that Cinchona was native to the islands. Governor Phenny (1724: 55) reported that "the Spanish have told several people that the Jesuit's bark abounds. But it has not been found for want of a curious enquirer." Quite likely the species referred to here was princewood (Exostema caribaeum), a close reative to Cinchona and a common small tree in the woodland. Princewood apparently was never cut for its bark on a commercial scale, although it is used in local medicine as febrifuge.

Timber Trees

Generally speaking, Bahamian timber has been protected by its naturally small size and comparatively few species have been cut for export. The most important of those that have is mahogany (Swietenia mahagoni) Although widely introduced elsewhere in the West Indies, mahagony is native to the Bahamas. There is no record of its introduction and it appears quite at home in the woodland. According to Catesby it was the most valuable timber tree in the islands, being better than oak for shipbuilding because it resisted shot without splintering (1731, II: 81). The historical record indicates that it was extensively cut in the early eighteenth century. Governor Rogers (1730) reported that "one of the best employments the inhabitants have had of late is sawing mahogany and Madera plank to ship to Europe." At the end of the eighteenth century it was still the most important timber tree although it had become rare on New Providence and neighboring islands due to over-cutting. The demand for Bahamian mahogany declined,in the nineteenth century, presumably because of the small size of individual trees.

During the course of the present study, mahogany was occasionally seen on Cat Island, particularly in the more remote areas. It was also seen in the settlements where it has been planted on a small scale. Its bark is valued in local medicine and most trees are characteristically scarred as a result.

Horseflesh (Lysiloma leucocephala), a tall leguminous tree, has also been exported under the trade name mahogany. According to Catesby (1731, II: 42), it was the second most valuable tree in the Bahamas after Swietenia. Like the true mahogany, its export declined in the nineteenth century although it was still being exported in "considerable quantities at the beginning of the present century" (Coker, 1905: 202). Cutting has made it a rare tree on Cat Island, as it was very infrequently seen in 1970.

Lignum vitae (Guiacum sanctum, G. officinale), whose resinous gum was thought to provide a cure for syphilis, was probably first cut in the sixteenth century by the Spanish. The early English accounts boast of its presence and its exploitation appears to have continued throughout the seventeenth and eighteenth centuries. The hard wearing properties of the wood made it one of the most valuable of Bahamian timber trees. In the nineteenth century the demand for it also declined because of its small size (Coker, 1905: 203). As in the case of horseflesh, cutting has made lignum vitae a rare tree on Cat Island. It was seen growing wild only in areas remote from the settlements. On the other hand, it has been planted on a limited scale as an ornamental.

A number of other native species have been cut for timber, although not on the same scale as those mentioned above. These include: ironwood (Krugiodendrom ferreum), boxwood (Buxus bahamensis), mastic (Sideroxylon foetidissimum), and princewood (Exostema caribaeum). With the exception of princewood, all were comparatively rare on Cat Island in 1970. The posssibility exists that they were always rare, but the fact that they are more commonly encountered in the more remote areas of the woodland suggests that selective cutting has reduced their importance.

Local Exploitation

The exploitation of native plants for local usage has long been an important part of Bahamian life. Furthermore, virtually every species in the woodland is recognized as being useful for some purpose. In the discussion that follows only those species whose importance in the woodland has been changed by exploitation are considered.

Several native fruits are gathered locally, most notably the sea grape (Coccoloba uvifera) and cocoa plum (Chrysobalanus icaco). Both are important on the whiteland and may have had their distribution patterns modified by accidental dropping of the fruits. Certainly the sea grape is commonly seen growing along the footpaths across the island although rarely in the woodland itself. The same"footpath" distribution is characteristic of the pondtop (Sabal palmetto) whose fruits are collected for hog feed. As was mentioned earlier fruits accidentally dropped in this way have produced an avenue of palmettoes through the McQueens savannah (Figure 14). The hog cabbage palmetto (Pseudophoenix vinifera) has been even more drastically affected by man's activities. Both its fruits and terminal buds have been collected for hog feed, and as a result it is now seen only in remote parts of the island. On the positive side, it has been occasionally planted as an ornamental.

In recent years, houses have been built with imported pine, although in the past they were entirely built with local wood. For support posts and beams hardwoods such as dollen plum (Reynosia septentrionalis), mastic (Sideroxylon foetidissimum), maderia (Swietenia mahogani), horseflesh (Lysiloma leucocephala), or cassada wood (Dipholis salicifolia) were used. For the more flexible cross-beams wattle (Eugenia spp.) or red mangrove (Rhizophora mangle) were preferred. Thatching would be done with the leaves of the Buffalo top Thrinax microcarpa). The traditional methods of thatching are African in origin. Only a few men in each settlement know the techniques and very likely they will soon be lost. Small fishing boats are still built locally, usually with horseflesh or mastic or if these are not available with wild locust (Lysiloma bahamensis).

The cutting of wood for fuel has probably reduced the local importance of several species. Buttonwood (Conocarpus erecta) is generally regarded as the best firewood, while black torch (Erithalis fruticosa), dollen plum (Reynosia septentrionalis), and white torch (Amyris elemifera) are also used.

A great many native species are used in bush medicine, although it seems unlikely that many have become rare because of it. Two that might have been over-exploited are the boarhog bush (Callicarpa hitchcockii) and manroot (Vallesia antillana). Both are ingredients in popular aphrodisiacs and are rarely seen in the woodland around the settlements.

In summary, it seems clear that a great number of woodland species have been cut for either export or local use. This exploitation began in the sixteenth century and continued with varying degrees of intensity until the present. Although some cutting has always been done locally much of the activity appears to have been based in Nassau. As Schoepf pointed out in 1784, the white inhabitants of New Providence employed their slaves cutting wood wherever it could be found:

> Wood-cutting is gradually becoming more difficult and less lucarative. On the islands lying next to Providence the best wood is always cut off, and thus there must be recourse to islands lying farther away, or the woods must be more deeply gone into (Schoepf, 1778: 34).

On Cat in 1836 it was thought necessary to have a man on guard in the north eastern part of the island to prevent Eleuthera men from cutting wood (Stiles, 1836). Even so by the middle of the nineteenth century the more accessible timber appears to have been taken. The surveyor Harvey, who visited the island in 1855, reported that:

> The timber on St. Salvador (Cat) is fine and large and might be made a profitable branch of commerce; maderia, mahogany, cassada, princewood and braziletta, yellow wood and lignum vitae are found in every part but in greatest abundance on the east side (Harvey, 1858: 78).

In other words, the valuable timber was already depleted on the west side of the island that is in the areas close to the settlements. The exploitation of dyewoods and valuable timbers appears to have declined in the second half of the nineteenth century. Exploitation for local use has continued, but even here the pressure has eased because of the import of cheap pine from Nassau.

As might have been expected, the species that have been selectively cut have varied in their capacity to recover. Some like lignum vitae (*Guaiacum sanctum*), wild cinnamon (*Canella alba*), and yellow wood (*Fagara flava*) are still rare even though they have not been cut on any scale since the nineteenth century. Other species, such as sweetwood bark (*Croton eluteria*) and logwood (*Haematoxylum campechianum*), have recovered comparatively quickly. The differences here are probably due to inherent differences in reproductive capacities and habitat tolerances. What is surprising is that for the Bahamas as a whole not one economically valuable species is known to have become extinct. Even though the pre-settlement composition of the woodland is not known there is no evidence to suggest that any species has been exploited to the point of extinction. The species involved have in fact proved remarkably resilient.

VII. THE INTRODUCTION OF ALIEN PLANTS AND ANIMALS

The Bahamas have not been isolated from the large-scale interchange of plants and animals that has characterized the tropical world during the last five hundred years. In spite of their late settlement by Europeans and the persistent failure of commercial agriculture, a great number of plants and animals have been introduced to the islands. Unfortunately, most of these introductions are undocumented, particularly for remote out-islands such as Cat. What follows therefore is a general review which deals for the most part with the Bahamas as a whole. The discussion of plants is limited to those woody species capable of establishing themselves spontaneously within the woodland. Except where stated, the alien status of the species discussed is well established either by documentary evidence or by the artificial nature of their distribution. The only animals considered are those that have had some impact on the composition of the woodland.

Introduced Plants

It seems likely that the Arawaks brought several species of fruit trees to the Bahamas. The guava (Psidium guajava), sugar apple Annona squamosa), custard apple (A. reticulata), dilly (Manilkara zapota), and hog plum (Spondias mombin) were all cultivated in pre-Columbian times in the West Indies (Roumain, 1942). Each species is capable of spreading from cultivation, although to what extent any of them actually did is not known. Perhaps significantly the early English accounts make no mention of any "wild" fruit trees.

The question is complicated by the fact that in the seventeenth and eighteenth centuries all the Arawak fruit trees were reintroduced as were several other New World species such as the avocado (Persea americana), genip (Melicoccus bijugatus), pawpaw (Carica papaya), and cashew nut (Anacardium occidentale). At the same time, the tamarind (Tamarindus indica), Indian Almond (Terminalia catappa), pomegranate (Punica granatum), and mango (Mangifera indica) were introduced from the Old World. Commercially the most important Old World introductions were species of citrus. The most valuable Bahamian exports in the early eighteenth century were limes (Citrus aurantium), lemons (C. limon), oranges (C. sinensis), and sours (C. aurantium). They were exported to North America together with dyewoods, timber, and medicinal barks (Catesby, 1731, I: xxxviii).

To what extent any of the citrus were able to become naturalized is not indicated in the historical record, although by analogy with what had happened in other parts of the West Indies it would seem likely that some escaped from cultivation. Harris (1965: 93) has emphasized the rapidity with which the lime and bitter orange spread spontaneously in the West Indies. According to Howard (1950: 345), Citrus aurantium has become established spontaneously on Bimini, in the north western Bahamas. On Cat Island, citrus were extensively planted in the 1850s (Harvey, 1858: 76); however, no feral trees were seen in the woodland in 1970.

In 1783 a plan was formulated to establish a botanical garden in the Bahamas, with one of its proposed purposes being to test plants from the South Seas (Pownall, 1783). A shipment of live plants and seeds was sent to the Bahamas in 1799 from the botanical garden at St. Vincent (Anderson, 1802: 45). Four important fruit trees included were the Indian Almond (Terminalia catappa), the mango (Mangifera indica), the otaheite gooseberry (Phyllanthus distichus). and the bread-fruit (Arctocarpus communis). All four were successfully established in private gardens and may, with the exception of the breadfruit, have escaped locally. In the nineteenth and present centuries, the development of private gardens, particularly in Nassau, led to the introduction of literally hundreds of new species and varieties of fruit trees. However, there is little indication that any of them have been able to become established as part of the wild vegetation.

In contrast to the fruit trees, few ornamentals appear to have been introduced before the eighteenth century. Catesby, who visited several islands during his stay in the Bahamas (1725-1726), included only two introduced ornamentals in his Natural History, the red frangipani (Plumiera rubra) and the coral tree (Erythrina corallodendrum). Neither species is capable of spreading spontaneously.

The naturalist Schoepf, who visited the Bahamas in 1784, described a large silk cotton tree (Ceiba pentandra) in Nassau which presumably had been planted there early in the eighteenth century (Schoepf, 1788: 37). According to Gardner and Brace (1889: 369), this tree had originally been introduced from South Carolina and was the source of all the other silk cotton trees on New Providence. The species is included in the Bahamas Flora where it is reported as being "spontaneous after cultivation" (Britton and Millspaugh, 1920: 275). There is a large silk cotton tree at the Bight settlement on Cat Island. However, it shows no evidence of successful regeneration.

Other ornamentals mentioned by Schoepf which may have become locally naturalized are the sand box tree (Hura crepitans) and "Barbados Pride" (Poiniana pulcherrima). According to Gardner and Brace (1889: 376), the latter was introduced to New Providence in 1886 by a Mr. Sanders. This must have been a late reintroduction. Neither species was seen on Cat Island during the present study.

During the nineteenth century a great many ornamentals were introduced to private gardens, but comparatively few appear to have spread spontaneously. Exceptions have been the poinciana (Delonix regia), the Australian pine (Casuarina equisetifolia), Jerusalem thorn (Parkinsonia aculeata), Spanish bayonet (Yucca aloifolia), and the cactus-like Euphorbia lactea. All of these are included in the Bahama Flora and all were observed to have spread locally on Cat Island.

In the present century the development of landscape gardening has meant a further increase in the introduction of ornamentals. However, few if any are adapted to life in the woodland and consequently their story is not relevant to the present study.

Cotton is one of the few aliens known with certainty to have been introduced by the Arawaks. According to the early Spanish accounts, it was cultivated in the Bahamas on a considerable scale (Craton, 1968: 25). Which species was involved is not certain, as both Gossypium barbadense and G. hirsutum were cultivated in the West Indies (Sauer, C.O., 1950: 535). Cotton presumably persisted after the islands were depopulated but for how long is not known. There is no mention of wild cotton in the early English accounts.

As indicated earlier, cotton was cultivated on a small scale in the early eighteenth century, extensively in the late eighteenth century, and again on a small scale in the nineteenth century. On Cat Island it has probably not been cultivated since the American Civil War. In 1970 individual bushes were occasionally seen in the woodland. Sea island cotton (Gossypium barbadense) is weedy and has been able to persist on a small scale in disturbed sites.

Sisal (Agave sisalina) was introduced to the Bahamas from Yucatan in 1845 (Morris, 1896: 4). After a rather slow start as a commercial crop, it was widely planted throughout the islands in the years 1887-1896. However, the productive life of the plant proved to be shorter than expected, and cultivation ceased. Since then it has been planted locally on a small scale and has proved remarkably persistent in the wild.

Bowstring hemp (Sansevieria thyrisiflora) was introduced to the Bahamas in the nineteenth century (Dyer, 1887). It was planted commercially on Cat Island in the 1940s, although like sisal it was not a commercial success. In 1970 it formed a thick carpet under second- growth woodland in the Orange Creek area, where it had formerly been cultivated. Presumably it will eventually be shaded out, but is currently slowing down the regeneration of the native species.

The "indigo weed" (Indigofera suffruticosa) was being cultivated on New Providence as early as 1698 (Craton, 1968: 89), and may even have been introduced in Arawak times. It is now widely distributed throughout the archipelago and was seen occasionally in weedy sites on Cat Island in 1970. The old-world indigo (Indigo tinctoria) was introduced in the late eighteenth century but did not grow well in the Bahamas (Brown, 1802: 27).

As was indicated earlier, logwood (Haematoxylum campechianum) was introduced to the Bahamas in 1722 from Honduras. Since then it has spread widely around the islands and has locally become important in the woodland. Another leguminous tree that was probably introduced in the eighteenth century is the sweet acacia (Acacia farnesiana). Catesby (1731, II: 45),includes a plate of what appears to be this species in his Natural History. Its original home is not known with certainty, although it has been accepted as native in Cuba (Little and Wadsworth, 1964:144). Its spines make it a valuable hedge plant and probably because of this it has been widely distributed throughout the Bahamas. On Cat Island it was occasionally observed in disturbed habitats such as roadsides.

The divi-divi tree (Caesalpinia coriaria) was introduced into the Bahamas in the early part of the nineteenth century in the hope of exporting its pods for tanning (Hamilton, 1836). Apparently the demand was not strong enough to justify large- scale planting, and the tree was never taken to the Out Islands. According to Britton and Millspaugh (1920: 174), it has spread locally from cultivation on New Providence.

Several species were introduced in the eighteenth century as fodder crops. The most important of these was Jumbay (Leucaena leucocephala a leguminous shrub from Central America. Leucaena has been widely planted throughout the archipelago, and is probably the most invasive of all the introduced trees or shrubs. Also valued as a source of fodder in the eighteenth century was the horseradish tree (Moringa oleifera). It had been introduced to Jamaica from the coast of Guinea in the seventeenth century (Edwards, 1819, I:481), and may have been brought from there to the Bahamas. The loyalists used it as fodder for sheep (Brown, 1802: 11). At present it is occasionally seen as an ornamental on Cat Island and is locally spontaneous.

Also used by the loyalists for fodder were Sesbania grandiflora and the "Pride of India" (Melia azaderach). Both of these old-world species have spread spontaneously. The latter has been planted as an ornamental and is occasionally seen in the settlements on Cat Island.

Although the historical record is far from complete, it does indicate that very few aliens become firmly established as part of the wild vegetation. In spite of the fact that a considerable number of plants have been introduced to the Bahamas during the past three hundred years, comparatively few have been able to spread very far without man's help. Daniel McKinnen aptly described the situation in 1803:

> The exotics which are introduced seem feebly and unsuccessfully to struggle with cold winds; the droughts, and unfriendly seasons; while a crop of hereditary and worthless weeds take possession of the soil prepared for cultivation, and extract all its nourishment to administer fertility, as they decay, to the native and unprofitable forest trees succeeding them, the elemi, silver-leaved palmettos, and hungry aborigines of the rocks (McKinnen, 1806: 351).

Just why this should be so, in contrast to the West Indies, where aliens covered extensive areas at very early dates (Harris, 1965: 113), is not immediately apparent. The question will be raised again later when the quantitative importance of aliens in Cat Island woodland is discussed.

Domesticated Animals

The introduction of alien animals has often brought about far-reaching changes in the vegetation of oceanic islands and this has certainly been the case in the Bahamas. Goats, horses, sheep, cattle, and hogs have all had an impact on the wild vegetation of the islands, especially in the areas close to the settlements.

Whether or not the Spanish stocked the island with livestock is not known. When the loyalists arrived on Cat Island in the 1780s they found plenty of wild hogs, although no mention is made of any other animals (Eve, O., 1784).

Presumably the hogs brought about changes in the woodland, although just what these were is difficult to assess. Very likely the wild population was eliminated by hunting in the nineteenth century. Domesticated hogs have had an indirect impact on the woodland through the gathering of hog feed. The native hog cabbage palm (Pseudophoenix vinifera) has become rare because of this pressure. In 1970 most families had at least one hog in their yards. They are, however, penned and fed largely on household scraps.

During the loyalist period Cat Island had the reputation of being one of the better islands in the Bahamas for the raising of livestock. According to one source (Powles, 1888:234), thousands of head of cattle were raised on the island at this time. After Emancipation cattle were still raised, although not in the same numbers as before (Underhill, 1862: 480). In recent years the Bahamian government has made a concerted effort to develop livestock farming. Pastures were established in several settlements (Arthurstown, The Bluff, The Bight) and planted with African grasses.[1] Unfortunately the scheme has had little success. The woodland was cleared with a bulldozer and the limestone surface hardened on exposure to the atmosphere and as a result even the drought-resistant African grasses have scarcely been able to survive.

In spite of reports of large cattle herds during loyalist times, it seems unlikely that livestock farming was ever much of a success. During the dry season the native grasses dry out and there is a general scarcity of forage. Furthermore, the broken, potholed nature of the limestone is dangerous for livestock. In 1970 only one herd of cattle was seen on the island, and this was being pastured on the whiteland near The Bluff settlement.

Horses were apparently numerous on the island during loyalist times. One Cat Island planter even imported thoroughbred stallions from England (Stark, 1891: 149). The horse population declined in the late nineteenth century, although horses continued to provide the main means of transportation on the island until automobiles arrived comparatively recently. It is doubtful whether any of the loyalist thoroughbred stock made any contribution to the present population of horses on the island. Cat island horses in

1. Three species were tested for use in the pastures: Rhodes grass (Chloris gayana), pangola grass (Digitaria decumbens), and star grass (Leptochloa plechtostachya). Three others were planted as possible fodder crops: elephant grass (Pennisetum purpureum), para grass (Panicum muticum), and Johnson grass (Sorghum halepense).

1970 were generally small and lean and had the distinct appearance of being both underfed and overworked. Both horses and cattle are mainly pastured on the whiteland where they feed on grasses and herbaceous weeds. Their main influence at present is to slow down the recovery of shrubs and trees.

Sheep were also introduced by the loyalists and were at one time quite numerous, especially at the southern end of the island. Grazing by sheep is of more interest to the present study in that it directly affects the woodland. Sheep, more so than cattle or horses, are content to browse. In the dry season when no grass is available they will eat the leaves of shrubs such a jumbay (Leucaena leucocephala ramshorn (Pithecellobium keyense) and pigeon berry (Rhacoma crossopetalum). This browsing has had a selective effect on the composition of the woodland.

The pasturing of sheep also affects the woodland in other ways. Some farmers will scatter grass seeds and jumbay before abandoning a field. When the last crop has been harvested, the field will be turned over to sheep. Grass seeds are cycled through the sheep's gut, and a thick growth of grass results. This means that soil development is accelerated but the recovery of the woody vegetation is retarded. In 1970 such effects were very localized on Cat Island, as only a few small herds of sheep were being raised. They are a white short-haired breed without horns.

Only the goat has had a really significant impact on the woodland. Unlike the other domesticates, the goat is content to browse at all times of the year. In 1970 the goat was the most numerous domesticate on the island, the total population amounting to several thousand. Cat Island goats are mostly coarse-haired, black or brown animals with short horns that curve over backwards. In recent years attempts have been made to upgrade the quality of the local breed with American stock.

This review of the history of plant and animal introductions does not entirely support the idea that alien species have a competitive advantage over insular species. Certainly as far as plants are concerned, few aliens have become well-established. On the other hand, domesticated animals have at various times been numerous on the island, and may in some cases have had a significant impact on the woodland. The nature of this impact is considered more closely in the section dealing with areal variation in the composition of the woodland.

VIII. METHODS OF ANALYSIS

Unfortunately, the historical record provides only a very qualitative indication of the extent to which the vegetation of Cat Island has been modified by man. It shows that for a period of at least a thousand years the woodland has been discontinuously cleared, burned, browsed, and selectively cut, but it does not show what the detailed consequences of these activities were. With this deficiency in mind it was decided to analyse the composition of the present woodland in such a way as to show in quantitative terms the extent to which it has been changed by man. More specifically the following questions were considered:

1. What are the detailed consequences of clearing and burning? How long does it take the woodland to recover? What species are involved and when do they become established?

2. To what extent has the woodland been changed by selective pressures such as grazing, cutting, and the use of fire? Which species have become less important as a result of these pressures? Which have become more important?

3. To what extent have alien plants been able to invade the woodland? Are they only a temporary feature of the vegetation or have they become permanently established?

Field Methods

Fortunately, it was possible to spend three field sessions on Cat Island: July to October 1967, June to August 1968, and June to August 1970. In addition short visits were made to three other Bahamian islands--Bimini, Mayaguana, and New Providence. Basically the field work consisted of plant collection and identification, interviews, and vegetation analysis.

Plant Collection and Identification

The Bahamian woodland is typically tropical in that two individuals of the same species are rarely seen together. This, together with the physiognomic similarity of so many species, made the taxonomic problem a difficult one in the early stages of the study. A large part of the first field season was therefore devoted to the collection of plant specimens. In total some 600 collections were made, not counting duplicates (Appendix I). As far as possible all the species encountered were collected. In the case of difficult genera, such as *Pithecellobium*, *Eugenia*, *Cassia*, *Coccoloba*, and *Lantana*, several collections of each species were made.

Provisional identifications were made in the field with the use of the keys in Britton and Millspaugh (1920) and Little and Wadsworth (1964). Local names provided useful if not always reliable clues as to the identity of many species. A nearly complete set of the plants collected was later sent to Dr. R.A. Howard of the Arnold Arboretum, and his determinations are the ones used in the present text.

Local Interviews

Because of the length of time spent in the field it was possible to develop close personal contacts with many of the local inhabitants, particularly in the settlements at the north end of the island. This in turn made it possible to gather a great deal of information relating to shifting agriculture, grazing, and the selective exploitation of woodland species.

Interviews were usually carried out on an informal basis without the use of any set questionnaire. A complicating factor here was the custom whereby the person interviewed usually provided the answers he or she thought were expected. This problem was avoided by not asking leading questions and by checking the reliability of the informant with questions the answers to which were already known. The older people were generally more knowledgeable since they had spent all their lives farming on the island. As far as the recent history of shifting agriculture was concerned, they were the only source of information. In general, Cat Islanders were both willing and knowledgeable informants. Furthermore, the information they provided was indispensable to the study as a whole.

Vegetation Analysis

Ultimately the success of this type of study depends on the ability of the investigator to accurately identify plants in the field. As was indicated above, the taxonomic problem was initially a difficult one; apart from a few weeds and aquatics, the Bahamian flora is very different from that of mid-latitude areas. Eventually, however, after walking through literally hundreds of miles of woodland and collecting every unknown, it became possible to identify on sight the vast majority of the species encountered. Once the flora was well-known it was possible to set up a sampling procedure that could be applied to the woodland as a whole.

In 1970 a sampling method was devised that would not only give answers to the questions posed above but would also provide a base-line against which further change could be assessed. Three hundred sampling sites were selected in different parts of the woodland, and since the entire woodland had been cultivated at one time or another, each sample site was in effect an abandoned field. The two criteria for selection were that the site could be accurately located on the available aerial photograph coverage[1] and that the vegetation appeared to be, or was known to be, of a uniform age.

The actual data collected consisted of a visual estimate of the cover within 25 x 1 meter quadrats in each field. Only woody species or succulents with a minimum cover of at least one quarter of a square meter in each quadrat were included. Herbs were omitted because of the marked seasonality of their occurrence and because a new sampling method would have been needed to deal with them adequately. In younger fields the quadrats were laid out in the form of a cross centered in the middle of the field. In the older fields, or in fields difficult to penetrate, a 25 meter belt transect was run as far into the field as possible. Measurements were made with a meter stick and a measured length of rope. The cover data were dictated into a portable tape recorder and later transcribed onto data sheets (Appendix III). For convenience each species encountered was given a code number. 120 species were encountered in the 300 fields sampled (Appendix I).

Once a field had been sampled it was given a number and classified on the basis of the following characteristics: (1) age since abandonment, (2) habitat-type, (3) height of vegetation, (4) soil-type, (5) moisture characteristics, and (6) distance from the nearest settlement. Finally, its location on the 1958 aerial photographs was fixed by means of a six-figure cross reference. Not all of the distinctions made above proved to be relevant to the present study, but the way in which they were established is as follows:

Age since abandonment. As can be seen from Figure 16, the woodland is in fact a patchwork of fields in different stages of recovery following clearing and burning. It was soon recognized that any analysis, if it were to be meaningful, would have to allow for these age differences. The age of the woodland was determined in two ways: local information on the history of land use, and tonal appearance on

1. Good quality stereoscopic coverage was available for the island at a scale of 1:12,500. The photographs were taken in 1958 by Spartan Aviation Services on contract to the Bahamian Government.

aerial photographs.

Local informants could usually provide a reasonably accurate age for fields abandoned less than 12 years ago, although beyond that memories were vague. For older abandoned fields the 1958 aerial photographs provided further clues as to age. Generally speaking, the older the woodland the darker its appearance on the aerial photographs. The reasons for this are basically twofold: (1) reflection from the limestone surface is reduced as succession takes place, and (2) pioneer species have generally lighter-colored leaves than the shade-tolerant species that replace them. This meant then that tonal differences on the aerial photographs provided a good indication the relative age of the woodland in the areas sampled, and by determining whether the area was white, light grey, dark grey or black, an approximate age-sequence was established.

Habitat type. As was indicated earlier, there is a variability in the woodland which reflects underlying differences in surface characteristics. To minimize the effects of this variability it was decided to classify the woodland on the basis of land surface or habitat characteristics. Initially all five basic landform types were used:

1. Holocene Dunes and Beach Ridges.
2. Young Pleistocene Marine Plains.
3. Young Pleistocene Dunes and Beach Ridges.
4. Old Pleistocene Marine Plains.
5. Old Pleistocene Dunes and Beach Ridges.

After analysis of the data collected, it became clear that habitat-types 2 and 4 could be combined, as also could 3 and 5. As far as the floristic composition was concerned the differences in each case did not appear to be significant. Furthermore, a low sample coverage in habitat type 4 limited its usefulness. The final breakdown therefore involved just three habitat-types:

1. Holocene Dunes and Beach Ridges.
2. Pleistocene Marine Plains.
3. Pleistocene Dunes and Beach Ridges.

In terms of local names these habitat-types are equivalent to the whiteland, flatland, and blackland respectively. In classifying the woodland indirectly by means of surface characteristics, the arbitrary problem classifying vegetation itself was avoided. Furthermore, a coherent framework was provided within which the processes of change could be analysed.

Height of vegetation. For each abandoned field sampled the average height of the vegetation was measured and recorded to the nearest meter. In most cases this was a meaningful figure, as the vegetation sampled was of a more or less uniform height. In the younger fields, sprouts which would characteristically project above the seedling-bushes by a meter or so were not included in the average.

Soil-type. Each sample site was classified as to whether the soil was white, black, or red. The main reason for making this distinction, in addition to that of habitat-type, was that the red soils are present in more than one habitat-type. Although they are mainly found in the flatland areas, they are also characteristic of the older Pleistocene dune ridges. However, the red soil areas are localized on the island and because of this only 34 red soil fields were sampled. Because of the small size of the total sample and because there was no indication that differences in soil type had any affect on the composition of the vegetation it was decided not to use the red soil fields as an independent unit. The white soils are simply equivalent to the whiteland habitat and the black soils to those Pleistocene surfaces without red soils.

Moisture class. Within the woodland there are differences that are independent of either soil or surface characteristics and are primarily due to differences in drainage conditions or exposure. In some areas, as for example on the leeward side of the Pleistocene dune ridges, the land surface is steep and any rain that does fall is quickly lost as run-off. Such areas are naturally droughty. Similarly, low-lying areas where the fresh-water lens is thin or non-existent are also droughty. The same is true of areas exposed to the full force of the trade winds; evapotranspiration rates are high and the trees are consequently stunted and slow-growing. On the other hand, in some low-lying areas, close to the seasonally-flooded savannas, the woodland is occasionally flooded.

In order to accommodate these differences, a three-fold classification was set up: xeric for droughty fields, hydric for seasonally-flooded fields, and mesic for intermediate fields. As it happened, only 15 xeric and 15 hydric fields were sampled, and visual inspection of their cover data suggested their floristic composition was not significantly different from the rest. Consequently these distinctions were ignored in the later analysis.

Distance index. Until recently few people on Cat Island had motor cars and even now most farmers walk to and from their fields along rocky footpaths. There is only one road on the island and this joins the settlements along the western and southern coasts. For most of its length it is not surfaced, and travelling from one end of the island to the other is a major undertaking, so much so that people from the northern end rarely if ever visit the southern end and vice versa. All of this emphasizes the fact that the frictional effect of distance is strong on Cat Island. The importance of this to the present study is that man's modifications of the woodland through clearing, burning, selective cutting, and grazing decreases in intensity with distance from the settlements. In order to determine the significance of this, each sample site was classified in terms of its distance in kilometers from the nearest settlement.

Aerial photograph reference. As was indicated above, the choice of sampling locations was in large part determined by whether or not the field in question could be accurately located on the 1958 aerial photographs. This was thought to be especially important insofar as it would make possible future sampling in the same location.

The location of each field sampled was fixed by a cross-reference on a 1958 aerial photograph. A 12-figure reference was used, the first three numbers of which referred to the flight number of the photograph, the second three to the frame number. The last six figures provided the cross-reference on the photograph itself, the first three representing the distance in millimeters from the left-hand margin and the last three the distance from the bottom margin, (Figure 24). At a scale of 1/12,500, one millimeter on the photograph represents 12.5 meters on the ground, so the sample site is fixed quite accurately.

Analysis of Field Data

After returning from the field, the data gathered were organized for analysis. The analysis involved plant identification, aerial photograph analysis, and computer analysis of the plant cover data.

Plant Identification

As was mentioned earlier, a full set of the plants collected was sent to the Arnold Arboretum and the names of all the species included were determined by Dr. R.A. Howard. In addition to this, several days were spent at various herbaria comparing duplicate specimens with earlier Bahamian collections. The Field Museum of Natural History collection of Bahamian plants was especially useful here, as it included a duplicate set of all plants collected during the

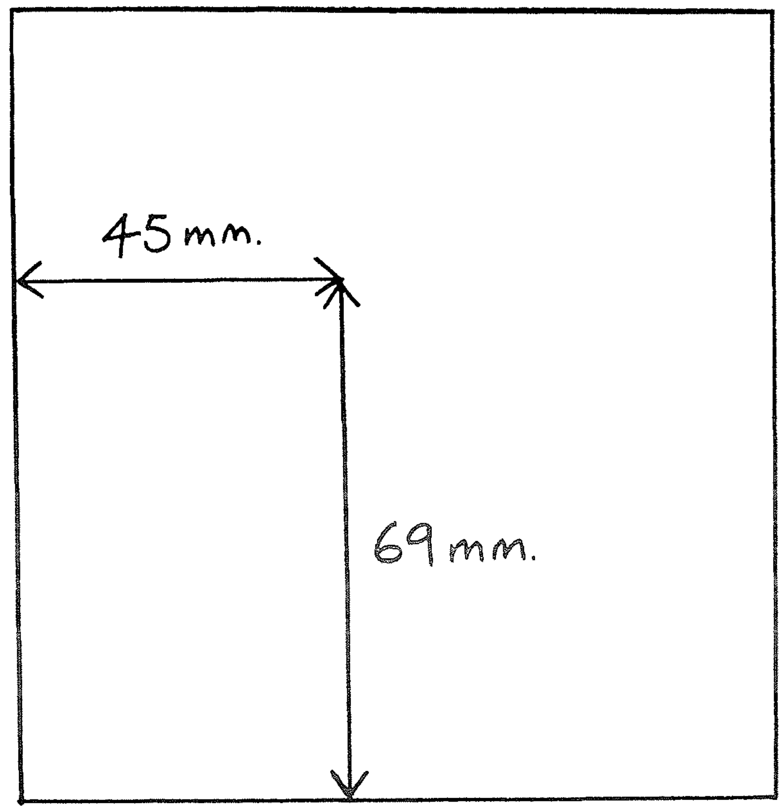


Figure 24. The aerial photograph reference grid. Each sample site was fixed by a 12-figure reference number; for example:

012 : 180 :: 045 : 069

012 = The flight number.
180 = The frame number.
045 = Millimeters from left edge of photograph.
069 = Millimeters from bottom edge of photograph.

compilation of the Bahama Flora (Britton and Millspaugh, 1920).

The herbarium work had two major objectives: first, to obtain some idea of the variability present in difficult taxa such as Pithecellobium, Eugenia, and Coccoloba, and second, to check the dates on the collections of alien species. In the last context the early collections by Catesby and others at the British Museum of Natural History were especially useful.

Aerial Photograph Analysis

The 1958 aerial photograph coverage of the island was an indispensable aid to field work. The photographs made it possible to pinpoint the location of the area sampled and also provided a good indication of the age of the woodland. Having returned from the field in 1970, further aerial photograph analysis was made possible by the acquisition of aerial photographs of the island taken in 1943.[2] This further analysis consisted of two parts: confirmation of the habitat-type classification, and the establishment of time-control for the age of the woodland.

Habitat-type classification. As every field sampled had been accurately located on the 1958 aerial photographs, it was quite a simple procedure to check whether or not the habitat-type assigned to the ground was confirmed by the aerial photographs. Stereoscopic coverage was available for 1943 and 1958, and on both series the land surface characteristics were easily identifiable.

Age determination. The 1958 aerial photographs provided an approximate guide to the age of the woodland, as abandoned fields appear progressively darker with age. In spite of the time lapse between photography and sampling, this relationship appeared to be quite real on the ground, except of course for those fields cultivated and abandoned after 1958. The tonal differences, however, give only a relative time scale. It was safe to assume that a dark area of woodland was older than a light area, but the actual age difference involved could not be determined from the 1958 photographs alone.

This problem was overcome by using the 1943 photographs in conjunction with those taken in 1958. More specifically,

2. The 1943 photographs were taken by the U.S. Navy as part of a wartime defense operation. Also of quite good quality, they are available in stereoscopic coverage at a scale of 1: 30,000.

by comparing the differences in tonal density between photographs of the same area it was possible to fix with a certain degree of accuracy the age of any part of the woodland that had not been cleared since 1958 (Table 3).

Computer Analysis

Once all the field data had been checked they were transferred from the data sheets (Appendix III) to IBM cards for computer analysis. Each of the categories in the age, habitat, height, soil, moisture, and distance classes was given a code number, and each of the species encountered was given the same code number that had been used to refer to it in the field (Appendix I).

Once the cards were in order programs were written to compute basically two kinds of information. First, how did the floristic composition of the woodland change through time? In other words, how did the woodland recover after clearing and burning? And second, how did the woodland vary with distance from the settlements?

Limitations of the Data

The methods employed in gathering the data were designed with two specific purposes in mind, namely, to evaluate the extent to which man had changed the floristic composition of the woodland and to provide a base-line against which future changes could be assessed. However, before proceeding with any discussion of the data, certain limitations should be made clear.

Taxonomy

As has been mentioned above, several genera contain species that are not easily distinguished in the field. For example, in the genus *Pithecellobium* all the individuals encountered were recorded as *P. keyense*. However, the leaf characteristics by which this species is differentiated from *P. unguis-cati* are somewhat variable and both species may therefore be present. Similarly, in the genus *Eugenia* two species, *E. buxifolia* and *E. longipes*, were quite distinct, but three others, *E. lucaya*, *E. myrtoides*, and *E. monticola*, were not, and some misidentification may have been made here. In the Euphorbiaceae two species may have been confused, *Drypetes diversifolia* and *Savia bahamensis*. Both are similar in terms of leaf characteristics and general appearance and may have been misidentified when flowers or fruit were not available. In the genus *Coccoloba*, *C. uvifera* and *C. krugii* are distinctive, but the widespread *C. diversifolia* was quite variable and may include more than one species.

TABLE 3

AGE AND TONAL DENSITY

AGE CLASS	DATE CLEARED	APPEARANCE ON 1943 PHOTOGRAPHS	APPEARANCE ON 1958 PHOTOGRAPHS
I (<5 yrs.)	1966-1970	Not Present	Not Present
II (5-14 yrs.)	1956-1965	Not Present	Light Grey or Not present
III (15-29 yrs.)	1940-1955	Light Grey or Not Present	Medium Grey
IV (30-50 yrs.)	1920-1939	Medium Grey	Dark Grey
V (>50 yrs.)	Before 1920	Dark Grey or Black	Black

In the final analysis the taxonomic problem was not a serious one. Because of the long period of time spent in the field it was possible to identify on sight the vast majority of the species encountered. Furthermore, most of the 120 species included in the systematic sampling are quite distinctive.

Coverage

Roughly two-thirds of the sample locations are in the northern half of the island, the main reason being that the field research was based in Arthurstown. Although the road along the island is only about sixty miles long, for the most part it is simply a rough track and travelling is therefore very difficult and expensive.

This uneven coverage is probably not a significant problem as there are few obvious differences between the northern and southern parts of the island. On the other hand, it does mean that the importance of alien species in the sample is less than it might have been. Logwood (*Haematoxylum campechianum*) was seen to be especially common around the two southern settlements of Port Howe and Old Bight.

As can be seen from Table 4, the coverage of the different age-classes is somewhat uneven. This reflects the variable character of the woodland itself. Large areas of woodland fall in the first three age-classes, whereas older woodland is comparatively hard to find. The same is true of the other variables indicated. Sample sites were chosen to give a good coverage of the woodland as a whole rather than to provide equal coverage within the different classes. This later proved to be a problem insofar as it necessitated the use of percentages in comparisons between classes with different sample coverage.

Rare Species

Even though the total sampled was large, rare species because of their very nature are not well represented. This is particularly unfortunate because it is most likely that it is the rare species have been most significantly affected by disturbance.

In spite of their limitations, the data gathered provide a comprehensive picture of

TABLE 4

THE NUMBER OF FIELDS (25 x $1m^2$)
SAMPLED IN EACH CATEGORY

Age	< 5 yrs.	5-14 yrs.	15-29 yrs.	30-50 yrs.	>50 yrs.	
Fields	60	80	83	52	25	
Habitat	Whiteland	Flatland	Blackland			
Fields	42	99	159			
Soil	Black	Red	White			
Fields	222	34	44			
Moisture	Xeric	Mesic	Hydric			
Fields	15	270	15			
Distance	1 km.	1-2 km.	2-3 km.	3-4 km.	4-5 km.	5 km.
Fields	77	73	55	50	30	12

the variable character of the woodland as it was in 1970.[3] As a cross-sectional sample of an uneven-aged population, they provide a basis for estimating what changes have occurred in the past and what changes are likely to occur in the future.

3. In order that the old field analysis may be repeated in the future, all the data gathered have been deposited in the Social Science Data Program Library at the University of Wisconsin. The full set of the 1958 aerial photographs may be obtained from either the University of Wisconsin Map Library; the Crown Lands Office, Nassau; or the Department of Overseas Surveys, Surbiton, England.

IX. THE IMPACT OF SHIFTING AGRICULTURE: AGE DIFFERENCES IN THE WOODLAND

Seen from the air, the Cat Island woodland is a patchwork quilt of abandoned fields in various stages of recovery (Figure 16). It was soon recognized that any analysis of man's impact would have to include some consideration of these age differences. Not only were they significant in themselves, but they also represented an inherent variability that complicated the analysis of the whole. Fortunately, the availability of aerial photograph coverage for 1943 and 1958 made it possible to fix within certain limits the age of any part of the woodland. By sampling fields of different ages, it was possible to determine indirectly the nature of recovery following abandonment.

An analysis of succession is in many ways relevant to the hypothesis of insular vulnerability. If the hypothesis is valid, several conclusions might be expected. First, the native species would be ill-adapted to this artificial form of disturbance and would be slow to recover after clearing and burning. Second, the native species would to a large extent be replaced by aliens, especially in the earlier stages of succession. And, third, the long history of repeated clearing and burning would have brought about a marked reduction in the number of native species present.

Because of the underlying differences in land surface characteristics, the woodland was dealt with in the context of the three habitat- types: the whiteland, flatland and blackland. Figures 25, 27, and 29 show in some detail the changing floristic composition in each habitat-type at different stages of recovery. The distinction between "important" and "minor" species is arbitrarily based on whether or not the species in question accounts for more or less than 5 percent of the area sampled in any one age-class. The minor species are shown collectively according to the age-class in which they reach their maximum value. As the diagrams are largely self-explanatory, what follows here is simply an elaboration of their more important characteristics. The account of each habitat-type concludes with a discussion of a representative aerial photograph sequence.

The Whiteland

The whiteland is a distinctive habitat-type and it is not surprising, therefore, that succession here is different

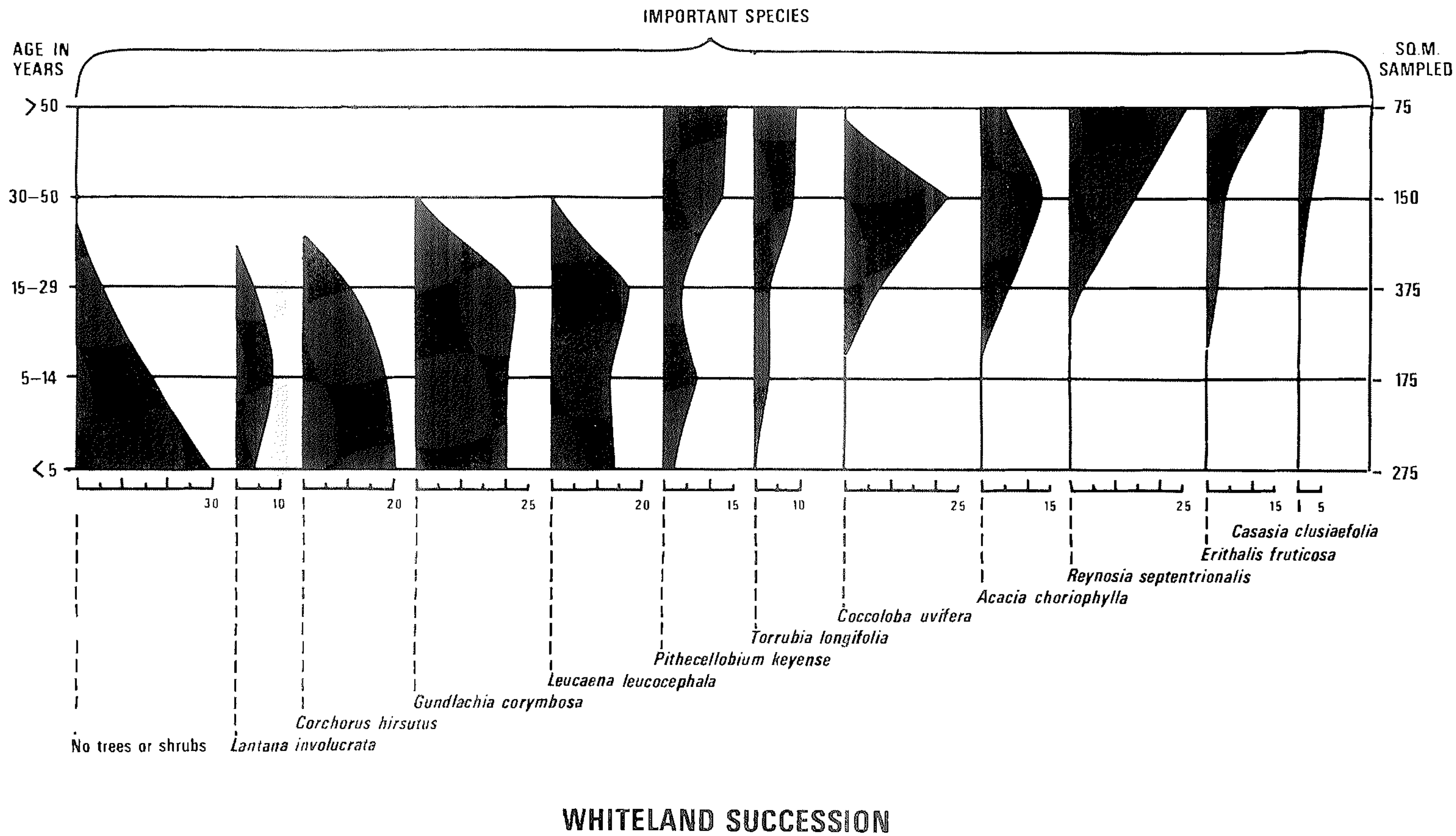
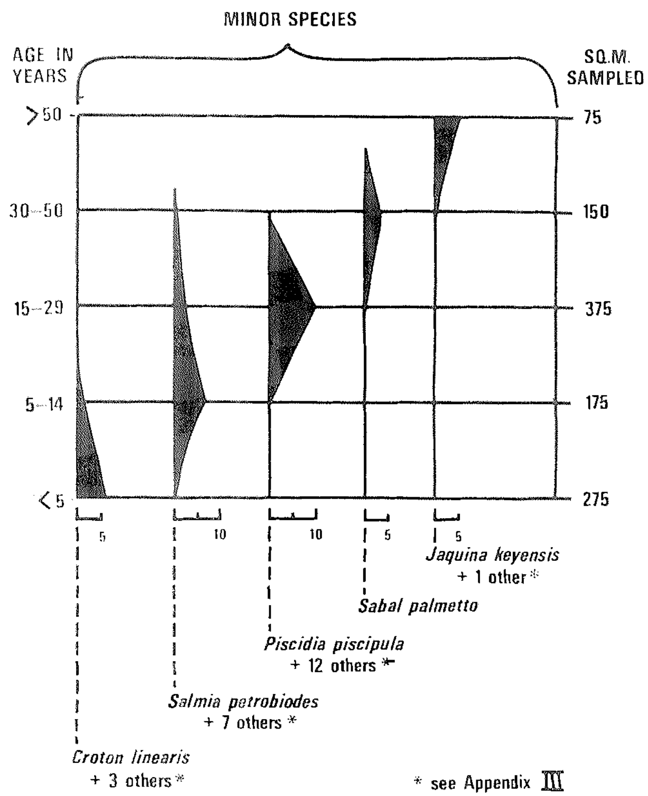


Figure 25A. Whiteland Succession Diagram (important species)



WHITELAND SUCCESSION

Figure 25B. Whiteland Succession Diagram (minor species) from that on the flatland or blackland. The main difference is that, in all age classes, a comparatively few species account for a large part of the total cover. Gundlachia corymbosa, Corchorus hirsutus, Leucaena leucocephala and Lantana involucrata dominate the first three age-classes (Figure 25A). All four are pioneer species, well-adapted to quickly colonizing open, droughty surfaces. Any particular field is usually invaded by only one or two of the four species, and these will then dominate the early stages of succession. Floristic differences between recently abandoned fields are probably due to chance factors, such as the timing of abandonment, rather than to basic environmental controls.

Gundlachia corymbosa is a shrubby composite rarely more than 2 meters tall. It grows naturally in the low, droughty areas around the margins of brackish ponds and salt-water lagoons, and from here has spread rapidly into artificially-disturbed habitats such as roadsides and abandoned fields. Its success can also be attributed to its prolific seed production and efficient dispersal capacities. Like many members of the Compositae, its seeds are dispersed by the wind. Corchorus hirsutus appears to be very similar to Gundlachia as far as habitat tolerances are concerned. It grows naturally in unstable dune environments inland from the coast. The fruit is a dehiscent capsule containing many small wind-dispersed seeds. Leucaena leucocephala unlike the other whiteland pioneers, is an introduced species. Significantly, it is only found in artifically- disturbed habitats such as roadsides and abandoned fields. Like Gundlachia and Corchorus, its seeds are largely wind-dispersed. However, its success can also be attributed to its ability to reproduce from sprouts.

The only other pioneer species to reach more than 5 percent in any particular age-class is Lantana involucrata. This aromatic shrub is somewhat smaller than the three species discussed above, rarely reaching 2 meters in height. It was seen growing in naturally-disturbed habitats, such as dunes and beach ridges, and also in droughty areas surrounding the salt-water lagoons. Unlike Gundlachia and Corchorus, Lantana depends upon birds for seed dispersal. This species has small, fleshy fruits that are conspicuously blue in color.

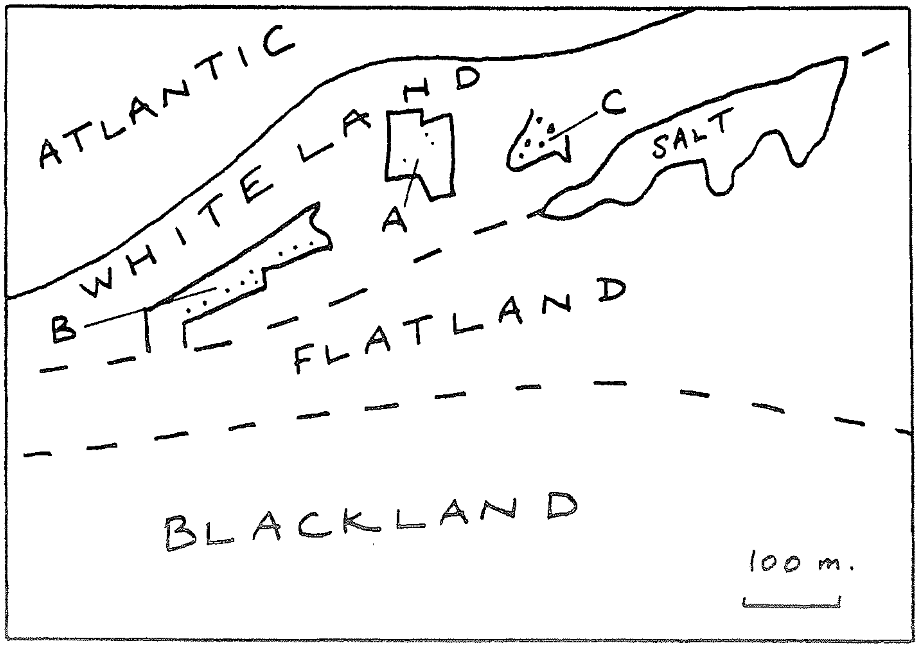
The pioneer shrubs are replaced after about 30 years by taller bushes, particularly Pithecellobium keyense, Torrubia longifolia, Coccoloba uvifera, and Acacia choriophylla. All of these species, with the exception of Torrubia, grow in dense thickets which gradually increase in area and eventually merge. The decline of the pioneers is probably in large part due to competition from the taller, more deeply-rooting species, although it is also possible that they are naturally designed for only a short lifespan. Older Gundlachia bushes, for example, were often seen to be damaged by root rot and other pathogens.

Pithecellobium keyense is a leguminous shrub or small tree that rarely reaches a height of more than 4 meters . It grows naturally in droughty areas, such as dunes and beach ridges, or the scrub-lands just above the salt-water lagoons. Its seeds are covered with bright red aril, an obvious adaptation to encourage dispersal by birds. As Figure 25 indicates, Pithecellobium is capable of colonising recently-abandoned fields but tends to become more important in the older age-classes.

A very similar successional pattern is shown for Torrubia longifolia. This small tree grows naturally in open, droughty habitats such as sand dunes and beach ridges and the occassionally flooded areas around the edges of the savannas. Like Pithecellobium, its fruits are well-adapted to dispersal by birds. A Torrubia tree in fruit is virtually covered with bright red berries.

In the penultimate age-class (30-50 years), Coccoloba uvifera accounts for nearly 25 percent of the total cover. According to Britton and Millspaugh (1920:116), this bushy tree reaches 15 meters in height in certain areas of the Bahamas. However, on Cat Island it was rarely seen to be more than 6 meters tall. It covers extensive areas of the whiteland, both along the coast and back into the dunes and beach ridges. Characteristically it forms dense thickets which gradually expand into formerly-cleared areas. As might be expected from its wide distribution along the coastlines of the New World tropics, its fruits are dispersed by ocean currents. Locally, however, birds, crabs, and man are important dispersal agents. As Figure 25A indicates, it was not encountered in the recently-abandoned fields. Its absence suggests that its seedlings need a certain amount of shade in order to become established.

A similar successional pattern is shown by Acacia choriophylla. Like Coccoloba, this small leguminous tree was not encountered in the recently-abandoned fields. It is not a prolific seed-producer and probably depends on birds, crabs, and lizards as means of dispersal. Proportionally it is more common on the whiteland than elsewhere in the woodland, which suggests that this may be its natural habitat. Its thick leaves are probably an adaptation to the dessicating winds that characterize the areas close to the coast.



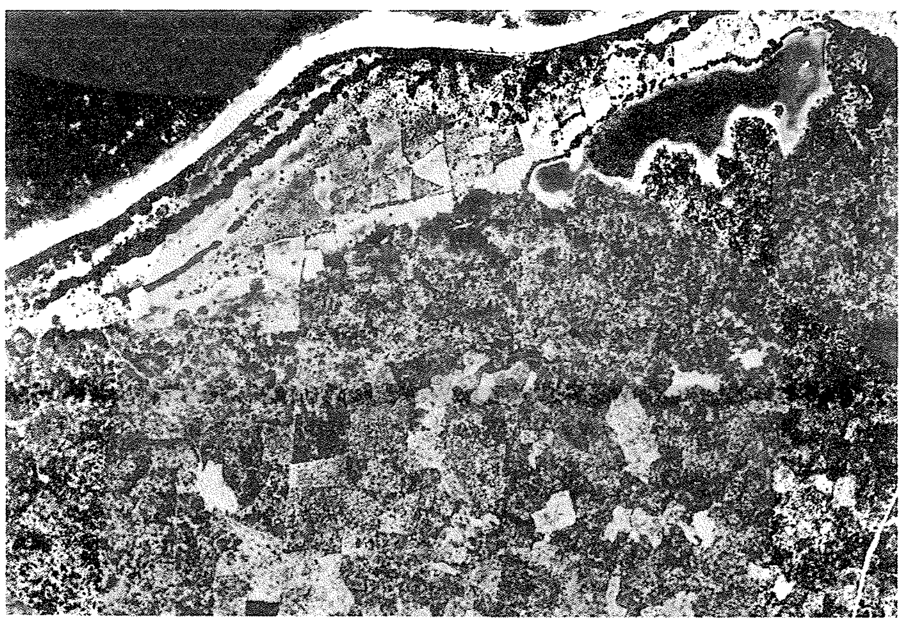
Figures 26 and 27 show a time-lapse sequence for a representative whiteland area, at south Bird Point. The most obvious difference between the two photographs is the decrease in the area cultivated. The generally darker tone of the whiteland on the more recent photograph does in fact represent the recovery of the woodland.

Three general stages of recovery can be identified. The flat grey tone, so widespread on the earlier photograph (for example at A), represents recently abandoned fields in which the cover is largely grasses and herbaceous weeds (see Figure 18). In 1958 many of these areas were characterised by a darker, fine stipple pattern, as for example at B. This represents the low shrub cover characteristic of fields between 5 and 15 years old (see Figure 19). The expansion of the taller, more deeply rooted, bushes can be identified at several locations in the older photograph (for example C). The beginnings of this later stage are also shown in Figure 41.

In general, the south Bird Point sequence supports the idea of a comparatively slow recovery on the whiteland. Several fields in cultivation in 1943 can still be identifed on the 1958 photographs. This is rarely the case for the other habitat types. On the other hand recovery is obviously taking place and given no further disturbance it is not too difficult to visualise the whiteland being eventually covered with the woodland.

Figure 26. Whiteland, South Bird Point 1943.

Figure 27. Whiteland, South Bird Point 1958.



Older woodland was hard to find on the whiteland because it has been so intensively used for agriculture. Age-class 5 (more than 50 years) is therefore based on a comparatively small sample. The data do suggest, however, that the bushy character of the woodland eventually changes as trees such as Reynosia septentrionalis and Erithalis fruticosa become more important. Even so, several smaller bushes, for example, Pithecellobium, Torrubia, and Casasia, still account for a significant percentage of the total cover.

The most important species in the oldest age-class is Reynosia septentrionalis. It is also common on droughty sites on the blackland and flatland. Like most of the species discussed above its natural habitat appears to be exposed limestone ridges just inland from the coast. Its seeds are dispersed by birds and small animals such as crabs and lizards.

The last two important species on the whiteland, Erithalis fruticosa and Casasia clusiaefolia, are both members of the madder family. Erithalis is a bushy tree which rarely reaches more than 4 meters in height. It is found in the woodland throughout the island but is especially common on the whiteland. Its small purple fruits are well-adapted to dispersal by birds, although it does not become established on the recently abandoned fields (Figure 25A).

Casasia clusiaefolia, has fruits that are adapted to dispersal by ocean currents, and probably because of this it is largely restricted to the whiteland. It is a shrub with a capacity for rapid growth and is characteristically present as a minor member of the whiteland thickets. Its seeds are locally dispersed by birds, crabs, and lizards.

An account of all 28 minor species encountered on the whiteland is beyond the scope of the present discussion. As can be seen from Figure 25B, they account for only a small percentage of the total cover in every age-class. This floristic simplicity contrasts sharply with the rest of the woodland. Figures 26 and 27 show a representative time-lapse sequence for the whiteland.

The Flatland

The flatland is also a distinctive habitat-type. The land surface consists of horizontally-bedded marine limestones of Pleistocene age. The limestone is indurated-and the surface therefore tends to be droughty. This in turn

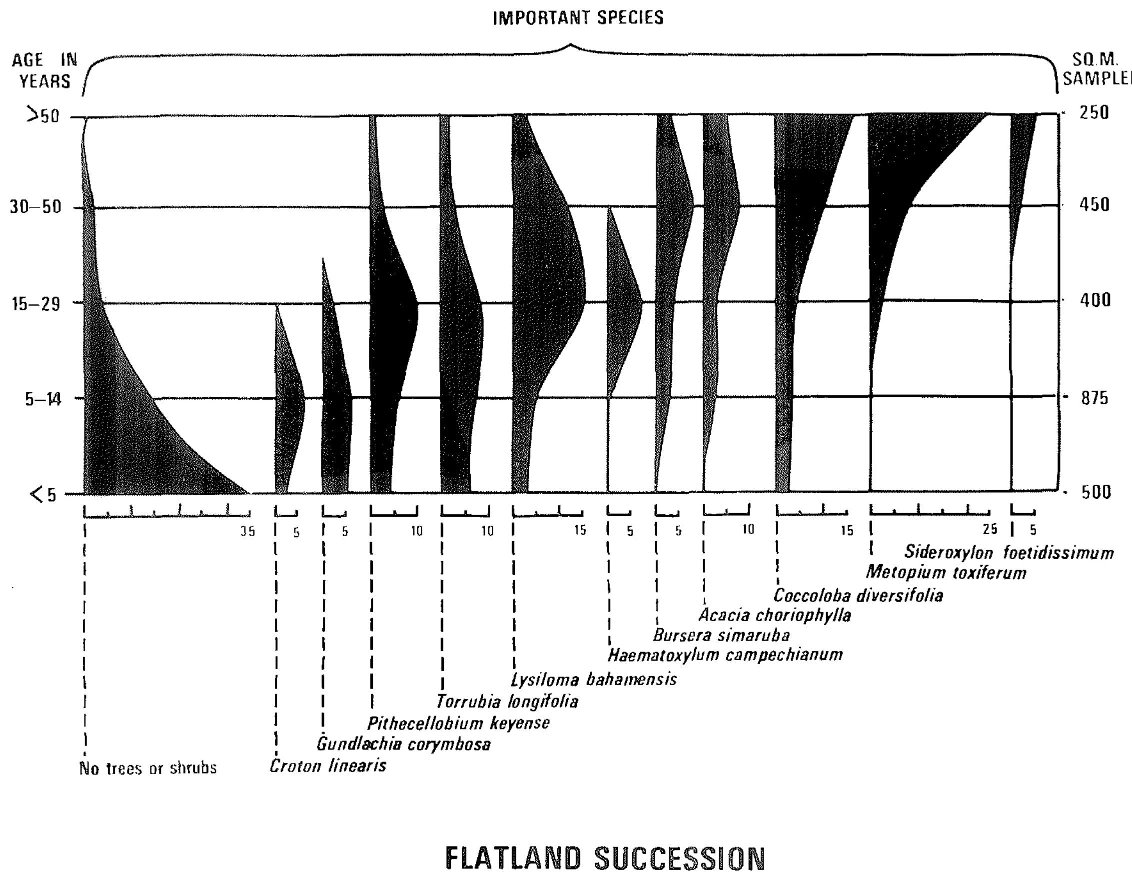
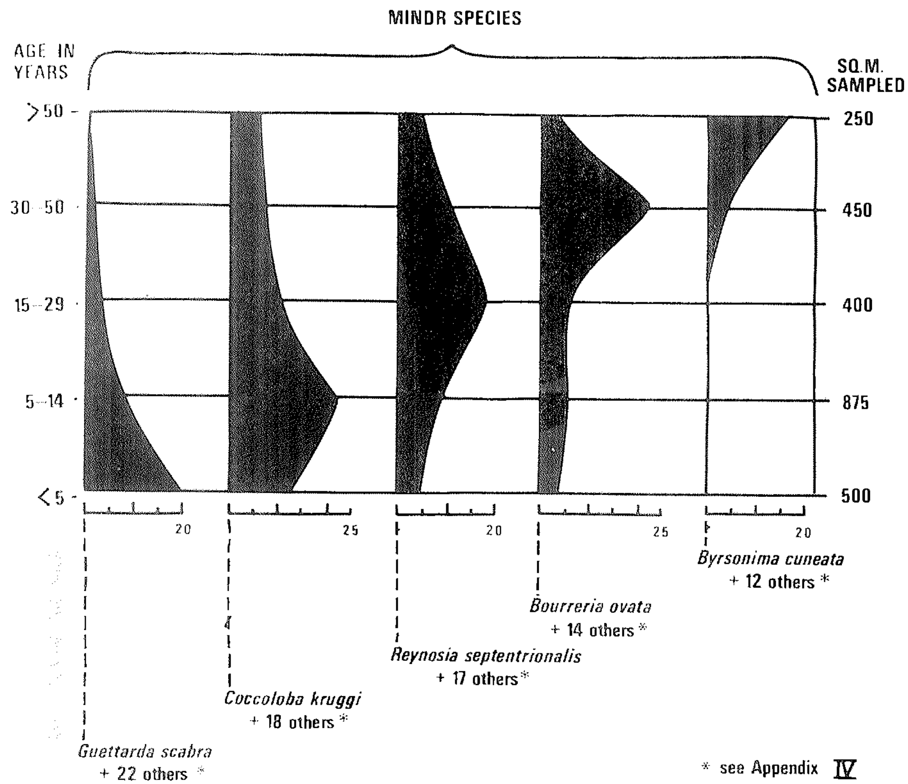


Figure 28A. Flatland Succession Diagram (important species)



FLATLAND SUCCESSION

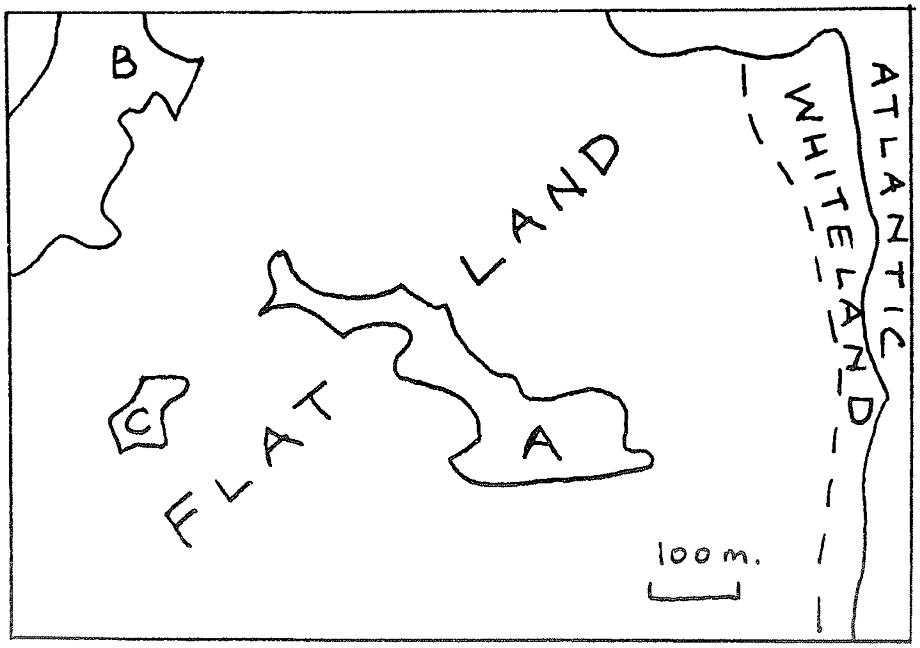
Figure 28B. Flatland Succession Diagram (minor species) means that recovery after clearing and burning is slow. As can be seen in Figure 28A, just over 34 percent of the ground in fields abandoned less than 5 years ago was bare of trees or shrubs, a slightly higher percentage than on the whiteland.

Even more important is the greater floristic diversity of the flatland. Although the number of important species is the same as on the whiteland, together they account for a much smaller percentage of the total cover. The balance is made up by 88 minor species (Figure 28B). Again, it is obviously impractical to deal individually with the minor species. The discussion that follows therefore deals largely with the dominants..

Croton linearis and Gundlachia corymbosa are the only two important species to reach their maximum cover values in the first or second age-classes. Croton linearis is a small, narrow-leaved member of the spurge family. It is not a prolific seed producer and relies primarily on birds as a means of dispersal. It grows naturally in exposed areas, for example, behind the coast, above the salt-water lagoons, and around the edges of the seasonally-flooded savanna. From these naturally droughty habitats it has invaded the recently-abandoned flatland fields. It also grows on the whiteland and blackland, but reaches its maximum cover value on the flatland.

As Figure 28A indicates, Gundlachia is clearly less important on the flatland than on the whiteland. Increased competition may be the reason for this, although environmental differences between the two habitats could also be important. Even so, Gundlachia's age distribution is much the same on the flatland as on the whiteland. Like Croton linearis, it is a typical pioneer species.

In the third age-class (15-29 years), four important species reach their maximum cover values: Pithecellobium keyense, Torrubia longifolia, Lysiloma bahamensis, and the introduced dyewood Haematoxylum compechianum. Together they account for 40 percent of the total area sampled. Pithecellobium and Torrubia have very similar cover values in each age-class and presumably have similar ecological tolerances. Lysiloma bahamensis is a common species on the flatland. A fast-growing leguminous tree, it is well-adapted to rather droughty conditions. It has extensive, horizontal roots that run along the level limestone surface. According to Britton and Millspaugh (1920: 158), in some areas of the Bahamas it may reach 16 meters in height. On Cat Island, however, it was rarely seen to be more than 10 meters tall. It reproduces vigorously by sprouts, and is also a prolific



Figures 29 and 30 show a time-lapse sequence for a representative flatland area just south of Flamingo Point. This is a particularly interesting area in that it has been relatively undisturbed. It has been protected by inaccessibility, the nearest settlement being 5 kilomenters away. The low elevation of the flatland here is indicated by the salt-water marsh at A.

In spite of the obvious differences in the quality of the photographs, their tonal variation gives a good indication of the rate of recovery. The dark area on Figure 29 represents woodland that was probably over a hundred years old. The light grey tones around its edges indicate recent clearing. Some of these fields were abandoned shortly after 1943 because their outlines are still visible on the 1958 photograph (B). However, their tonal appearance is different; on the 1943 photograph they are light grey, on the 1958 photograph medium grey. This tonal change suggests that medium grey areas on the 1943 photograph were probably cleared around 1930.

Another point to note is that small fields tend to recover more rapidly than large fields. This can be seen by comparing B and C on both photographs. The reasons for this are undoubtedly complex but probably involve seedling supply and microclimatic differences. In general the flatland fields appear to recover more quickly than the whiteland fields, recently cleared fields on the 1943 photograph being rarely visible in 1958.

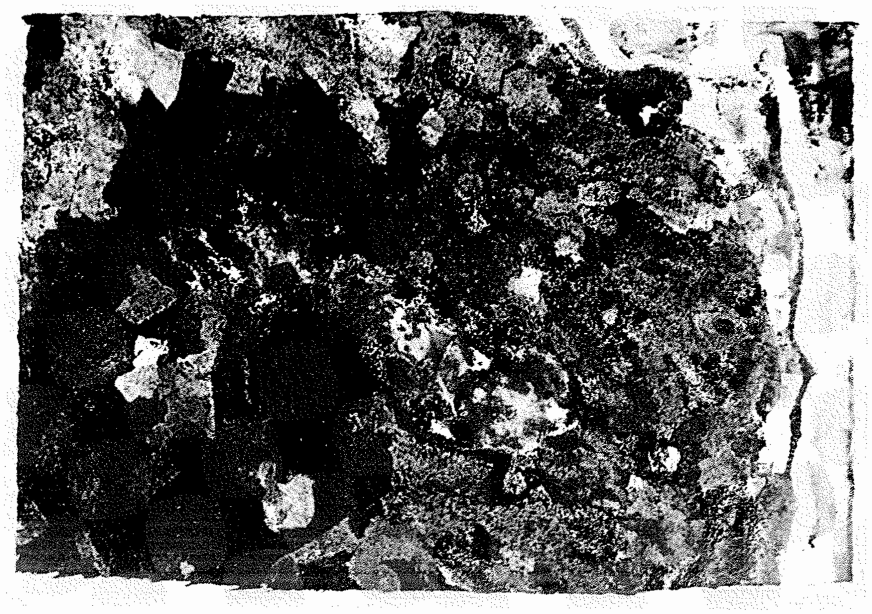


Figure 29. Flatland, Flamingo Point 1943.

Figure 30. Flatland, Flamingo Point 1958.

seed-producer. Its pods are dehiscent, the small dark brown seeds being widely dispersed by the wind. In the intermediate-age fields it effectively replaces the pioneer bushes, such as Gundlachia and Croton linearis. After thirty years, however, it in turn is replaced by other species (Figure 28A). The introduced dyewood, Haematoxylum campechianum, accounts for just over 5 percent of the cover in the intermediate age-class. Surprisingly, it is the only alien among the 11 important species in this habitat-type.

In the penultimate age-class (30 to 50 years), two important species reach their maximum cover values: Bursera simaruba and Acacia choriophylla. Bursera is a rapidly-growing tree, easily distinguished by its birch-like bark. Like many of the woodland species, it fruits prolifically and reproduces vigorously from sprouts. These characteristics have made it an important species in the woodland. As Figure 28A shows, both Bursera simaruba and Acacia choriophylla have similar age distributions. Had the area sampled on the whiteland been greater, the same would probably be true in Figure 25A. Both species have similar ecological tolerances.

In the oldest age-class (greater than 50 years), Coccoloba diversifolia and Metopium toxiferum emerge as dominants, accounting together for 45 percent of the total area sampled. Sideroxylon foetidissimum also reaches its highest value, accounting for just over 5 percent of the total. Coccoloba diversifolia is an erect fast-growing tree. On Cat Island it was rarely seen to be more than 10 meters tall. As a prolific seed-producer and efficient sprouter it is well-adapted to colonising abandoned fields. It was encountered in all age-classes on the flatland (Figure 28A). Its importance in the older woodland can probably be attributed to its ability to outgrow the more widely-branching species such as Lysiloma bahamensis, Bursera simaruba, and Acacia choriophylla. The same is probably true of Metopium toxiferum. Like the pigeon plum, Metopium is an erect fast-growing tree. It also fruits prolifically, with birds being the main means of dispersal. Unlike the pigeon plum, it was not encountered in the recently-abandoned fields. Its absence suggests that it needs a certain amount of shade in order to become established. It is also a less efficient sprouter than Coccoloba. Sideroxylon foetidissimum is clearly restricted to the older woodland. According to Britton and Millspaugh (1920: 321), it grows to 25 meters in some parts of the Bahamas. On Cat Island, however, it was never seen to be more than 12 meters tall. This valuable timber tree has been selectively cut and is probably less important now than it was in the pre-European period.

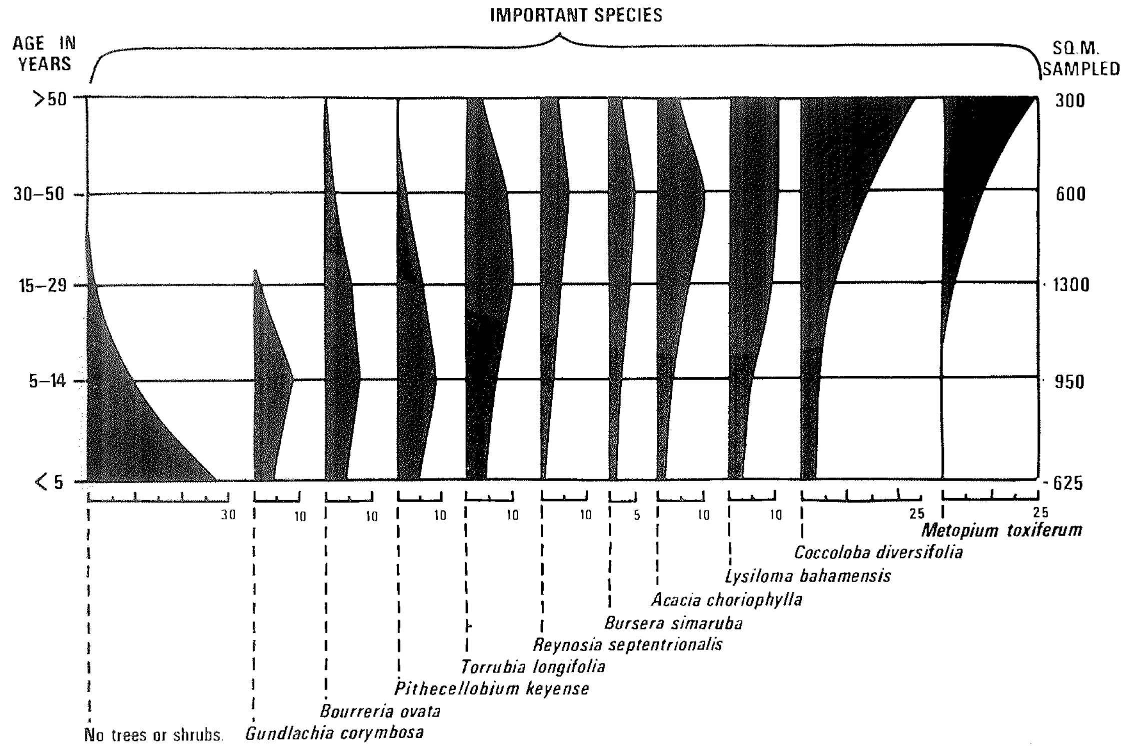
As far as the minor species are concerned, it can only be emphasized that they account for a large percentage of the total cover, over 40 percent in most age-classes. Their collective age distributions in Figure 28B are interesting in that they suggest that many of the species are present in several age-classes. Only the species reaching their maximum cover values in the older woodland have a limited age distribution. As might be expected, these are sensitive species, intolerant of the open, droughty conditions that characterize the recently-abandoned fields. Figures 29 and 30 show representative time-lapse sequences for the flatland.

The Blackland

The blackland differs from the flatland in that the limestone surface is broken and irregular. Soil erosion is therefore reduced and colonization by plants is facilitated. This is shown in the "no trees and shrubs" curve in Figure 31A. In every age-class, the area of bare ground is proportionally lower for the blackland than for the flatland. In fact, the rapidity with which succession takes place is an important reason for the early abandonment of fields on the blackland. The blackland is also floristically diverse. A total of 105 different species was encountered in the sampling, only 10 of which reached 5 percent in any one age-class.

The youngest age-class (less than 5 years) is particularly diverse. Although no important species reaches its maximum cover value here, 30 minor species do. In the second age-class (5 to 14 years), Gundlachia corymbosa, Bourreria ovata, and Pithecellobium keyense reach their maximum cover values. Of these, only Gundlachia is restricted to the younger age-classes. As on the whiteland and flatland, it was not encountered in woodland over 30 years old.

Bourreria ovata is a small tree or shrub, rarely more than 5 meters tall. It grows naturally in droughty areas close to the coast and near the salt-water lagoons; from here it has spread into the abandoned fields. Its bright red fruits are primarily dispersed by birds. It also sprouts vigorously, and because of this is commonly encountered in the recently-abandoned fields. Pithecellobium keyense has almost the same age-distribution as Bourreria. Unlike the situation on the whiteland, where it reaches its maximum cover value in the oldest age-class (more than 50 years), here it has its maximum in age-class 2 (5 to 14 years). This illustrates well the basic difference between the xeric whiteland habitat and the more mesic blackland.



BLACKLAND SUCCESSION

Figure 31A. Blackland Succession Diagram (important species)

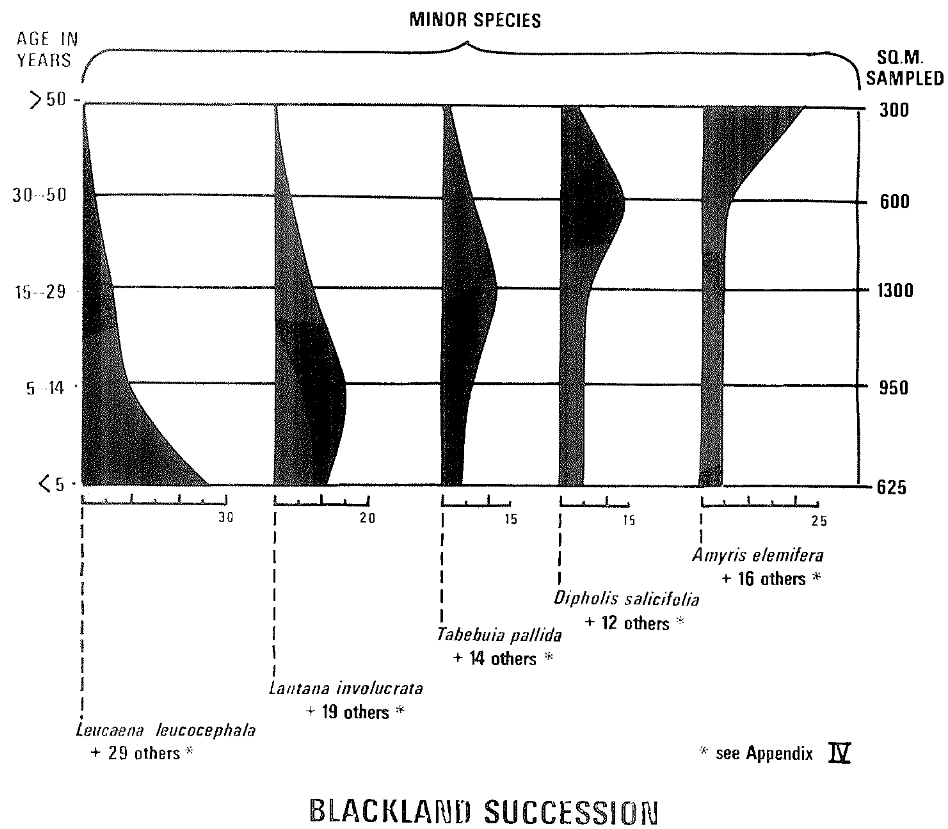
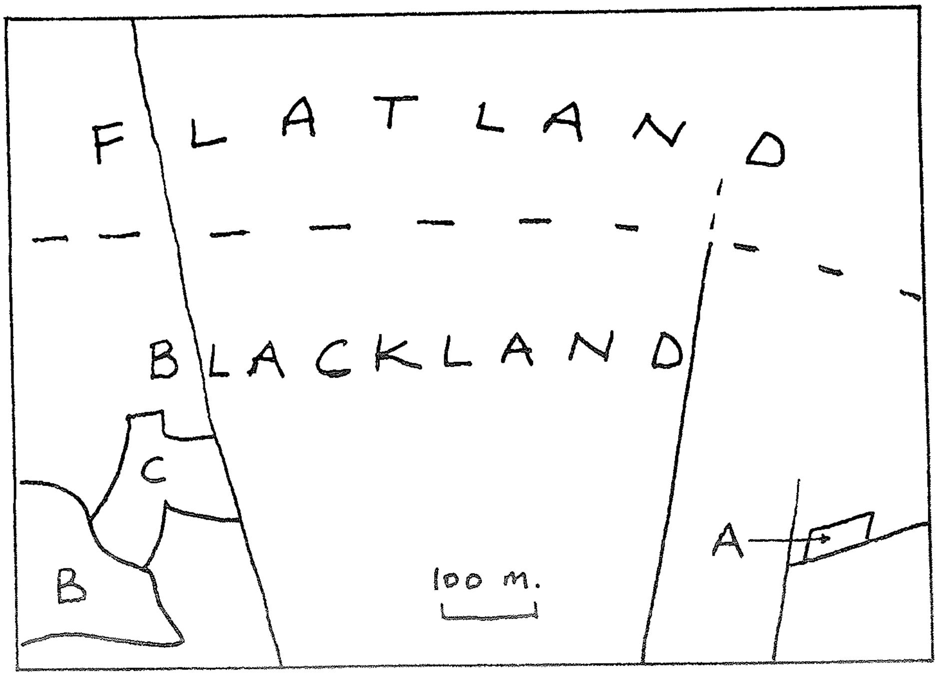


Figure 31B. Blackland Succession Diagram (minor species)



Figures 32 and 33 show a time lapse sequence for a representative blackland area near Dumfries. Unlike the whiteland and flatland sequences discussed earlier, there was no decrease in cultivation here between the years 1943 and 1958. The reason for this was probably accessibility. The settlement of Dumfries is only half a kilometer away to the west.

Again the tonal variation between the two photgraphs gives a good idea of the age of the woodland. Only a small area appears dark on both photographs, as for example at A. The dark area in the lower left part of the photographs (B) is an area of red mangrove around the Dumfries Blue Hole. Dark areas such as A were probably at least 50 years old in 1958.

Again the change from light grey to medium grey, as for example at C, indicates the rate of recovery. By analogy it seems likely that the medium grey areas on the earlier photograph were cleared around 15 years before to 1943.

For the area as a whole it is interesting to note that such a large proportion (more than 75 percent) of the woodland shows evidence of having been cleared within the time span covered by the two photographs. On the other hand the rate of recovery is obviously rapid. Few recently cleared fields on the 1943 photograph are visible on the 1958 photograph.

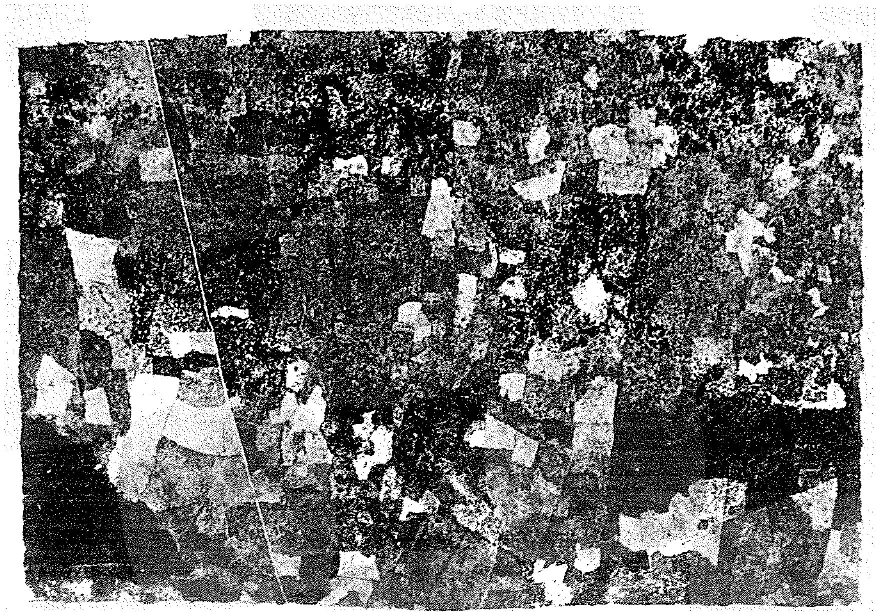
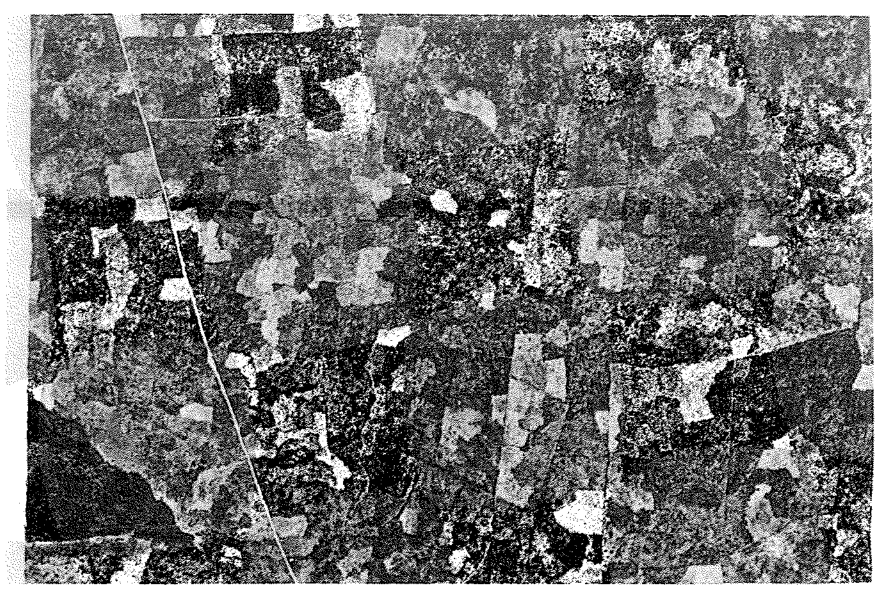


Figure 32. Aerial Photograph of Blackland, 1943

Figure 33. Aerial Photograph of Blackland, 1958



The same is true of Torrubia longifolia. On the whiteland Torrubia reaches its maximum cover value in the oldest age-class (more than 50 years), while on the blackland it has its maximum in the intermediate class (15 to 29 years).

In the penultimate age-class (30 to 50 years) , Reynosia septentrionalis, Bursera simaruba, and Acacia choriophylla reach their maximum cover values. All three have been discussed above and therefore need little additional comment here. It is interesting to note, however, that Bursera and Acacia have very similar age distributions. This reinforces the conclusion reached earlier that both species have similar ecological tolerances.

In the oldest age-class (more than 50 years), Lysiloma bahamensis, Coccoloba diversifolia, and Metopium toxiferum all reach their maximum cover values, and together account for 55 percent of the total cover. Lysiloma appears to be more persistent on the blackland than on the flatland, although why this should be so is not immediately apparent. Metopium and Coccoloba have very similar age-distributions in both habitat-types.

As far as the minor species are concerned, the obvious conclusion is that the woodland is floristically diverse in all age-classes (Figure 31B). The implications of this are discussed below. Figures 32 and 33 show representative time-lapse sequences for the blackland.

The Woodland as a Whole

The old field data show quite clearly that there are important differences in the nature of succession in the three habitat types. Two of the variables measured, height and floristic diversity, are shown in Figure 34. The whiteland is clearly distinctive. Compared with with the flatland and blackland it is floristically impoverished. An average of less than 7 species were encountered in each field sampled, regardless of age. Furthermore, only 12 species accounted for more than 75 percent of the total cover (Figure 25A). The whiteland is also different in that its rate of recovery after clearing and burning is relatively slow. This can be seen from the aerial photographs and also from the fact that pioneer species, such as Gundlachia corymbosa, Leucaena leucocephala and Corchorus hirsutus are more important and more persistent on the whiteland than elsewhere. Similarly, those species that are characteristic of the older whiteland fields, such as Torrubia longifolia, Reynosia septentrionalis, Erithalis fruticosa, and Pithecellobium keyense, all reach their maximum cover values in intermediate-aged fields in the rest of the woodland. There is no equivalent on the whiteland to the "highwood" that characterizes the older woodland elsewhere on the island. This pioneer aspect of the whiteland probably reflects the inherent instability of the habitat.

The whiteland vegetation is also distinctive in its generally shrubby nature. Even the older trees were on the average less than 4 meters tall (Figure 34). The stunted aspect of the vegetation is probably in large part due to its exposed location near the coast. Other physiognomic variables were not recorded, but it is probably correct to say that there is a higher percentage of evergreens on the whiteland then elsewhere.

Floristically there are no major differences between the whiteland and the rest of the woodland. A few species, such as Casasia clusiaefolia, Scaevola plumierii, and Coccothrinax argentea, are restricted to the whiteland; however, most species, are found in all three habitat-types. Differences between the the flatland and blackland are less clear. In terms of floristic diversity, the number of species encountered was, on the average, slightly higher on the blackland than on the flatland, especially in the younger age-classes (Figure 34).

The rate of recovery, at least in the earlier stages of succession, appears to be more rapid on the blackland than on the flatland. This can be seen when one compares the aerial photograph sequences (Figures 29, 30; Figures 32, 33) and when one compares the "no trees and shrubs" curves on Figures 28 and 31. Vegetation recovers more quickly on the blackland than on the flatland, for several reasons. The surface of the limestone is more broken, which means less soil erosion and a generally more mesic edaphic situation. The broken surface also reduces the severity of fire, and therefore increases the frequency of sprouting. All of this is probably responsible for the greater floristic diversity of the blackland and the greater height of the vegetation in any particular age class.

As far as the individual species are concerned, there are few major differences between the two habitat-types. Perhaps the most significant is the greater importance of Lysiloma bahamensisand Haematoxylum campechianum on the flatland. This may be a result of more droughty conditions on the flatland. The fact that the curves for individual species are generally smoother for the blackland than for the other two habitat-types is probably a reflection of differences in the area sampled in each case. The smoothness of the blackland curves is reassuring, in that it

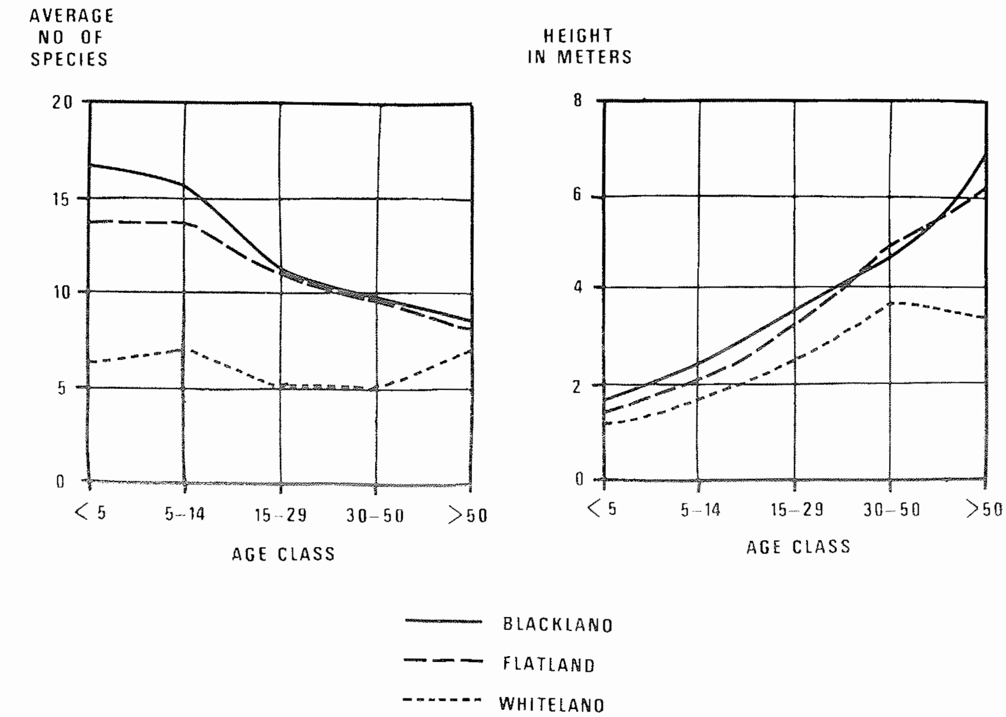


Figure 34. Graphs showing Diversity and Height against Age, for each Habitat Type

suggests that real processes are represented.

Taking the woodland as a whole it is probably fair to say that the whiteland is quite distinctive in all the age-classes, whereas the differences between the flatland and blackland are only significant in the younger and intermediate age-classes.

The Nature of Recovery

In view of the supposed vulnerability of insular vegetation the old field data are in many respects surprising.

Perhaps the most striking characteristic of the woodland is the speed with which it recovers. As can be seen from the aerial photograph sequences, fields recently cleared in 1943 were barely visible in 1958. Although there are some exceptions (on the whiteland and in exposed areas), elsewhere woody plants very quickly colonize the limestone surface. The woodland is in fact inherently weedy. This is also shown, at least for the flatland and blackland, by the way in which most of the important species are encountered in every age-class. In other words, the recovery of the woodland does not involve the classical succession of species, each replacing the other, but rather a change in the area covered by species already present. Even the older woodland consists, for the most part, of species that are capable of colonizing recently-abandoned fields.

It is interesting to speculate whether this weediness is in itself a result of repeated clearing and burning by man with species pre-adapted to this type of disturbance having increased at the expense of the more sensitive types. Whether or not this has actually happened is impossible to determine without evidence of the composition of the pre-settlement vegetation. Fortunately, the problem can be approached indirectly. In the following section, areal variation in floristic composition is used as a clue to determine to what extent man has modified the woodland.

Another surprising aspect of the old field data is the great number of native species present in the recently abandoned fields. According to the hypothesis of insular vulnerability, very few native species would be expected to have adapted to the artificial habitats created by shifting agriculture. Yet on Cat Island, particularly on the flatland and blackland, literally dozens of native species are involved in the early stages of succession. Furthermore, the number of species encountered actually declines with age (Figure 34). This decrease in species diversity is the opposite of what usually occurs in the early stages of succession (Loucks, 1970: 17; Odum, 1971: 256). In part, it must be admitted, it may be an artifact of the constant area sampled. Fewer species were encountered in the older woodland because the larger trees took up a greater proportion of the area sampled. Even so, it is generally true that the older woodland contained fewer species than the younger woodland. As can be seen from Figures 28 and 31, two species, *Metopium toxiferum* and *Coccoloba diversifolia*, dominate the older woodland.

Again, it is interesting to speculate whether this floristic impoverishment is in itself a result of repeated clearing and burning and that slow-growing, shade-tolerant species were formerly more numerous in the woodland than they are today. This possibility is also considered in the following section.

Another significant aspect of the old field data is the limited importance of alien species. Only seven aliens were encountered, and together they accounted for less than 6 percent of the area sampled. This low total was not entirely unexpected in view of the historical evidence discussed earlier, but even so it does not conform with the usual role of alien plants on small oceanic islands. According to several recent interpretations of insular vulnerability (Elton, 1958; Harris, 1965), alien plants have a competitive advantage over native species in vegetation that has been disturbed by man. The whole of the Cat Island woodland has been drastically disturbed during the past thousand years, and yet few aliens have been able to get established.

In summary, the analysis of age-differences in the woodland has produced several results. First, the rate of recovery after clearing and burning has been shown to be surprisingly rapid. Second, the data indicate that a great many native species are pre-adapted to withstand the effects of clearing and burning. And third, the invasion by alien species has had only limited success. In view of the supposed vulnerability of island life all three findings were unexpected.

X. THE IMPACT OF SELECTIVE PRESSURES: AREAL VARIATION IN THE WOODLAND

On many small islands, woody vegetation has been virtually removed by grazing, selective cutting, and burning. On Cat Island this has not been the case. The woodland has survived. Even so, the question remains as to what extent its floristic composition has been changed. As was emphasized, the data gathered in 1970 show the nature of vegetation change in an indirect way. Comparative analysis of abandoned fields of different ages indicates the probable nature of succession, but it does not show the actual changes that have occurred in a truly historical sense. These can only be determined from historical evidence, and for Cat Island the historical evidence is frustratingly thin. In spite of this deficiency, the question as to what extent man has changed the floristic composition of the woodland can be approached in other ways.

One approach would be to monitor future changes. If the frequency of shifting agriculture continues to decrease, it would seem likely that those species sensitive to clearing and burning will increase in importance at the expense of the weedy types. Just how long it would take the woodland to recover to its pre-settlement condition is difficult to assess. Recovery at present may be rapid, but it is by no means complete.

A second approach would be to analyse the areal variation within the contemporary woodland. More specifically, by comparing disturbed areas close to the settlements with remote, comparatively undisturbed areas, it should be possible to determine something of the selective nature of man's impact. This was the approach taken in the present study.

As was indicated earlier, the intensity of many selective pressures decreases with distance from the settlements. Because of this, each of the 300 sample sites was classified in terms of its distance from the nearest settlement, so that the nature of floristic variation with distance could be computed. In order to simplify the analysis, the 42 whiteland sites were not included. Their floristic composition is so different from the rest of the woodland that to include them would have introduced too many uncontrolled variables. On the other hand, as the blackland and flatland had been shown to be floristically similar in the age- variation analysis, they were combined in this part of the study. The resulting 258 sample sites were classified, both as to age and to distance from the nearest settlement.

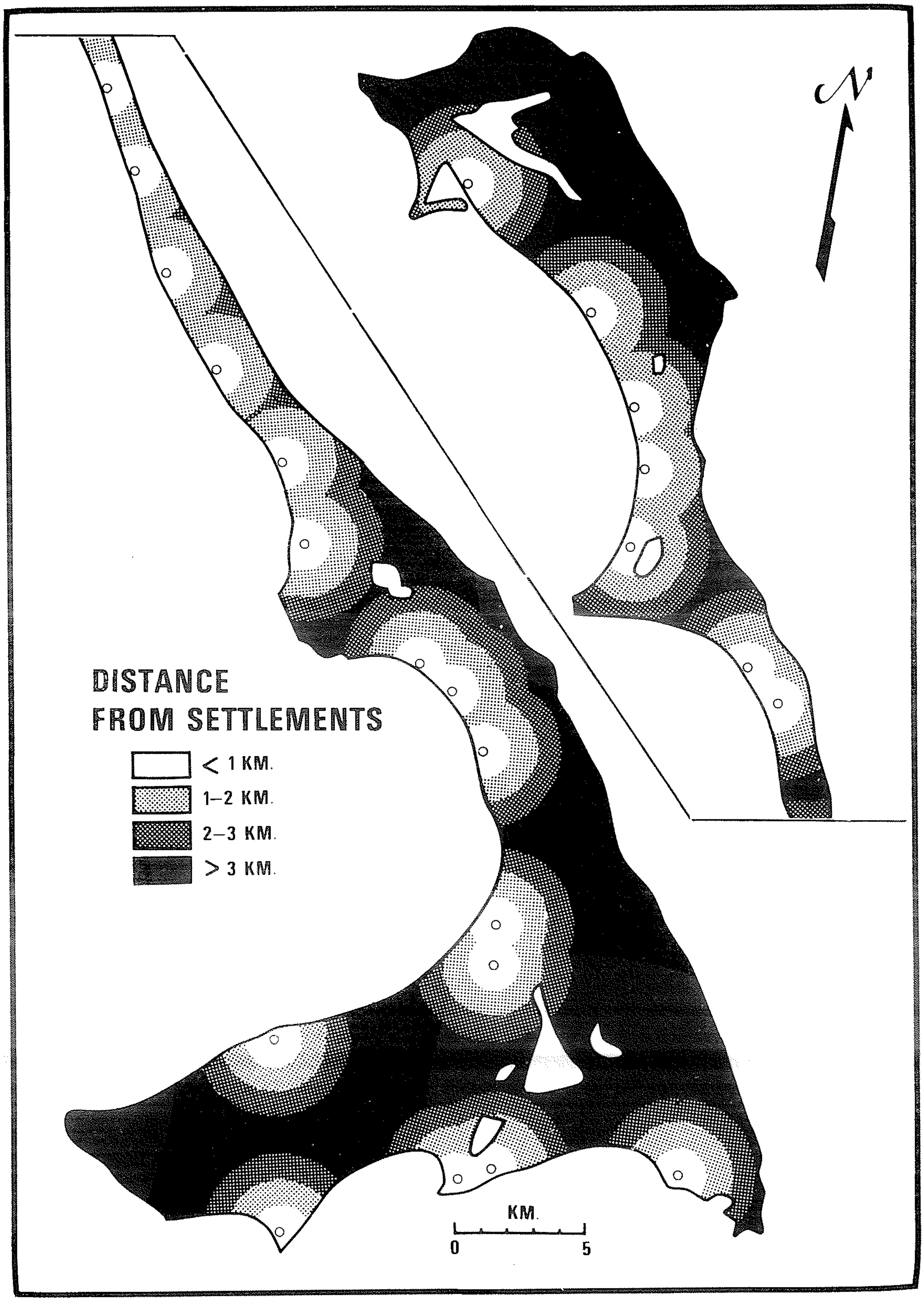


Figure 35. Map showing Distribution of Distance Classes

After initial analysis, it became clear that the fifth age-class (more than 50 years), and the fifth and sixth distance-classes (4 to 5 kilometers; 5 to 6 kilometers) did not have adequate sample coverage to make reliable interpretation possible. They were therefore combined with the fourth age-class and fourth distance-class, respectively. The areal distribution of the four distance-classes is shown in Figure 35.

Goats and the Woodland

Grazing and browsing by domesticated animals have drastically changed the vegetation of many parts of the world. Especially significant have been the changes brought about on small oceanic islands where native plants have evolved without defensive mechanisms against such pressures. On Cat Island, horses, hogs, sheep, cattle, and goats have all had an impact on the woodland. For several reasons, however, it was decided to limit the analysis to a study of the effects of grazing and browsing by goats.

Initial observations in the field suggested that of all the domesticates on the island, goats had probably had the most important influence on the floristic composition of the woodland. They were the most numerous domesticate, and unlike sheep, cattle, and horses, which only browse under duress, they are quite happy to eat the leaves of bushes and trees. They prefer young leaves, shoots, or seedlings, and in this way influence regeneration rates. A recently-grazed area has a characteristically "clean" appearance, the surface having been stripped of all herbaceous growth and seedlings (Figures 36, 37).

In order to determine the extent to which goats had modified the woodland, a working hypothesis was proferred. It was assumed that palatable species would be rarer close to the settlements than in remote areas, while the opposite would be true of unpalatable species. The first problem, then was to determine which species were palatable and which were unpalatable.

Palatable and unpalatable species.

Contrary to popular opinion, goats do have discriminating palates; some species they prefer and others they avoid. In order to determine these preferences, two approaches were used. First, local inhabitants, experienced in agricultural matters, were interviewed on the subject of goat-feeding habits. In this way, a basic check-list of preferred and

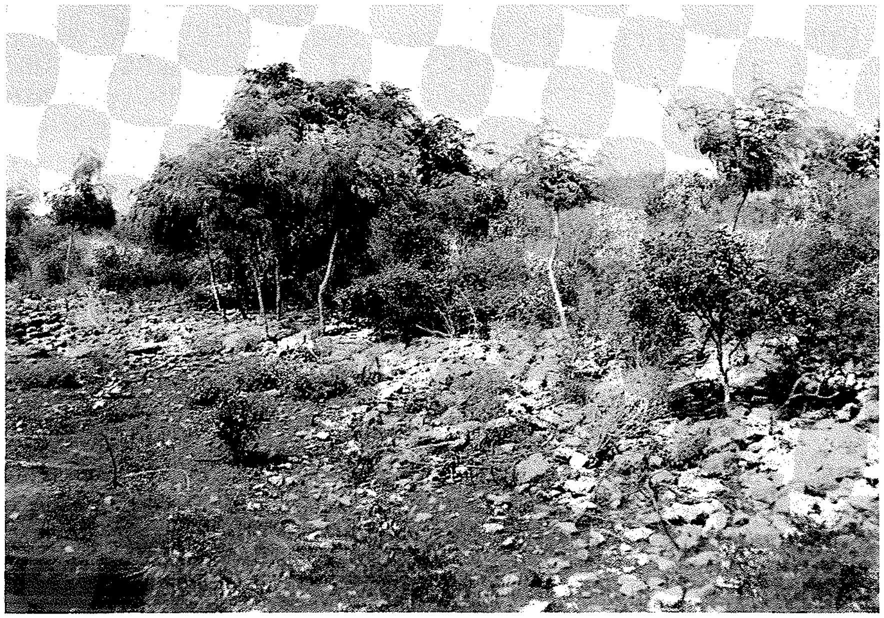


Figure 36. An area near Bennet's Harbour intensively grazed by goats. Note the Leucaena bushes in the center of the photograph have been browsed to a height of about one and a half meters. The other bushes in the foreground, Cassia bahamensis, are unpalatable to goats.

Figure 37. Another heavily grazed area near Bennet's Harbour. Cassia bahamensis is very common on the level ground where virtually no herbaceous growth has survived.

avoided species was set up. Second, the reliability of this information was checked by offering the species in question to hungry goats. Perhaps significantly, only five common woodland species were found that the goats really like to eat (Table 5). In contrast, 18 species were found that even hungry goats refused to eat (Table 5). Most of the unpalatable species have strongly aromatic or poisonous leaves, the spurge, legume, and myrtle families being well represented.

Floristic composition and distance.

Because of the cost of wire, there are few fenced pastures on the island, and as a result the goats have to be tethered. This is necessary because of the threat they pose to crops, and in turn means they have to be tended at least once every other day. The goats quickly exhaust the accessible food supply and have to be moved to new areas. Also, they have to be watered because of the lack of surface water. Because they have to be tended so frequently, the local people are reluctant to tether them too far from home, and consequently the intensity of grazing pressure decreases as a function of distance from the settlements.

In order to determine to what extent grazing and browsing had changed the woodland, the percentage cover values for the palatable and unpalatable species were calculated at the different distances from the settlements. The resulting graphs are shown as Figure 38. Originally it was intended to calculate the percentage cover values for each individual species, but for the sake of simplicity they are presented here as two groups.

Reassuringly, the cover values show that, with a few exceptions, there is a positive relationship between palatability and distance, and a negative relationship between unpalatability and distance. Furthermore, the species included account for about 60 percent of the total area sampled, so the curves can be taken as representative of the woodland as a whole.

In the youngest fields it is interesting to note that the palatable species are less important than they are in the older age-classes. This is probably due to the custom of tethering goats in recently-abandoned fields. Just why the unpalatable species are also less important is not easy to explain. It may simply be due to the fact that such a great number of species, not included in either group, are present in the recently-abandoned fields. In spite of their low values, the two curves show very nicely the expected relationship between grazing pressure and distance.

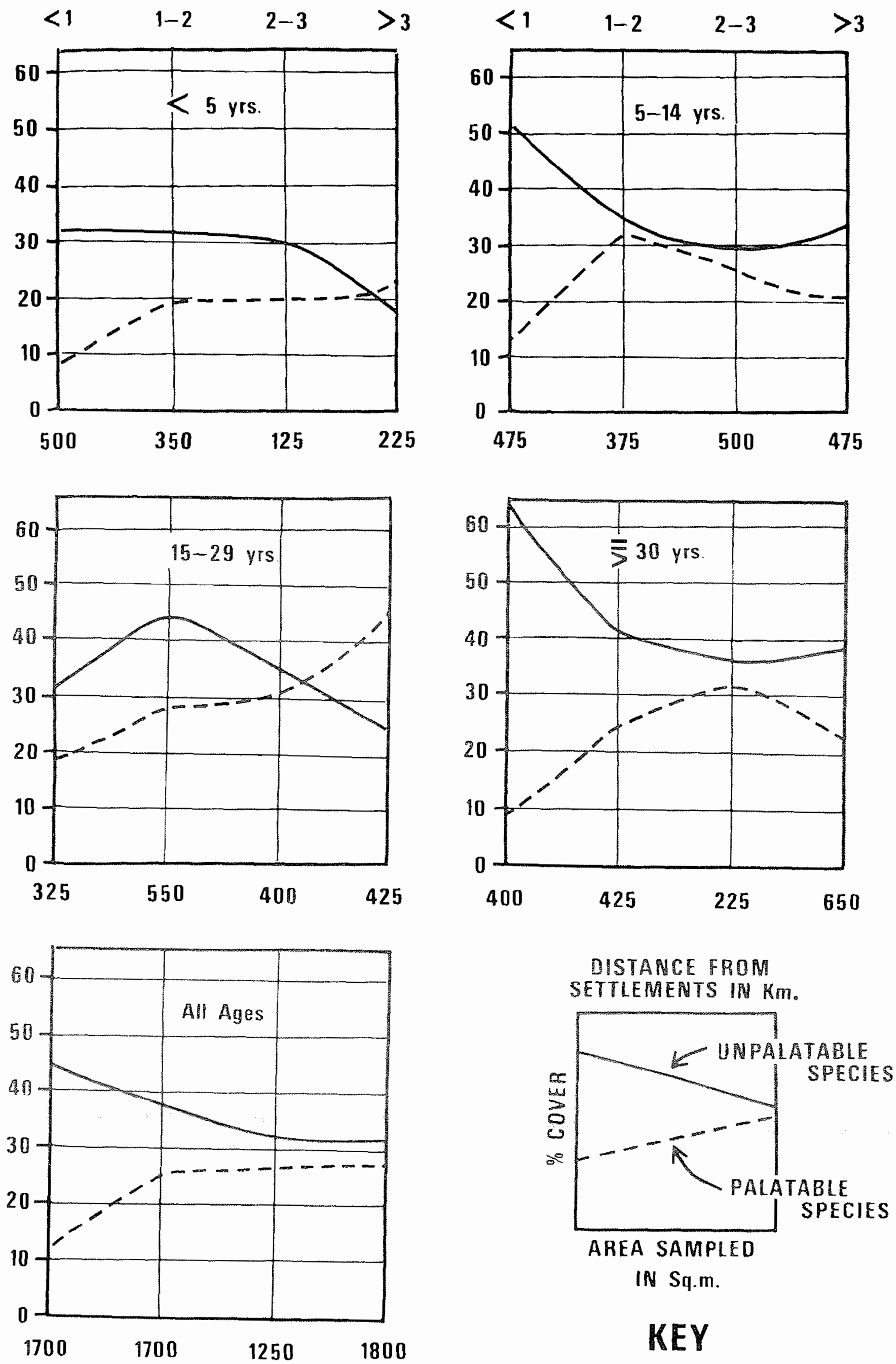


Figure 38. Graphs showing Age/Distance Unpalatable Species

TABLE 5

SPECIES INCLUDED IN THE ANALYSIS OF BROWSING BY GOATS

Palatable Species

1. Torrubia longifolia
2. Acacia choriophylla
3. Leucaena leucocephala
4. Bursera simaruba
5. Pithecellobium keyense

Unpalatable Species

1. Corchorus hirsutus
2. Lantana bahamensis
3. Croton linearis
4. Gundlachia corymbosa
5. Croton bahamensis
6. Coccoloba diversifolia
7. Metopium toxiferum
8. Exostema caribaeum
9. Lantana involucrata
10. Cassia bahamensis
11. Eugenia buxifolia
12. Eugenia monticola
13. Bourreria ovata
14. Croton eluteria
15. Malphigia polytricha
16. Lysiloma bahamensis
17. Piscida piscipula
18. Croton lucidus

In the second age-class, the sample-sites less than 1 kilometer from the settlements show very definitely the expected relationship, with unpalatable species being roughly four times more important than palatable species.

However, at distances of more than 2 kilometers, the unpalatable species show an unexpected decline, and after 3 kilometers increase again. No obvious explanation can be offered for these changes, other than that some other variable besides grazing pressure is involved.

Similarly, in the third age-class the percentage value for the palatable species is anomalously low in the sites closest to the settlements. This may reflect a somewhat lower sample coverage in this category, although just how is not clear. For the more distant sample sites, the curves behave as expected, and suggest that the impact of grazing is restricted to within 3 kilometers of the settlements.

For the older sample sites the curves show very well the expected relationship in the first three distance categories. Only in the more remote fields does the curve for the palatable species drop unexpectedly. Again, this must be attributed to some variable other than grazing pressure, possibly increased competition from species not included in the two groups, conceivably from species that for other reasons are more important in remote areas, such as economically-valuable species or species sensitive to clearing and burning.

When all the different age-classes are combined, it is interesting to note that the irregularities average out. The resultant curves show a nice symmetrical arrangement, which suggests that the impact of grazing is restricted to within a zone less than three kilometers from the settlements. At distances of more than three kilometers the average cover for the two groups is more or less constant.

The implications of the data.

The first point to be made is that the working hypothesis was proved to be valid. Palatable species are rarer in heavily grazed areas than in lightly-grazed areas, while the reverse is true of unpalatable species. This apparently obvious relationship was not immediatedly apparent in the field, and only became clear after the analysis of the data.

Also significant is the extent to which grazing and browsing have modified the compostion of the woodland. The woodland close to the settlements might be aptly described as "goat-proof." Also, the fact that so many unpalatable species could be identified in contrast to so few palatable species was probably not fortuitous. Palatable species have undoubtedly become rarer in the woodland around the settlements. Whether or not this has actually happened cannot be proved without historical evidence, but in view of the data presented above, it seems more than likely that this has been the case. Certainly if the goat population declines it will be interesting to see how the woodland recovers.

It is also interesting that grazing pressure is restricted to a zone within 3 kilometers of the settlements. This confirms the qualitative impression obtained in the field, few goats being seen beyond this distance. On the same point, it should be noted that just over two-thirds of the sites sampled in the old field study fall within the 3-kilometer limit. It follows, therefore, that the composition of the woodland as described in Chapter 8 has to a large extent been determined by the goat.

The differences in the cover values between the different age-classes strongly suggest that the intensity of grazing had varied in the past. For example, the palatable species are generally more important in the 15- to 30-year age-class than in any other age-class, even in the sample sites more than 3 kilometers from the settlements. The possibility exists that the goat population was low during this time period, although no local information was obtained which suggested this had been the case.

The complicated nature of the data makes it difficult to evaluate as far as individual species are concerned. It is interesting to note, however, that the two dominants in the older woodland, *Coccoloba diversifolia* and *Metopium toxiferum*, have very different cover values in the oldest age-class. Even though both species are unpalatable, the former decreases in importance away from the settlements while the latter increases. Obviously some variable other than grazing determines the importance of *Metopium*. For *Coccoloba* it seems safe to assume that unpalatability is in large part responsible for its variable importance in the woodland.

Other Domesticates

The goat is probably not entirely to blame for the changes described above. Sheep, horses, hogs, and cattle have all exerted selective pressures on the woodland, although in each case the pressure has been different. Sheep, for example, prefer herbs, and will only browse reluctantly. Similarly, cattle and horses usually graze on the whiteland, or seasonally-flooded savanna, and only browse in the woodland during the dry season. Furthermore, the number of woody species that horses find palatable is limited. The leaves and pods of the leguminous shrub *Leucaena leucocephala*, that provide preferred feed for goats cause horses to lose their hair and even hooves (Little and Wadsworth, 1964). Hogs have had an indirect impact on the woodland insofar as the fruits and young leaves of several palms are gathered for hog feed. *Pseudophoenix* is known locally as the "Hog-cabbage palm," and is now rare in the woodland close to the settlements. There were no feral hogs on Cat Island in 1970, although they were reported to have been common in the past.

Selective Cutting

Of all the pressures that man has exerted on the woodland, selective cutting was the easiest to define. Most of the species involved were identified in the historical record, and those that were not were determined on the basis of local information. Out of the 120 species encountered in the sampling, 15 were known to have been selectively cut on such a scale that their frequency in the woodland was probably affected. These consist of dyewoods, timber trees, and species valued for fuel or fodder (Table 6). The details of their use were discussed earlier and need not be repeated here. Suffice it to say that their value to man has made them vulnerable.

The selective cutting of economically valuable or useful species is basically a similar process to the grazing and browsing of domesticated animals. The species that are cut decline in importance, while the species that have no value increase to take their place. However, in the discussion that follows, only the former are included, as the increase in species that are not cut was less amenable to analysis than was the increase in unpalatable species. More specifically, it was impossible to determine which species increased at the expense of those that were selectively cut. Originally it was intended to deal with each of the economically valuable species individually; however, because of the limitations of time and space, they are here considered collectively.

Selective Cutting and Distance

There are few roads on the island, and any heavy loads have to be carried by horses. Lighter loads are carried in traditional African style, on the head. Either way, the frictional effect of distance is strong, and as a result remote areas of the woodland have been comparatively undisturbed. During field work this was recognized in a

TABLE 6

SPECIES INCLUDED IN THE ANALYSIS OF SELECTIVE CUTTING

1. *Caesalpinia bahamensis*
2. *Haematoxylum campechianum*
3. *Croton eluteria*
4. *Swietenia mahagoni*
5. *Lysiloma latisiliqua*
6. *Guiacum sanctum*
7. *Krugiodendrom ferreum*
8. *Mastichodendrom foetidissimum*
9. *Erithalis fruticosa*
10. *Pseudophoenix vinifera*
11. *Dipholis salicifolia*
12. *Amyris elemifera*
13. *Thrinax microcarpa*
14. *Callicarpa hitchcockii*
15. *Vallesia antillana*

qualitative way. The question remained as to whether or not the same effect would be shown in the old field data. As with the analysis of grazing and browsing, a working hypothesis was established which assumed that valuable species would be more important in remote areas of the woodland than in areas close to the settlements.

In the two youngest age-classes, the expected distribution is generally followed. The 15 species increase in importance away from the settlements. Even so, it is probably unwise to place too much weight on these curves, as the total values are so low (Figure 39).

As was the case with the palatable and unpalatable species, the third age-class (15 to 30 years) includes some anomalies. When compared with the second age-class (5 to 14 years), the first two distance-classes have increased cover values while the last two actually decline, just the opposite of what was expected. The species largely responsible for the high value in distance-class 2 is *Erithalis fruticosa*. Just why it should have been so important here is

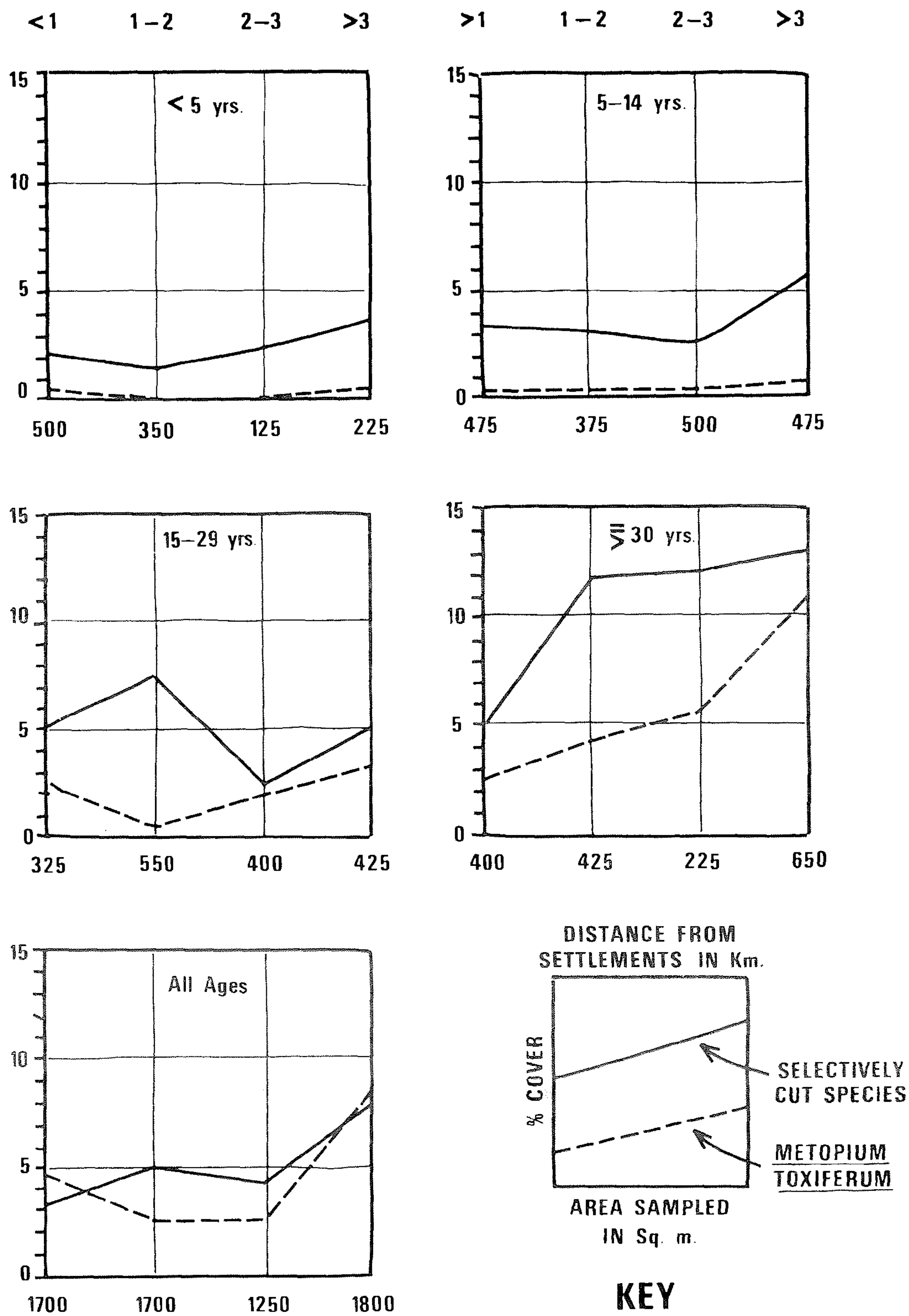


Figure 39. Graphs showing Age/Distance Distributions of Selectively-Cut Species, and Metopium Toxiferum

not immediately apparent.

The oldest age-class very definitely shows the expected pattern. The cover-values for the sites less than 1 kilometer from the settlements are significantly lower than for the last three distance- classes. Furthermore, the cover-values for the last three classes are between 6 and 9 percent higher than in the previous age-class.

The composite curve showing all ages together shows approximately the expected distribution. However, its usefulness is questionable, because it masks what are very real differences between the different age-classes.

Implications of the Data

Again the working hypothesis was proved largely correct. The assumption that the selectively-cut species would be less common close to settlements than in remote areas is supported by the data. On the other hand, for the first three age-classes the total cover values for the 15 species are very low. This means that a relationship between distance and selective cutting cannot be clearly defined for the younger woodland.

It is interesting to speculate whether these low totals are themselves a result of selective cutting, although again without historical evidence this cannot be proved. It appears that the species involved do not have the ability to recover quickly after cutting. Certainly very few of the 15 species are common in recently-abandoned fields. In other words, they are more vulnerable to disturbance than are the common woodland species.

Somewhat surprising is the narrowness of the zone affected by selective cutting. In the oldest age-class, the impact is restricted to within a radius of 1 kilometer from the settlements. This probably reflects the general decline in demand for the 15 species during the present century.

Had the areas sampled been greater the whole question as to how significant have been the effects of selective cutting would be more easily answered. Unfortunately, many of the species that have been selectively cut are still rare, and because of this they were not encountered in the sampling. *Fagara flava* the dyewood, *Buxus bahamensis* the timber tree, and *Canella alba* the medicinal bark were each seen only once in the woodland. The statistical significance of rare species cannot be adequately measured in a broad survey of the kind undertaken here. In spite of their limitations, however, the old field data do show something of the consequences of selective cutting, and in view of the fact that the demand for many of the species has declined in recent years it should be interesting to monitor future changes.

Combined Selective Pressures

Any analysis of the effect of selective pressures is complicated by the fact that usually more than one pressure has been involved. For example, clearing and burning, which are non-selective in the sense that fields are established without too much concern as to what species are present, are selective insofar as they give an advantage to species that can sprout or that have the ability to colonize recently-abandoned fields. Furthermore, the frequency of clearing and burning decreases with distance from the settlements in generally the same way as the intensity of selective-cutting and browsing. The net result is that several selective pressures may be exerted on certain species at the same time.

Originally it was hoped to analyse the impact of clearing and burning in the same way as grazing, browsing, and selective cutting, but unfortunately it was not possible to isolate a group of species that would unambiguously show this effect. It has only been possible to show the impact of grazing, browsing, and selective cutting because the species involved were known with certainty. This was not the case with clearing and burning. Rather than avoid the problem completely, the following discussion considers the case of the poisonwood tree (Metopium toxiferum); as the second most important species in the older woodland, its distribution is worth considering.

Metopium toxiferum

Metopium, a close relative of poison ivy and poison sumach, is characterized by a caustic sap poisonous to the touch. It is a common tree in the older woodland, and grows in a wide range of edaphic conditions, from the driest sites to the wettest. As can be seen from Figure 39, it has an anomalous distance distribution in the woodland.

In the first age-class (less than 5 years), it is rare, and is only present in the areas closest to and furthest away from the settlements. In the second age-class (5 to 14 years), its importance increases slightly while the same distance pattern is maintained. In the third age-class (15 to 29 years), there is a significant increase in the cover values while again the species is more important in the first and last distance classes than in the intermediate classes. In the older age-classes (more than 29 years), there is a continued increase in cover values, although this time there is a progressive increase in importance away from the settlements. The composite age-values show the characteristic U-shaped distribution.

The variable importance of Metopium with distance from the settlements suggests several interesting possibilities. Its greater importance in the more remote areas suggests that it is sensitive to some pressure positively associated with the settlements. Metopium is cut on a small scale for its timber in certain parts of the West Indies (Little and Wadsworth, 1964: 290), although there is no evidence to suggest it has ever been exploited in the Bahamas (Coker, 1905: 205), and according to local reports it has never been cut on Cat Island. Selective cutting, therefore, does not account for the distribution.

A more likely explanation is that Metopium is sensitive to clearing and burning. Unlike many of the woodland species, it is not a prolific sprouter, and its seedlings were rarely seen in the recently-abandoned fields. Figures 28 and 31 suggest that it requires a certain amount of shade for successful germination. Assuming this to be correct, the question remains as to why the cover-values are higher in the sites closest to the settlements than they are in the intermediate classes. A plausible explanation here is that the species is unpalatable to the browsing animals. For obvious reasons it is avoided by goats and other domesticates.

The variable importance of Metopium in the woodland is therefore probably due to the interaction of at least two selective pressures. Unpalatability gives it an advantage near the settlements, while sensitivity to clearing and burning puts it at a disadvantage; in effect, each pressure is working in the opposite direction. The U-shaped distribution suggests that the unpalatability-advantage overrides sensitivity to clearing and burning near the settlements, but that the opposite is true at intermediate distances. Just why this should be so is not immediately apparent, but could easily be determined with more field work.

Obviously the combined effect of the selective pressures is going to be different for each individual species. A palatable species which happens to be economically valuable and sensitive to fire is going to be rare even in the remote areas of the island. An unpalatable species of no use to man and with a vigorous sprouting ability is going to be common. Ideally, it would have been preferable to study the effects of selective pressures on three floristically similar islands: one that had only been grazed and browsed; one that had only been selectively cut; and one that had been cleared and burned for agriculture. Unfortunately, three such islands do not exist.

Distance and Diversity

According to the hypothesis of insular vulnerability, the floristic composition of the woodland should have been significantly impoverished by grazing, browsing, selective cutting, clearing, and burning. The data discussed above hardly suggest that this has been the case. In order to consider the question of impoverishment more closely, it was decided to compute the number of species present per unit area sampled in the different age and distance-classes. The resultant totals are shown in Table 7.

TABLE 7

DIVERSITY, DISTANCE AND AGE

The average number of woody species encountered per 25 x $1m^2$ sample.

	KM. FROM SETTLEMENTS			
Less than 5 yrs.	15.70	15.21	15.00	15.20
5-14 yrs.	14.11	14.87	14.95	15.11
15-29 yrs.	11.62	10.68	11.56	10.41
30 yrs. or older	10.78	9.77	9.00	9.00
All ages	12.40	12.28	12.57	11.12

Significantly, there are no major differences in species diversity between the different distance classes. In fact, apart from the second age-class, the sample sites less than 2 kilometers from the settlements have slightly higher averages than those more than 2 kilometers away from the settlements.

The important conclusion to be drawn from this is that, although the species sensitive to selective pressures have become rare close to the settlements, they have been replaced by a similar number of insensitive species. The discovery that so many native species are pre-adapted to withstand the impact of grazing, browsing, selective cutting, clearing, and burning was unexpected. The question as to why this is the case will be considered later.

XI. THE INVASION OF ALIEN PLANTS

Unlike the situation prevailing on remote islands such as the Hawaiian islands, comparatively few species of alien plants have become well-established in the Bahamas. Of the 120 woody species encountered during the course of the present study, only six were clearly identified as alien, and together they accounted for only 5 percent of the total cover.

The Species Involved

Leucaena leucocephala

Leucaena is a leguminous shrub with a pantropical distribution. Its original home is usually cited as Central America, although the details of its history are not clear. This is certainly so for the Bahamas. Its alien status is not confirmed by the historical record, but is strongly suggested by its localized distribution in artificially-disturbed habitats; characteristically it is a pioneer in abandoned fields, pastures, and roadsides.

It was probably introduced to the Bahamas in the early eighteenth century as a fodder crop. One of Catesby's plates (1731, II: 42) looks very much like *Leucaena* and is identifed as such by Britton and Millspaugh (1920: 162). However, the text clearly refers to the native *Lysiloma leucocephala*, so the determination remains doubtful. The naturalist Schoepf, who visited the islands in 1784, includes a *Mimosa glauca* in a check list of the more common plants, but gives no information as to its use or origin. Very likely the species he refers to is *Leucaena leucocephala*. On the other hand, there is surprisingly no mention of *Leucaena* in Brown's account of fodder plants in use on his plantation around the turn of the eighteenth century (1802:11). A plantation journal from Watlings Island for the year 1831 includes references to the planting of "cow bush" and "cow peas," but the identification of the species involved is not certain (Deans Peggs, 1957: v).

What is certain is that by the end of the nineteenth century *Leucaena* was widely distributed around the archipelago (Hitchcock, 1893:166). On Cat Island in 1970 it was locally common in recently-abandoned fields, pastures,and along roadsides.

Haematoxylum campechianium

Logwood is a thorny, leguminous tree with a rather shrubby habit. The heart-wood, which is deep reddish purple, is the source of the dye Haematoxylon. A native of Central America, logwood was widely introduced around the Caribbean during the late seventeenth and early eighteenth centuries (Wilson, 1936). Fortunately, there is a definite date for its introduction to the Bahamas. As was indicated earlier, Catesby reports that it was brought from the Bay of Honduras in 1722. As far as Cat Island is concerned, it seems likely that it was introduced by the loyalists at the end of the eighteenth century. Its present distribution is very localized in old plantation areas near Port Howe and Old Bight.

Manilkara zapota

The sapodilly is one of the most common fruit trees in the Bahamas. Supposedly Central American in origin, it was probably first introduced to the islands by the Arawaks. It is easily planted from seed in the Bahamas, and its fruits are characterized by a wide variability in size and shape (Morton and Morton, 1946: 88).

It was probably re-introduced to Cat Island in the late eighteenth century by the loyalist planters. In 1970 few families did not have at least one tree in their yard. In the woodland it is seen characteristically by the side of footpaths and only occasionally in the middle of a field. Presumably a large percentage of the woodland trees have grown from seeds, either intentionally planted or casually discarded. Both the fruit and seed are large and are probably not dispersed far by natural mechanisms.

Indigofera suffruticosa

Whether or not the New World indigo is native to the Bahamas is uncertain. It was cultivated in South America in pre-European times and may have been brought to the islands by the Arawaks (Harris, 1965). There are references to the cultivation of indigo around the turn of the seventeenth century, although what species was involved is not clear (Craton 1968: 89). The Asiatic indigo (Indigofera tinctoria) had probably been introduced by this time. Schoepf (1788) includes an Indigofera argentea in his list of common plants, and according to Britton and Millspaugh this is a synonym for the New World species (1920: 180).

In nineteenth century botanical literature, Indigofera suffruticosa (syn. I. anil) is recorded for several of the

Bahama Islands, although not for Cat (Hitchcock, 1893: 166). It is certainly rare on the Island at present, and its alien status is suggested by its localized distribution in artificially-disturbed habitats.

Gossypium barbadense, G. hirsutum

Cotton is one of the few cultivated plants known to have been introduced to the island by the Arawaks. However, that it could have persisted the wild after the Arawaks left seems doubtful. More than likely, the cotton seen in the woodland today can be attributed to eighteenth-century or even later introductions. At least four varieties were cultivated in the nineteenth century: Anguilla, Flyaway, Bourbon, and Georgia (Johnston, 1867). The first three appear to have been varieties of sea island cotton (G. barbadense), while the latter may have been a long-staple variety of upland cotton (G. hirsutum). Both species are listed in the Bahama Flora, although upland cotton is only recorded for one island, Rum Cay (Britton and Millspaugh, 1920: 274). The species encountered on Cat Island in 1970 was sea island cotton. A weedy shrub, it was characteristically seen in disturbed habitats, such as roadsides or gardens, and only occasionally in the woodland.

Heliotropium angiospermum

Unlike the five species discussed above, scorpion tail has never been planted. A woody herb rather than a bush, it is a widely-distributed tropical weed. Like many weeds its origins are uncertain. However, its irregular distribution in artificially-disturbed habitats strongly suggests that it is not native to the Bahamas. It has been present on Cat since at least the late nineteenth century (Hitchcock, 1893: 168), but was rarely seen in the woodland in 1970.

The Extent of the Invasion

One of the more important conclusions reached by Elton in his The Ecology of Invasions (1958: 142) was that simple communities are more prone to invasion than communities which are rich in species. Harris reached much the same conclusion in his study of the Outer Leewards. He suggested that the extent to which alien plants were able to become established varied from place to place according to the history of disturbance and the floristic diversity of "ecological resistance" of the native vegetation. Whether this was also true of the Cat Island woodland was a basic question considered in the analysis of the old field data. In the discussion that follows, the three habitat-types types and five age-classes are used as an organizing framework.

The Whiteland

As can be seen from Table 8, only 2 aliens were encountered in the whiteland samples, *Leucaena* and *Gossypium*, with *Leucaena* being by far the most important. As was shown earlier, *Leucaena* was in fact the third most important pioneer on the whiteland only exceeded in the first two age-classes by *Gundlachia* and *Corchorus*. In the third age-class it replaces *Corchorus* to a certain extent, but it is still not as important as *Gundlachia*. In the older woodland it declines quickly (Figure 25).

The importance of *Leucaena* on the whiteland must in part be attributed to planting. In the pre-automobile era a great number of horses were grazed here, and it seems more than likely that some of the *Leucaena* thickets owe their origin to planting. Their persistence must in large part be attributed to the species's ability to sprout. This method of reproduction is especially effective in the loose sand substrate. Clearing and burning have little impact on the shrub, making it a troublesome weed (Figure 40). In intermediate-aged fields, *Leucaena* usually forms dense thickets 2 to 3 meters in height (Figure 41). The close cover naturally prevents regeneration by other species. However, as Table 8 shows, in fields over 30 years old it accounts for only 2 percent of the average cover. What appears to happen is that the taller, more deeply-rooted shrubs, such as *Coccoloba uvifera* and *Acacia buxifolia*, gradually extend their cover at the expense of *Leucaena*. If clearing and burning were to cease and natural regeneration allowed to take place, it seems unlikely that *Leucaena* would be able tp persist.

Cotton (*Gossypium barbadense*) was the only other alien encountered on the whiteland. It was seen only once and in an area very close to the edge of the whiteland. Together with *Leucaena* and *Guilandina*, it formed a dense thicket 3 to 4 meters high. According to the early historical accounts, cotton never grew well on the whiteland, and there is no evidence to suggest it was ever planted there in any quantity. Although the data do not show it, cotton was more frequently seen on the blackland and flatland than on the whiteland. In either case, it accounts for a very small part of the total cover.

Several other aliens were seen on the whiteland,

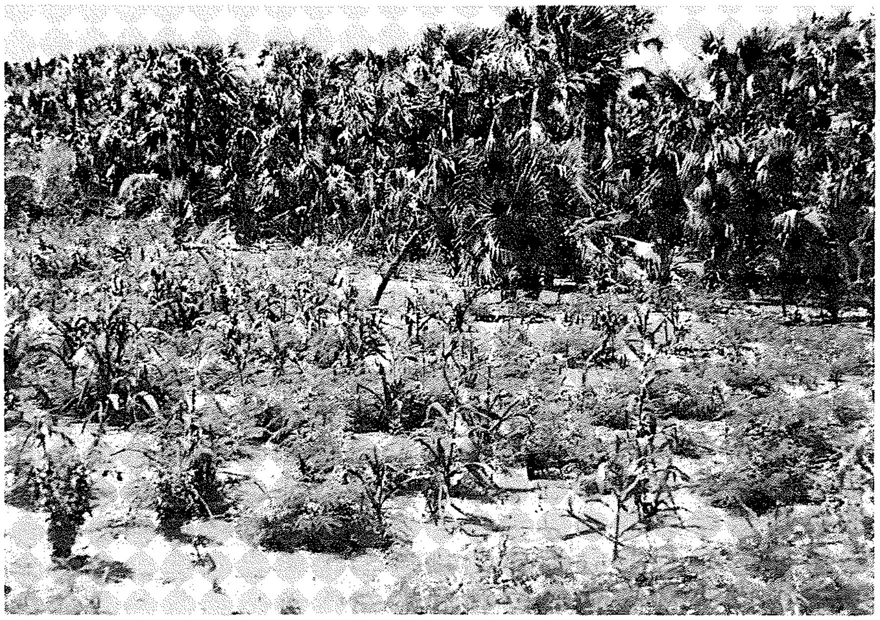


Figure 40. A whiteland corn field infested with *Leucaena leucocephala*. This field, close to the edge of a seasonally- flooded palmetto thicket, had been abandoned because of the difficulty of eradicating *Leucaena* sprouts.

Figure 41. Here an older *Leucaena* thicket, probably 15-20 years old, is being replaced by native species. *Casasia clusiafolia* is in the left foreground and *Coccoloba uvifera* to the right and in the background.

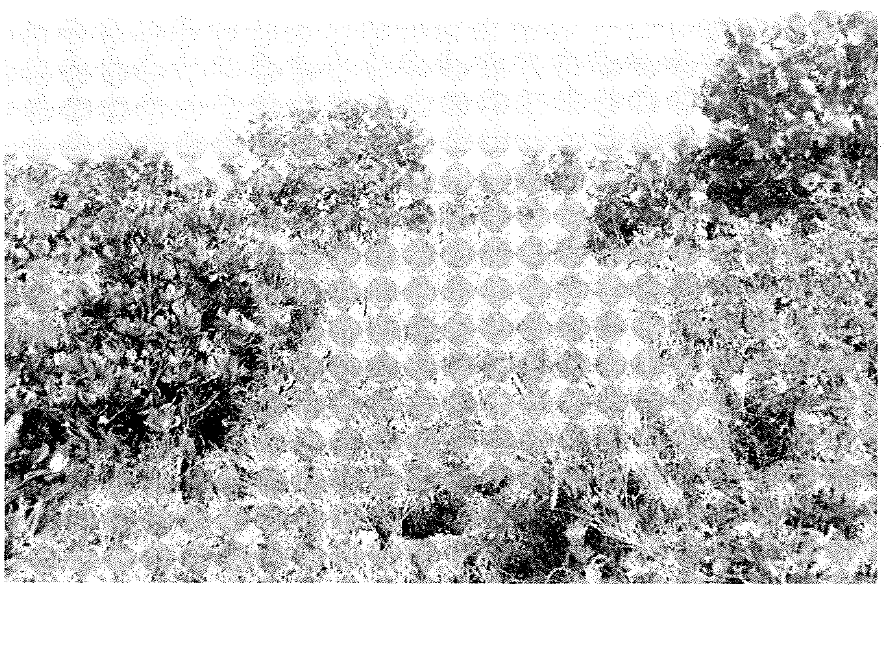


TABLE 8

PERCENTAGE COVER ALIEN SPECIES

AGE IN YEARS	<5	5-14	15-29	30-50	>50
WHITELAND					
Leucaena.....	13.73	12.14	17.27	2.00	0.00
Gossypium....	0.00	0.00	0.80	0.00	0.00
Total	13.73	12.14	18.07	2.00	0.00
FLATLAND					
Leucaena.....	2.35	3.23	3.19	0.94	0.00
Haematoxylum.	0.00	1.30	7.25	0.67	0.00
Total	2.35	4.53	10.44	1.61	0.00
BLACKLAND					
Leucaena.....	3.62	2.08	3.40	0.36	0.08
Haematoxylum.	0.07	0.00	0.04	0.00	0.00
Manilkara....	0.00	0.00	0.00	0.19	0.95
Heliotropium.	0.03	0.13	0.00	0.00	0.00
Indigofera...	0.34	0.13	0.00	0.00	0.00
Total	4.06	2.34	3.44	0.55	1.03
ALL HABITATS					
Leucaena.....	5.05	3.46	5.87	0.75	0.04
Haematoxylum.	0.03	0.61	1.42	0.23	0.00
Gossypium....	0.00	0.00	0.14	0.00	0.00
Manilkara....	0.00	0.00	0.00	0.13	1.25
Heliotropium.	0.02	0.06	0.00	0.00	0.00
Indigofera...	0.17	0.00	0.00	0.00	0.00
Total	5.27	4.13	7.43	1.11	1.29

although they were not encountered in the sytematic sampling. The most important by far was Casuarina equisetifolia, the Australian Pine. Although usually restricted to a narrow zone just above the high tide mark, Casuarina has in certain areas escaped inland. It is occasionally seen along roadsides or in similar open habitats. Surprisingly, it has not been able to invade the recently-abandoned fields, although just what prevents it is not immediately obvious.

Also occasionally seen on the whiteland was sisal (Agave sisalana). Extensively cultivated in the latter part of the nineteenth century, it is still planted on a very small scale. Most of the sisal on the whiteland had the appearance of being planted, although some natural increase may have occurred. More conspicuous was its wild relative Agave americana, locally known as "the Bamboo". Its flowering stalk reaches a height of 10 meters or so, while its basal leaves are 2 meters tall.

Coconuts (Cocos nucifera) are often planted on the whiteland, usually as a means of satisfying government regulations, which require "improvement" of land grants. However, the coconut is definitely a cultigen here and no natural regeneration occurs.

Overall, very few woody aliens have been able to successfully establish themselves on the whiteland. Leucaena, which was formerly planted as a fodder crop, is the only alien to have become an important part of the wild vegetation.

The Flatland

Again, on the flatland only two aliens were encountered in the systematic sampling, Leucaena and Logwood. Taking the five age-classes as a whole, Leucaena was slightly more important than Logwood in both absolute and percentage terms (Table 8).

On the flatland the indurated rock surface makes the ability to reproduce from sprouts less advantageous than on the whiteland, and perhaps because of this, Leucaena is less important. Competition from the greater number of species adapted to this habitat has probably also been a factor. Whatever the reason, Leucaena covers a much smaller area of the woodland than it did on the whiteland. On the other hand, in terms of importance in different age-classes the pattern is much the same. It also seems likely that if clearing and burning were to cease, Leucaena would not be able to persist for long.

The cover values for logwood cannot be properly interpreted without some further information. Logwood has a very localized distributiion on Cat Island. It was seen to be especially common in the areas east of Old Bight and northeast of Port Howe. It was never encountered in the northern half of the island, where most of the sampling was carried out. This localized distribution, undoubtedly the result of its comparatively recent introduction, has meant that the average values in Table 8 are somewhat misleading. In the areas where it was encountered it was very common, but the averages are low because over much of the island it has not yet become established. Whether it will or not in the future is another question.

The difference in the cover values for logwood in the different age-classes is probably a reflection of the history of land use in the areas sampled. For example, in a large flatland area east of Old Bight, logwood trees 3 to 4 meters tall were surrounded by a great variety of native shrubs and small trees. Logwood regeneration was very poor, although twenty to thirty years ago it had apparently been good. This change in the woodland probably reflects a decrease in the intensity of land use in the area. As over the rest of the island, in the fifteen years between 1943 and 1956 the area under cultivation decreased significantly, and since 1956 it has declined even further. In open conditions thirty years ago, logwood was able to reproduce well, but since then it has been less successful and the native species have had a chance to recover. Furthermore, in the continued absence of disturbance, it seems likely that logwood will not only have difficulty in reproducing but will be outshaded by the taller native species such as poisonwood (Metopium toxiferum) and pigeon plum (Coccoloba diversifolia). Both were actually seen to be growing up through the laterally-branching arms of the logwoods. It is probably significant that logwood was not encountered in the older woodland.

Although logwood was planted in the past, it seems likely that most of the present growth is spontaneous. The demand for the dyewood declined in the late nineteenth century, and it probably has not been planted since. Even so, it is still recognized locally as a valuable tree and is spared because of this during clearing and burning.

Again, as on the whiteland, several aliens were seen that were not encountered in the systematic sampling. Particularly common are the two fiber plants, sisal (Agave sisalina) and bowstring hemp (Sansevieria sp.). Fruit trees such as the sapodilly (*Manilkara zapota*), mango (*Mangifera indica*), tamarind (*Tamarindus indica*), and genip (*Melicoccus bijugatus*) were occasionally seen, although most of them had the appearance of being planted. The pawpaw (*Carica papaya*) was seen, both planted and wild, in cultivated or recently-abandoned fields. Overall, however, aliens have been less successful on the flatland than on the whiteland.

The Blackland

Five aliens were encountered on the blackland (Table 8). The higher number can probably be attributed to the greater area sampled here. *Leucaena* has similar cover values to those recorded on the flatland and was generally observed to have the same patchy distribution. Logwood was much less important. In part, this may be due to thin sampling in the area where logwood is ill-adapted to the more mesic blackland habitat. In its natural habitat in British Honduras, logwood grows on the low, seasonally-flooded areas of the coastal plain (Wilson, A.M., 1936). The sapodilly was the only alien encountered whose importance increased in the older age-classes. Unlike the others it is capable of reaching a size equal to most of the native species. According to Britton and Millspaugh it is "spontaneous after cultivation" in the Bahamas (1920: 324). However, as was indicated above, its ability to reproduce independent of man was not clearly established on Cat Island, and, as the old field data indicate, it has made little progress in the woodland.

The two doubtful aliens, *Indigofera* and *Heliotropium*, were each encountered only twice and therefore account for a very small fraction of the total cover. Furthermore, they were very rarely seen elsewhere in the woodland. Both are restricted to recently-abandoned fields and will be replaced when natural regeneration takes place.

All the aliens listed above as seen but not sampled on the whiteland and flatland, were also present on the blackland, as also were *Acacia farnesiana* and *Euphorbia lactea*. None, however, were of anything more than local importance or showed any indication of becoming permanently established. In total, aliens were even less important on the blackland than on the flatland.

The Woodland as a Whole

In general terms the conclusion reached by Elton and Harris, that success of aliens is determined by the diversity of the native vegetation, is supported by the data presented above. The progressive increase in the importance of aliens from the blackland, to the flatland, to the whiteland is inversely proportional to the floristic diversity of the native vegetation. Just why this should be so is not immediately apparent. In part it appears to be determined by the behavior of only two of the aliens, Leucaena and logwood; the former appears to be well-adapted to the whiteland, while the latter is well-adapted to the flatland. Competition from native species is probably not as important as the diversity hypothesis suggests. Leucaena, for example, is more important on the blackland than the flatland in three of the five age-classes.

The significant conclusion is that alien plants have had limited success in the woodland. In spite of repeated clearing, burning, and grazing, very few species have been able to get established. Furthermore, the area they cover is small and their presence promises to be ephemeral. This situation contrasts sharply with that in the Outer Leewards, where, according to Harris (1965: 59), aliens "exceed natives in total mass of vegetation over extensive areas," or in Barbados, where Watts (1970: 100) has reported that aliens are dominant in certain grassland areas, secondary woodland, and thickets.

XII. THE STABILITY OF THE WOODLAND

In view of the supposed vulnerability of island life, the most unexpected characteristic of the woodland to emerge from this study is its capacity to recover from disturbance by man. In spite of almost a thousand years of clearing, burning, selective cutting, and, more recently, grazing and browsing, the woodland has survived. This is not to suggest that it has survived unchanged. Sensitive species have become rare, while species pre-adapted to disturbance have increased in importance. In fact, the present stability of the woodland may in large part be the result of man having given a selective advantage to weedy types. Even so, the surprising fact remains that so many of the native species are inherently weedy. Furthermore, there is no concrete evidence that any one species has become extinct. This does not, of course, preclude the possibility of extinctions in the prehistoric period, but it does provide a marked contrast with the Hawaiian Islands, where literallly dozens of species are known to have either become extinct or be seriously threatened with extinction (Fosberg, 1971: 6). The possible reasons for the unexpected resilience of the Cat Island woodland are the subject of the present chapter.

Adaptations to Clearing and Burning

In spite of a seasonally-dry climate and thin or non-existent soils, the woodland recovers very quickly after clearing and burning. The woodland is in fact inherently weedy. This weediness can be considered in three different contexts: seed dispersal, seedling establishment, and regeneration from sprouts.

Seed Dispersal

The discontinuous existence of an offshore archipelago such as the Bahamas, or indeed the West Indies as a whole, must have had an important influence on the evolution of plant-dispersal mechanisms. The Bahamas are not remote islands such as the Hawaiian Islands or the Galapagos; they are close to each other, and to Florida and the Greater Antilles. Ocean currents reach them after having passed through the whole of the Antilles. They are frequently crossed by hurricanes and other tropical storms. Furthermore, many migrating birds spend their winters in the islands, or at least visit them on their way north or south. With all these means of dispersal regularly available, the arrival of a viable seed in the Bahamas is not the rare, chance event it is in Hawaii.

A great many of the woodland species are prolific berry-producers, an obvious adaptation to dispersal by birds. The vast majority of woodland species are adapted to dispersal by birds, a small number are wind dispersed, and an even smaller number are adapted to dispersal by ocean currents. Unlike many plant species, which on reaching remote islands have had the efficiency of their dispersal mechanisms reduced (Carlquist, 1965: 241), the species in the Cat Island woodland have retained efficient dispersal mechanisms.

The relevance of all this to the present study is that a recently-cleared field is in fact an "island" in the evergreen woodland. The existence nearby of so many species pre-adapted to reach islands accelerates the rate of succession. If the intensity of the "seed rain" on abandoned fields on Cat Island could be measured, it would undoubtedly be high.

Seedling Establishment

Weediness involves more than prolific seed-production and efficient dispersal mechanisms. The ability to grow in droughty, disturbed habitats is also important. Recently-cleared fields in the woodland are certainly droughty and disturbed habitats. In fact, on first sight it is hard to imagine that any plant, wild or cultivated, could survive in such a difficult environment (Figure 42, 43). The existence of so many native species that can raises the question as to where they developed this ability. On Cat Island there are at least three possibilities: the savanna/evergreen woodland transition, the mangrove/evergreen woodland transition, and active sand dune situations.

The savanna/evergreen woodland transition. Around the upper margins of the seasonally- flooded savanna is a zone that is only flooded after exceptionally heavy rains, perhaps once every four or five years. Here woody growth is possible on a short-term basis only, and the only species able to survive are those capable of quick dispersal and establishment on what is virtually a bare limestone surface (Figure 44). *Gundlachia corymbosa* and *Tabebuia bahamensis*, both wind-dispersed species, are common in these areas, as also is *Torrubia longifolia*, a prolific berry-producer. All three are also important in the early stages of succession on the abandoned fields. *Randia mitis*, *Byrsonima cuneata*, and *Evolvulus squamosus* are also often encountered in this

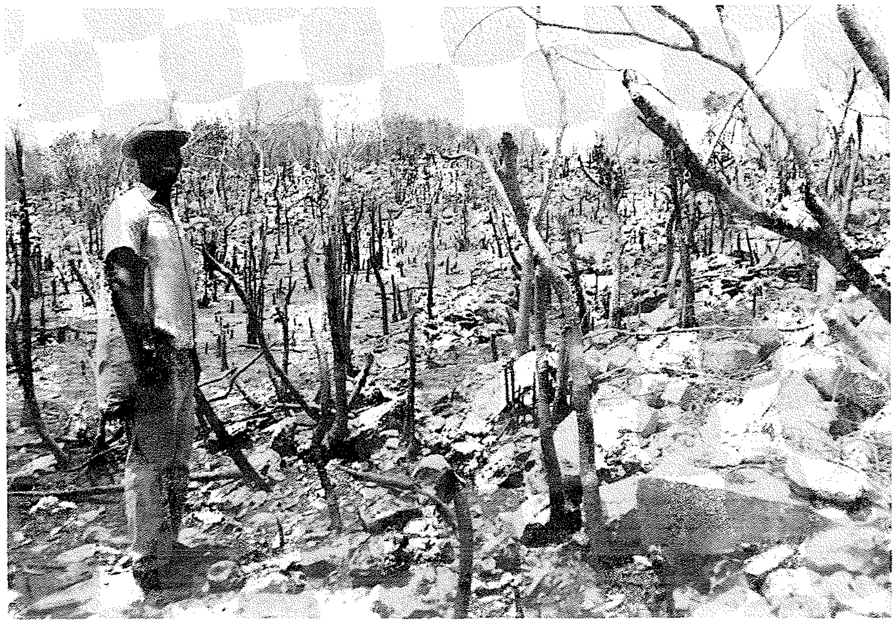


Figure 42. A recently burned blackland field. The area where the man is standing is the lowest part of the field and therefore has the thickest accumulation of ash, probably 10 to 15 centimeters. On higher ground the surface is more than 75 percent bare limestone.

Figure 43. A two year old blackland field. The rocky nature of the blackland surface is well shown here. Most of the regeneration is a result of sprouting. As the photograph was taken in early June crops are not yet visible. The banana in the background is the only exception.

Figure 44. Savanna/woodland transition. This indicates something of the naturally open aspect of the savanna/woodland transition. Herbs on the lower ground give way to palmettoes (Sabal palmetto) and hardwoods on the well-drained sites. The two saplings that have become established in the foreground are: Torrubia longifolia in the center ad Tabebuia bahamensis to the right.

Figure 45. Mangrove/woodland transition. Along the center of this photograph is the normal high tide mark. On the lower ground to the left is Rhizophora mangle. To the right are plants adapted to brackish conditions, Gundlachia corymbosa in the foreground and Coccoloba uvifera in the background.

environment, although of these only Randia was commonly seen in the old fields.

The seasonally-flooded savannas cover only a small area of Cat Island at present (Figure 22), but they were probably more extensive in the past, particularly when the Bahama Banks were only slightly above sea level. Looking at the North American subtropics as a whole, it seems likely that the savanna/woodland transitional zone has been an important breeding ground for weedy types.

The salt water/evergreen woodland transition. Inland from the salt-tolerant vegetation of the coast and tidal flats, there is a transitional zone in which only the most drought-resistant of the woodland species can grow (Figure 45). Not only are these areas periodically washed with salt spray, but the fresh water lens is either thin or non-existent. During droughts, the only source of fresh water is condensation in the form of dew.

The floristic composition of this transitional zone appears to be largely determined by the nature of the sub-strate. On the loosely-consolidated dunes and beach ridges, several pioneer species are found, such as *Lantana involucrata*, *Corchorus hirsutus*, *Croton linearis*, *Gundlachia corymbosa*, and *Salmea petrobioides*. On the harder Pleistocene surfaces, small trees are more common. Figure 46 shows the species present on a low Pleistocene beach ridge. In both environments, the salt water/evergreen woodland transition is an important breeding ground for old field pioneers. The naturally droughty nature of the surface is basically similar to the surface of a recently abandoned-field.

Active sand dunes. There are no active sand dunes on Cat Island at present. A few small blow outs were observed on the Holocene dune ridges, but, in each case, in an area disturbed by man. The three dune ridges that comprise such a large part of the island are all fossil features. In spite of this, active sand dunes have probably played an important role in the development of weediness in Bahamian vegetation. Dune formation and erosion was a characteristic feature of the Bahamian environment even before the sea-level oscillations of the Pleistocene. Furthermore, in several not very remote areas of the West Indies, there are dune systems still active today; for example, along the northern coast of Puerto Rico, where many of the Cat Island old field pioneers, or their congeners, are present in the sand dunes (Cook and Gleason, 1928).

Not all the old field pioneers have been accounted for in this brief survey, but the implication is clear.

KEY TO FIGURE 46

1. *Rhizophora mangle*
2. *Laguncularia racemosa*
3. *Conocarpus erecta*
4. *Erithalis fruticosa*
5. *Gundlachia corymbosa*
6. *Rachicallis americana*
7. *Reynosia septentrionalis*
8. *Coccoloba diversifolia*
9. *Metopium toxiferum*
10. *Casasia clusiafolia*
11. *Pithecellobium keyense*
12. *Torrubia longifolia*
13. *Jaquinia keyensis*
14. *Coccothrinax argentea*
15. *Manilkara jaimiqui*

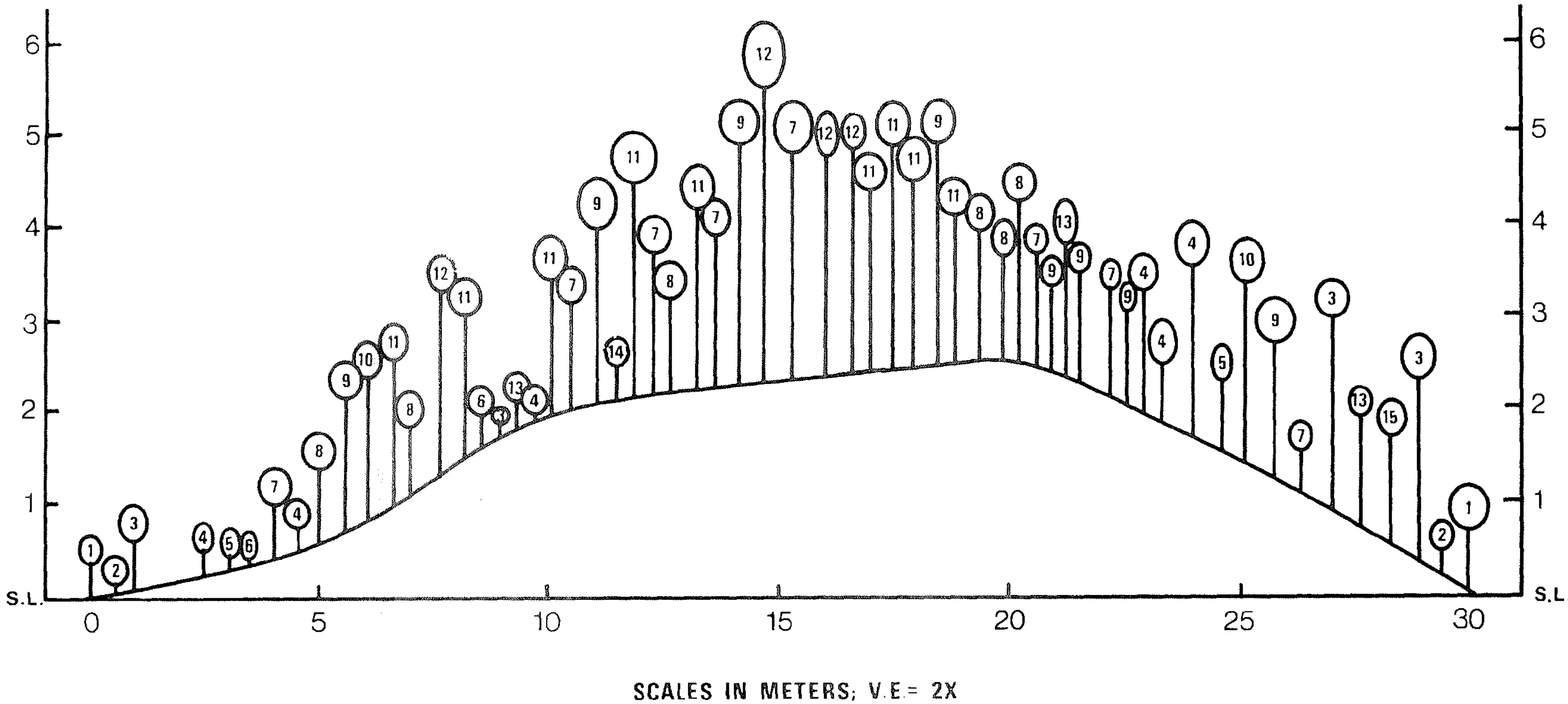


Figure 46. Diagram showing the Floristic Composition across a Low Limestone Ridge

Naturally open, droughty, or unstable habitats have always existed on Cat Island, and in similar environments throughout the North American subtropics. Certain plant species have adapted to these habitats, and when man created similar habitats they simply expanded their range. As has been shown elsewhere, the expansion of naturally weedy types into artificially-disturbed habitats is a widespread phenomenon (Sauer, J.D. 1950; Anderson, 1952).

Regeneration from Sprouts

Clearing is rarely complete. A great many native woodland species have the ability to sprout vigorously after cutting and burning. If a field is severely burned, all the pre-existing species may be killed. But this is rarely the case; most farmers are reluctant to burn too deeply because it results in lower yields. Consequently, sprout weeding occupies a large part of the farmer's time during the first year of cultivation. After a field is abandoned, any surviving sprouts have an obvious advantage over seedlings. Usually they can be identified by the way they project over the general level of the vegetation. The rapid recovery of the woodland after cultivation can in large part be attributed to the fact that so many species can reproduce from sprouts.

Sprouting ability is probably, in part at least, an adaptation that has developed as a response to breakage by hurricane-strength winds. Craighead (1962:17) has described how many of the tropical hardwoods in southern Florida recovered quickly after defoliation and breakage during hurricane Donna. Among the trees that responded most rapidly with new leaves were *Lysiloma bahamensis*, *Bursera simaruba*, *Coccoloba diversifolia*, *Swietenia mahagoni*, and *Zanthoxylum fagara* (syn. *Fagara pterota*). Significantly, all of these species are common in the old fields on Cat Island.

Lightning fires have also played a role in developing the ability to sprout. In southern Florida, it is now recognized that lightning fires have had an important influence on the development of the natural vegetation (Robertson, 1962). Furthermore, many of the tropical hardwoods have the ability to reproduce from sprouts. As Craighead has indicated:

> When fires destroy these hammocks..some roots usually survive. The regeneration from root suckers produces a new stand that is practically identical to the old. Repeated fires, however, destroy all of the hardwoods in time (Craighead, 1971: 157)

Even though lightning fires have not been common on Cat Island in the recent past, it seems unlikely that this has always been the case. Repeated clearing, burning, and grazing have prevented the accumulation of litter, and therefore reduced the chances of fire. In pre-human times, windfall and a deep litter accumulation would have provided ample fuel for lightning fires. Significantly, fires are especially severe in the southern Florida hardwood hammocks during the dry season after a hurricane. At such a time the accumulation of dead wood on the ground provides an ideal condition for fire.

Lightning fires and hurricanes have therefore both played a role in the development of sprouting ability. This background of natural disturbance has, in effect, preadapted the woodland to withstand many of the types of disturbance introduced by man. Because so many species have the ability to regenerate from sprouts, the impact of shifting agriculture has not been as drastic as it might have been otherwise.

Resistance to Grazing and Browsing

In view of the fact that no grazing or browsing mammals are native to the Bahamas, it was surprising to find that so many species were unpalatable to goats. The situation on Cat Island is very different to that on Three Kings Island, New Zealand, where goats have reduced a floristically diverse woodland to a woodland composed of only one species (Turbott, 1963) or on St. Helena, where goats brought about the complete removal of woody species (Darwin, 1839:486-487).

Just why so many species should be resistant to grazing and browsing pressures on Cat Island was not immediately obvious. The unpalatable species are unpalatable because of several reasons: some are poisonous, some are strongly aromatic, and some are armed with sharp spines or stinging hairs. More than likely, these characteristics developed in response to many pressures, of which grazing by mammals is only one.

Seasonal drought may have played a role in the development of essential oils, which assist in water conservation by reducing evaporation rates. Similarly, spiny leaves are also often regarded as an adaptation to droughty conditions. Insect larvae consume a considerable volume of plant material every year, and must have played a significant role in the evolution of the woodland species. Mammals may also have been important. Many of the trees and shrubs now found in the evergreen woodland were formerly present in what is now the south central United States. Presumably they could have developed defensive mechanisms against grazing there. Even today, deer browse in the floristically similar woodland on the Florida Keys (Craighead, 1971: 97).

The whole question is a complicated one and rather than speculate further the point might simply be made that many woodland species are pre-adapted to withstand grazing and browsing by domesticated animals.

Resistance to Invasion by Alien Plants

In spite of repeated disturbance, very few alien plants have been able to establish themselves in the woodland. There are probably three basic reasons for this: the nature of the woodland as an environment for plant life, the nature of the aliens that have been introduced, and the lack of efficient dispersal mechanisms.

Life in the evergreen woodland poses many problems that each alien species must be able to cope with. As has been repeatedly stressed, this low limestone island is in many ways a difficult, environment for plant life. For the native species it is not difficult because they have adapted to it and similar environments over a geologically long period of time. This is not the case with most aliens. Drought, hurricanes, fire, an almost pure limestone surface, and a diverse array of plant pathogens are all natural hazards that any alien species must cope with if it is to become permanently established. Superimposed upon all this is the problem of competition with the native plant species, with their prolific seed production and rapid growth rates.

The difficulties facing alien plants in the Bahamas are well illustrated by the repeated failure of attempts to establish commercial crops. Cotton, citrus, tobacco, and sisal have all failed commercially, either because of an insect pest or some other environmental problem (Mooney, 1905). Even with help from man, life in the Bahamas is too difficult for a great many invaders. Perhaps significantly, the only two successful aliens, Leucaena and Haematoxylum, are native to environments not too different from the Bahamas.

On the other hand, the general failure of aliens to invade the woodland must in large part be attributed to the nature of the aliens themselves. Most of them have been cultigens, incapable of spreading far without help from man. The herbaceous weeds that have been introduced are largely restricted to open habitats, such as roadsides and gardens. Yet, paradoxically, even though the woodland has been repeatedly disturbed by man, very few aliens have been able to get established. This raises the question of dispersal mechanisms.

Cattle have never been numerous on Cat Island. This has meant that an important plant-dispersal mechanism has been missing. Cattle have not played the role they have in parts of the West Indies, that of reducing the importance of native species and increasing the cover of aliens.

All of this does not necessarily mean that there are no species in existence which, given a chance could become permanently established in the woodland. For example, there are woodland species that grow on other Bahamian islands but not on Cat which presumably could become established if they were introduced. Looking further afield, it seems more than likely that there is a long list of potentially successful immigrants. Aliens can succeed without help from man, as Casuarina has shown along the coast.

The Significance of Diversity

Since Darwin's time, the assumption that diversity is synonymous with stability has been generally accepted. Darwin originally emphasized the importance of diversity because he was impressed by the success of continental species on oceanic islands. However, as has been shown more recently, the success of continental species on oceanic islands can largely be attributed to prior disturbance by man (Allen, 1936; Egler, 1942; Harris, 1962). In other words, most aliens do not have a competitive advantage because they evolved in floristically and faunistically more diverse environments; their advantage is due to the fact that they have evolved to withstand the types of disturbance associated with man.

In many parts of the world man has brought about a marked reduction in diversity. Natural vegetation that was floristically diverse has been replaced by secondary vegetation consisting of relatively few species. Surprisingly, on Cat Island this does not appear to have been the case. There are no significant differences in diversity between the remote, relatively undisturbed areas of the woodland and the areas close to the settlements. In fact, if the woodland is considered as a whole, man has actually increased its floristic diversity by the introduction of alien species. Although the number of aliens that have become established is not large, it probably exceeds the number that have become extinct. The question whether the woodland is more stable now than it was in presettlement times is difficult to answer. Presumably it is more resistant to the types of disturbance introduced by man, but on the other hand it may be less resistant to natural forms of disturbance, such as hurricanes or disease outbreaks.

It is probably true to say that the importance of the relationship between diversity and stability has been overemphasized in recent island studies. Diversity offers a collective advantage in the face of selective pressures such as insect pests, but means little where large-scale pressures such as clearing and burning are concerned. The resilience of Cat Island woodland is not due to floristic diversity, but to the fact that so many species are preadapted to withstand the types of disturbance introduced by man.

The Nature of Insularity

The anomalous resilience of the woodland can also be attributed to the imprecise meaning of the word island. Some islands are more insular than others. Before the arrival of man, remote islands such as the Galapagos or the Hawaiian islands were colonized by rare, chance migrations. The successful colonists evolved in isolation, and often diverged to form new species or even genera. These endemics are by their very nature vulnerable, and because of their limited numbers are likely candidates for extinction, regardless of their reproductive capacities or ecological tolerances.

On the other hand, islands such as Cat or indeed any island in the Bahamas or West Indies, are not characterized by endemic populations.[1] As far as plants are concerned, a constant interchange of seeds and pollen retards the evolution of new types.[2] Most of the species encountered in the Cat Island woodland are widely distributed around the North American subtropics. Each species consists of a large number of individuals, and the chances of extinction are therefore reduced.

1. On this point it is interesting to note that Taylor (1921) attributed the low rate of endemism in the Bahamian flora, less than 15 percent, to the geological youthfulness of the islands. As has been emphasized above, this has probably not been an important factor.
2. On several occasions, while at the northernmost point of Cat Island, a constant stream of butterflies, notably cloudless sulphurs (*Phoebis* spp.) and the Gulf fritillary (*Agraulis vanillae*), was seen being blown towards Eleuthera by the Trade Winds.

Insularity and, therefore, vulnerability depend not so much on distance, or the past presence or absence of land bridges, but on accessibility in terms of plant and animal dispersal capacities. Cat Island, like most islands, is much less accessible to animals than it is to plants. Its fauna is therefore impoverished, and the extinction of only a few species has a greater overall significance. The implication of all this is that the vulnerability of island life varies, not only from island to island, but from species to species. Vulnerability is a more variable factor than has generally been recognized.

Three recent studies in the Lesser Antilles have all emphasized the importance of limited accessibility as a basic reason for vulnerability (Harris, 1965; Watts, 1966; Merrill, 1958). While this may be true as far as animals are concerned, it seems unlikely that it is also true for plants. The Lesser Antilles are close to each other and to the continent of South America. Like the Bahamas, they are not inaccessible in the same way as Hawaiian Islands or the Galapagos. On the contrary, their accessibility has probably played an important role in decreasing their vulnerability to disturbance by man.

The Variable Intensity of Man's Impact

As a final point in this general discussion of the stability of the woodland, it should be emphasized that the human population density on Cat Island has always been low. As can be seen from Table 9, Cat is virtually uninhabited when compared to the islands of the Lesser Antilles. Barbados, for example, has 529 inhabitants per square kilometer, in contrast to only about 13 per square kilometer on Cat.

The significance of the low population pressure is that man's impact on wild vegetation has been less intense on Cat Island than it has been elsewhere. On Barbados, the woodland was almost completely cleared before the end of the seventeenth century (Watts, 1966: 45), and today some 50 percent of the cultivable land is permanently in sugar cane (Gourou, 1961: 211).

The high population densities that are characteristic of so many islands must be considered in any discussion of insular vulnerability. As Merrill (1958), Harris (1965), Watts (1966), and Kimber (1968) have indicated, the native plant and animal life of the Lesser Antilles has been drastically disturbed by man. The question arises, then, to what extent the degree of disturbance is due to an inherent vulnerability on the part of the plants and animals, and to

TABLE 9

AREA AND POPULATION OF SMALL WEST INDIAN ISLANDS, 1950-1958

(Gourou, 1961:208-209; *Sharer, 1955:92)

	Area in sq. km.	Population	Inhabitants per sq. km.
Barbados	431	235,000	529
Grenada	340	91,000	267
Martinique	988	239,000	240
Saint Vincent	340	81,000	238
Saint Thomas	68	14,000	205
Montserrat	80	14,000	177
Saint Christophe	175	30,000	169
Anguilla	85	14,000	164
Guadeloupe	1,503	229,000	150
Sainte Lucie	620	92,000	148
Tortula	30	7,000	140
Antigua	440	57,000	130
Saint Barthelemy	21	2,354	120
Saint Martin	52	5,377	103
Marie Galante	150	15,182	101
Nevis	140	11,300	88
Dominica	790	65,000	80
Sainte Croix	205	14,000	68
Desirade	27	1,654	46
CAT ISLAND*	240	3,000	13

what extent to the density of human population. In a sense it is misleading to compare the extent of change on a small, densely-populated island with that on comparatively uninhabited continental areas. Islands are vulnerable in the sense that they may become densely populated. This does not necessarily mean that island life is inherently more vulnerable to disturbance than that on the continents. The variable intensity of man's impact complicates any comparative analysis of insular vulnerability.

In conclusion, the stability of the woodland is the result of many factors. Basically, it reflects a long period of adaptation to natural disturbances: hurricanes, fires, sea-level change, erosion, and deposition. Because the woodland species are adapted to these various types of disturbance, man's impact has been less important than it would have been otherwise.

XIII. REVIEW AND CONCLUSIONS

The main purpose of this study was to determine the extent to which man has modified the vegetation of a small island in the Bahamas, Cat Island. In a broader sense, the question was considered whether or not the vegetation of Cat Island was vulnerable to culturally-induced disturbance in the same way as the vegetation of remote islands, such as the Hawaian Islands or the Galapagos.

The nature of man's impact on vegetation of Cat Island was determined by the use of both historical and ecological evidence. Particular attention was given to the mixed evergreen-deciduous woodland that covers most of the island.

The historical record for the Bahamas in general, and for Cat Island in particular, is frustratingly thin. Even so, the evidence recovered clearly shows that the Bahamas have not escaped the processes of change that have affected nearly all tropical islands during the period of human settlement. In the comparatively short period of a thousand years, the Cat Island woodland has been drastically disturbed by clearing, burning, selective cutting, grazing, and browsing. Unfortunately, the historical record is painfully qualitative and gives no clear indication as to what the consequences of this disturbance have been. In order to remedy this deficiency, a detailed analysis was made of the present woodland.

As no previous work of this kind had been attempted for this type of vegetation, it was necessary to develop what was basically a new methodology. With the aid of aerial photograph coverage for the years 1943 and 1958, 300 sampling sites were established, and at each site the percentage cover in 25 x 1 square meter quadrats was determined. These data were then analysed to determine the extent to which the floristic compostion of the woodland varied with respect to age and intensity of disturbance.

The most important conclusion to be drawn from the analysis was that the Cat Island woodland is remarkably well-adapted to withstand the types of disturbance introduced by man. This resilience is shown in three basic ways. First, a great number of native trees and shrubs are capable of quickly colonizing disturbed habitats as abandoned fields. Second, there is no evidence to suggest that any particular species has become extinct. And third, with few exceptions, alien plants have not been able to establish themselves in the woodland.

On the other hand, the woodland has not persisted unchanged since pre-settlement times. As a result of clearing, burning, selective cutting, grazing, and browsing, sensitive species have become rare, and have survived as important members of the woodland only in remote, relatively undisturbed areas. Conversely, weedy types have increased in importance; formerly restricted to naturally-disturbed or droughty habitats, they have expanded into the areas disturbed by man. This sequence of events is not a new one. The same changes have occurred wherever vegetation has been disturbed by man. What is unusual about the evergreen woodland is that such a large proportion of the species present are inherently weedy.

All of this does not mean that the hypothesis of insular vulnerability should be rejected. The high rate of extinctions on the Hawaiian islands and the Galapagos is indisputable evidence of vulnerability. The important point is that islands vary in their vulnerability as also do different species on any particular island.

The differences between the conclusions reached in this study and those reached in similar studies in the Lesser Antilles can probably be attributed to several factors. First, Cat Island has differed from many tropical islands in its persistently low population density. This has meant that man's impact on the vegetation has not been as severe as it has been elsewhere. Second, the Bahamas, because of their off-shore location, seasonal drought, and background of natural disturbance, are characterized by vegetation which is pre-adapted to withstand the kinds of disturbance introduced by man. And third, in view of the inadequacy of the historical record and the absence of any previous analysis of this type, it was necessary to develop a basically new methodology. This empirical approach prevented the easy acceptance of any theoretical interpretations.

Although small and insignificant in some respects, Cat Island has provided a useful setting for a study of man and vegetation change. In spite of a thousand years of discontinuous settlement, man's impact on the woodland has been surprisingly slight. What changes will occur in the future will depend largely on social and economic conditions in the colony. A decrease in the intensity of shifting agriculture will allow the woodland to continue its overall recovery. An increase will cause a reversion to conditions similar to those that existed in the late nineteenth century. Either way, the data gathered here will provide a useful base-line against which future change can be assessed.

ACKNOWLEDGMENTS

This study owes much to the help and encouragement of others. I am particularly indebted to J. Gordon Nelson, who first introduced me to the "Man and Vegetation Change" theme in the Rocky Mountains of western Canada. At the University of Wisconsin I was given the chance to explore the theme further, and received much help and sound advice from Jonathan Sauer, William Denevan, the late Andrew Clark, and Hugh Iltis. F.R. Fosberg of the Smithsonian Institution also gave valuable advice in the early stages of the project.

On Cat Island, the inhabitants of Wilson Bay and Arthurstown contributed a great deal to the success of the field work. Particular thanks are due to Japhet King, Constable Samuel Seymour, Ned Isaacs, and my constant companion in the bush, Isaac Dean Junior. Thanks are also due to the late Biddle Page and his wife Valerie for their generous hospitality. Bryce Scott also kindly provided accommodation on the island. In Nassau, Oris Russell, the Minister of Agriculture, was helpful in many ways. Thanks are also due to Gerald Isaacs, the Chief of Customs, for his help in obtaining authorization to import fieldwork equipment. It is a pleasure to acknowledge that the cost of field work was partly alleviated by a Research Assistantship and a Knapp Travelling Fellowship from the University of Wisconsin.

I completed the dissertation (Byrne, 1972) while at the University of Toronto, where I was a Lecturer in Geography at Erindale College. There I received valuable assistance in computer programming from Seigfried Schulte. Thanks are also due to Norman White, who drew all the maps and diagrams, and to Steve Jaunzems, who helped with many aspects of the photography.

The present text is a revised version of the Ph.D. dissertation, and for comments on style and content I would like to thank my father Henry Byrne, Jonathan Sauer, and F.R. Fosberg.

The camera-ready copy of the manuscript was typed on the Unix system at the University of California, Berkeley Computer Center by Lucille Oberlander and Dianne Byrne and for their efforts I am especially grateful.

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APPENDIX I.

A systematic list of the plant species encountered on Cat Island. The numbers without parentheses following the name are the collection numbers of voucher specimens deposited in the herbaria of the Arnold Arboretum, Harvard University, and the University of Wisconsin. Species without numbers are sight records. An asterisk indicates that the species was encountered in the old field study. The number in parentheses following these species represents the code number used to identify them during computer analyses.

ACANTHACEAE

* Anthacanthus spinosus (Jacq.) Nees, 534, (75).
Dicliptera assurgens (L.) Juss., 381.
Ruellia tuberosa L., 238, 553.

AIZOACEAE

Sesuvium portulacastrum L., 199.

ALISMATACEAE

Echinodorus berteroi (Spreng.) Fawc., 568.

AMARANTHACEAE

Achyranthes aspera (L.) Mill., 173.
Alternanthera paronychioides St. Hil., 328.
Amaranthus spinosus L., 547.
Centrostachys indica (L.) Standley, 173.
Gomphrena globosa L., 211.
Iresine diffusa H. & B. ex Willd., 580.
Philoxerus vermicularis (L.) P. Beauv., 456.

AMARYLLIDACEAE

Agave americana L., "Bamboo".
* A. sisalana Perrine, "Sisal", (104).
Hymenocallis declinata (Jacq.) M.J. Roem., 92.

ANACARDIACEAE

Mangifera indica L., "Mango".
* Metopium toxiferum (L.) Krug. & Urban., "Poisonwood," 38, 474 (49).
Spondias mombin L., "Hog plum".

ANNONACEAE

Annona glabra L., "Pond apple."
A. muricata L., "Soursop."
A. squamosa L., "Sugar apple," 41.

APOCYNACEAE

Anagadenia berterii (A. DC) Miers., "Lice root," 106,257, 476.
Echites umbellata Jacq., 14.
Catharanthus rosea (L.) G. Don., "Periwinkle."
Nerium oleander L.
* *Plumiera obtusa* L., "Milk bush," 249 (115).
* *Vallesia antillana* Woods., "Man root", 126 (39).

ASCLEPIADACEAE

Asclepias curassavica L., 398.
Calotropis procera (Ait.) Ait. f., 56.
Cryptostegia grandiflora R. Br., 469.
Cynanchum eggersii (Schlt.) Alain, 435.
C. northropiae (Schlecht.) Alain, 383.
C. sp. 490.

BATIDACEAE

Batis maritima L.

BIGNONIACEAE

Crescentia cujete L., 350.
* *Jacaranda coerulea* (L.), Griseb., "Clock bush" 252 (22).
* *Neobracea bahamensis* Britton, 422, 520 (110).
* *Tabebuia bahamensis* (Northrop) Britton, "Five finger," 302, 479, 485 (21).

BOMBACACEAE

Ceiba pentandra (L.) Gaertn.

BORAGINACEAE

* *Bourreria ovata* Miers., "Strong bark," 36, 54, 80, 113 (67).
* *Cordia bahamensis* Urban, "Black granny bush", 213, 415, 416 (11).
C. britttonii (Millsp.) Macbr., 311.
C. lucayana (Millsp.) Macbr., 455.

C. *sebestena* L.
* *Heliotropium angiospermum* Murr., "Scorpion tail", 1, 187, 544, (90).
H. *curassavicum* L., 59, 543.
H. *inaguense* Britton, 378.
Mallatonia gnaphalodes L., "Bay lavender", 20.
Tournefortia volubilis L., "Soldier vine".

BROMELIACEAE

Ananas comosus, "Pineapple".

BURSERACEAE

* *Bursera inaguensis* Britton, "Beau Kamalamay", 251 (37).
* B. *simaruba* Sarg., "Kamalamay", 52, 298 (36).

BUXACEAE

Buxus bahamensis Baker, "Boxwood," 445, 531.

CACTACEAE

* *Opuntia dillenii*, (Ker-Gawl), Haw., "Prickly pear" (94).

CANELLACEAE

Canella winterana (L.) Gaertn., 161.

CARICACEAE

Carica papaya L.

CASUARINACEAE

* *Casuarina equisetifolia* Forst., 91, (83).

CELASTRACEAE

* *Crossopetalum rhacoma* Crantz., 212, 439, (23).
* *Maytenus buxifolia* (A. Rich.), Griseb., 76, 228, (41).

CHENOPODIACEAE

Atriplex pentandra (Jacq.) Steud., 110.
Chenopodium murale L., 510, 545.
Salicornia perennis Mill., 108.

COMBRETACEAE

* *Conocarpus erecta* L., "Buttonwood", 22, 299, 300, (89).
Laguncularia racemosa (L.) Gaertn., 89.
Terminalia catappa L., "Indian almond."

COMMELINACEAE

Rhoeo spathacea (Desv.) Stearn

COMPOSITAE

Ageratum conyzoides L. spp. *latifolia* (Cav.) Johnson, 9, 327, 504.
A. muticum Girseb., 112.
Ambrosia hispida Pursh., 104.
A. paniculata Michx., 496.
Aster bahamensi Britton., 117, 577.
Bidens pilosa L., 204.
Borrichia arborescens (L.) DC., 72.
Chaptalia dentata (L.) Cass., 574.
Eclipta prostrata (L.) L., 575.
Emilia sonchifolia (L.) DC., 569.
Erigeron canadensis L., 197, 563.
Eupatorium bahamense Northrop, 407.
E. capillifolium (Lam.) Small, 589.
E. lucayanum Britton, 70.
* *E. villosum* Sw., "Bitter sage," 335, (2).
Flaveria linearis Jacq., 500.
F. trinervia (Spreng.) Mohr., 440.
Gaillardia pulchella Foug., 315.
Gochnatia bahamensis (Urb.) Howard & Dunbar, 256, 276.
G. ilicifolia Less., 312.
* *Gundlachia corymbosa* (Urb.) Brit., "Horsebush," 304,(32).
Iva imbricata Walt., 77.
Lactuca intybacea Jacq., 484.
Melanthera deltoidea Michx., 116.
Parthenium hysterophorus L., 172.
Pectis linifolia L., 450.
Pluchea purpurascens (Sw.) DC., 4, 333, 337.
P. rosea Godfrey, 526.
Porophyllum ruderale (Jacq.) Cass., 557.
* *Salmea petrobioides* Griseb., 406, (55).
Sonchus oleraceus L., 266, 540, 560.
Tridax procumbens L., 239.
Verbesina encelioides (Cav.) Benth. & Hook., 316.
Vernonia bahamensis Griseb., 419.
V. cinerea (L.) Less., 539.
* *Wedelia bahamensis* (Britton) O.E. Schulz, 102, 310, (106).
W. Trilobata (L.) Hitch., 508.

CONVULVULACEAE

Evolvulus alsinoides L., 405.
E. sericeus Sw., 265.
* E. squamosus Britton, "Broom bush", 17, 290, (4).
Ipomoea acuminata (Vahl) R.&S., 307.
I. batatas (L.) Lam., 404, 409, 458.
I. microdactyla Griseb., 465.
I. triloba L., 61, 146.
I. macrantha R. & S. 354.
Jacquemontia cayensis Brit., 436.
J. jamaicensis (Jacq.) Hall. F., 271, 377.
Merremia dissecta (Jacq.) Hall., 549.

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Bryophyllum pinnatum (Lam.) Kurz., 185.

CRUCIFERAE

Cakile lanceolata (Willd.) D.E. Schulz, 105.
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Abilgaardia monostachya (L.) Vahl, 181.
Cyperus elegans L., 366.
C.filiformis Sw., 511.
C. fulgineus Chap., 347.
C. ligularis L., 363.
C. odoratus L., 565.
C. planifolius L.C. Rich., 551.
Dichromena colorata (L.) Hitchc., 121.
Eleocharis cellulosa Torr., 119. 576.
E. geniculata (L.) R.&S., 389, 512.
Fimbristylis cymosa R.Br., 460.
F. dichotoma (L.) Vahl, 516, 523.
F. ferruginea (L.) Vahl, 63.
Mariscus jamaicensis (Crantz) Britton, 90.
Rhynchospora cyperoides (Sw.) Mart., 578.
R. stellata (Lam.) Griseb., 121.
Scleria lithosperma (L.) Sw., 152.

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EBENACEAE

* Diospyros caribaea (A.DC) Standley, 273, 462, (29).

ERYTHROXYLACEAE

* Erythroxylon areolatum L., 487, (18).
* E. rotundifolium Lunan, 255, 444, (17).

EUPHORBIACEAE

Acalypha alopecuroides Jacq., 593.
Argythamnia candicans Sw., 453.
A. lucayana Millsp., 515.
* Bernardia dichotoma Muell. Arg., 360, (78).
* Bonania cubana A. Rich., 486, (80).
Breynia nivosus (W. Smith) Small, 498.
Chamaesyce blodgetti (Engelm) Small, 69.
C. hirta (L.) Millsp. 167, 246.
C. hypericifolia (L.) Millsp., 167, 215, 247.
C. lechioides (Millsp.) Millsp., 431, 530, (119).
C. mesembrianthemifolia (Jacq.) Dugand, 10.
* Croton bahamensis Millsp., "Pepper bush", 451, (43).
* C. eluteria (L.) Sw., "Sweetwood bark", 35 214, 270, 483, (68).
* C. linearis Jacq., "Granny bush", 16, 432, 471, (25).
* C. lucidus L., 79, 95, (88).
C. rosmarinoides Millsp., 254.
* Drypetes diversifolia Krug & Urb., 382, 489, (15).
Euphorbia heterophylla L. 3, 64.
E. lactea Haw.
* Grimmeodendrom eglandulosum (Rich.) Urb., 112, 533, (112).
* Gymnanthes lucida Sw., "Crabwood", 424, 480, (12).
Hippomane mancinella l., "Manchineel."
Manihot esculenta Crantz.
Pedilanthus tithymaloides Poit., 497.
Phyllanthus acidus (L.) Skeels., "Otaheite gooseberry."
P. carolinensis Walt. ssp. saxicola (Small) Webster, 461.
* P. epiphyllanthus L., "Rockbush", 134, (53).
P. niruri L., 170.
Ricinus communis L., 160.
* Savia bahamensis Brit., 365, 446, 454, (56).

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* Banara reticulata Griseb., 155, (116).
Casearia bahamensis Urb., 275.
Xylosma ilicifolia Northrop, 591.

GENTIANACEAE

Eustoma exaltatum (L.) Griseb., 87.

Sabbatia stellaris Pursh., 525.

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* Scaevola plumieri (L.) Vahl., 19, (108).

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A. pertusus (L.) Willd., 371.
Aristida tenipes Cav., 359.
A. vilifolia Herit., 592.
Brachiaria subquadriparia (Trin.) Hitchc., 353, 538.
Cenchrus echinatus L., 26, 231.
C. tribuloides L., 208.
C. viridis Spreng., 13.
Chloris barbata (l.) Sw., 368.
C. gayana Kunth, "Rhodes grass", 342.
C. petraea (Sw.) Desv., 27.
C. sagraeana A. Rich., 536.
Cymbopogon citratus (D.C.) Stapf. f., "Lemon grass", 51.
Cynodon dactylon (L.) Pers., "Bermuda grass", 535.
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D. decumbens Steut., "Pangola grass", 343.
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Distichlis spicata (L.) Greene.
Eleusine indica (L.) Gaertn., 66.
Eragrostis ciliaris (L.) R.Br., 58, 144.
E. ciliaris (l.) R & Br. var. laxa Ktze., 388.
E. tenella (L.) Beauv. ex R. & S., 588.
Lasiacis divaricarta (L.) Hitch., 133, 227.
Leptochloa domingensis (Jacq.) Trin., 114.
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Panicum dichotomiflorum Michx., 386.
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Stenatophorum secundatum (Walt.) Kuntze, 561.

Trichachne insularis (L.) Nees, 505.
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Leonotis nepetaefolia (L.) R.Br., 495.
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Scutellaria havanensis Jacq., 503.
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* Nectandra coriacea Griseb., 514, 518, (42).
Persea americana Mill., "Avocado", 48.

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Abrus precatorius L., "Bead vine".
Acacia acuifera Benth., 356.
* A. choriophylla Benth., "Cassina", 430, 478, (9).
* A. farnesiana (L.) Willd., "Sail needle", 475, (97).
* Ateleia gummifera (DC.) Dietr., 357, (77).
* Caesalpinia bahamensis La., "Braziletto", 402, (81).
* C. ovalifolia Urb., "Nickers", 268, (107).
Cajanus cajan (L.) Millsp., "Pigeon pea", 148.
* Calliandra formosa (Dth.) Benth., 358, (114).
Canavalia rosea (Sw.) DC., "Sea Bean", 229, 338.
* Cassia bahamensis Mill., "Stinking pea", 124, (64).
* C. biflora L., (118).
C. diffusa DC., 392.
* C. lineata, 159, 288, (8).
C. obutsifolia L., 391.
C. occidentalis L., 124, 463.
C. tora L., 322.
Centrosema virginianum (L.) Benth. 146, 269, 334, 502.
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Desmanthus virgatus (L.) Willd., 306, 448.
Desmodium canum (Gmel.) Schinz & Thellung, 329.
D. glabrum (Mill.) DC., 552.

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Galactia rudolphioides (Gmel.) B. & H., 96, 305.
G. spiciformis T. & G., 336.
G. striata (Jacq.) Urb., 195.
Guilandina bonduc L., "Nickers", 268.
* Haematoxylum campechianum L., "Logwood", (92).
* Indigofera suffruticosa Mill., 318, (103).
* Leucaena leucocephala de Wit.,= L. latisiliqua (L.) Gillis., "Jumbay" 93, (35).
* Lysiloma bahamensis Benth., "Wild tamarind", 82, 284, (74).
* L. latisiliqua (L.) Benth., "Horseflesh", 191, 253, (33).
Macroptilium lathyroides (L.) Urb., 564.
Parkinsonia aculeata L., "Jerusalem thorn".
* Piscidia piscipula (L.) Sargent, "Dogwood", 34, (86).
* Pithecellobium keyense Britton "Ramshorn", 49, 81, 103, 200, 301, (52).
Rhynchosia Sp. 195.
Sophora tomentosa L., 287.
Stylosanthes hamata (L.) Taub., 82, 554.
Tamarindus indica L., 189, 233.
Tephrosia cinerea (L.) Pers., 321.

LILLIACEAE

Aloe barbadensis Mill
Sansevieria sp., "Bowstring hemp".
Smilax havanensis Jacq., 492.
Yucca aloifolia L., "Spanish bayonet".

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Linum bahamense North., 529.

LOGANIACEAE

Cynoctonium mitreola (L.) Brit., 528.
Spigelia anthelmia L., 293.

LYTHRACEAE

Ammania latifolia L., 562.

MALPIGHIACEAE

* Bunchosia glandulosa (Cav.) DC., 513, (82).
* Byrsonima lucida (Sw.) DC., 482, (7).
* Malpighia polytricha A. Juss., "Touch me not", 140, 587, (70).

Triopteris jamaicensis L., "Cough vine".

MALVACEAE

Abelmoschus esculenthus (L.) Moench "Okra".
Abutilon permolle (Willd.) Sweet, 144, 248, 494.
* *Gossypium barbadense* L., 427, (120).
Herissantia crispa (L.) Briz., 282.
Malvastrum corchorifolium (Desr.) Brit., 464, 501.
Melochia tomentosa L., 449.
Phymosia abutiloides (L.) Desv., 590.
Sida acuta Burm., 182, 194, 390.
S. ciliaris L., 101, 573.
S. spinosa L., 396.
S. urens L., 559.
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MELIACEAE

Melia azedarach L., "Pride of India".
* *Swietenia mahagoni* (L.) Jacq., 178, (38).

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Artocarpus altilis (Park.) Fosb., 570.
* *Ficus jacquinifolia* A. Rich, 468, (111).

MORINGACEAE

Moringa oleifera Lam., 506.

MUSACEAE

Musa paradisiaca L.

MYRICACEAE

Myrica cerifera L.

MYRSINACEAE

* *Rapanea guyanensis* Aubl., 452, (122).

MYRTACEAE

Eucalyptus tereticornis Sm., 517.
Eugenia axillaris (Sw.) Willd., 423.
* *E. buxifolia* (Sw.) Willd., 262, 289, (65).
* *E. longipes* Berg., "Sweet Margaret", 222, (85).
E. lucayana (Brit.) Alain, 250.

* *E. monticola* DC., 234, (66).
* *E. myrtoides* Poir., 295.
Psidium guajava L., 123, 169.

NYCTAGINACEAE

Boerhaavea coccinea Mill., "Hogweed", 165, 243.
Commicarpus scandens (L.) Standley "Rat ears", 216.
* *Torrubia longifolia* Britton, "Beefwood", 83, (1).
* *T. obtusata* (Jacq.) Brit., 519, (121).
Pisonia rotundata Griseb., 571.

NYMPHAEACEAE

Nymphaea ampla (Salisb.) DC. var. pulchella (DC.) Casp., 367.

OLACACEAE

Schoepfia chrysophylloides (Rich.) Planch, 395.
Ximenia americana L., 379.

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Forestiera segregata (Jacq.) Krug & Urb., 384,443.
Jasminum fluminense Vell., 546.
J. sambac Ait., 566.

ONAGRACEAE

Jussiaea suffruticosa L., 567.

ORCHIDACEAE

* *Epidendrum sp.*, 29, 224.

PALMAE

* *Coccothrinax argentea* Sarg., "Silver top", (60).
Cocos nucifera L.
* *Pseudophoenix vinifera* (Mart.) Becc., "Hog cabbage palm", (98).
* *Thrinax microcarpa* Sarg., "Buffalo top", (5).
* *Sabal palmetto* (Walt.) Lodd., "Pond top", (50).

PAPAVERACEAE

Argemone mexicana L., 33.

PASSIFLORACEAE

Passiflora cuprae L., 320.
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PLUMBAGINACEAE

Plumbago scandens L., 399.

POLYGALACEAE

* *Polygala obovata* Blake, "Strip me naked", 317, (100).

POLYGONACEAE

Antigonon leptopus H. & A., 372.
* *Coccoloba diversifolia* Jacq., "Pigeon plum", 46, 448, 491, (46).
* *C. krugii* Lind., 351, (47).
* *C. uvifera* Jacq. "Sea grape", (59).

PORTULACEAE

Portulaca oleracea L., 164.
P. rubricaulis H.B.K., 348.
Talinum triangulare (Jacq.) Willd., 244.

POTAMOGETONACEAE

Potomogeton heterophyllus Schreb., 582.

PUNICACEAE

Punica granatum L.,."Pomegranate".

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Auerodendron northropianum (Urb., 240.
Colubrina elliptica (Sw.) Briz., & Stern, 373.
* *C. ferruginosa* (Mill.) Sarg., 260, (124).
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* Krugiodendron ferreum (Vahl) Urban, "Ironwood", (34).
* Reynosia septentrionalis Urb., "Dollen plum", 47, (14).
Zizyphus taylori (Brit.) Johnston, 277.

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Rhizophora mangle L., 332.

ROSACEAE

Chrysobalanus icaco L., "Coco plum", 466.

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* Antirrhea myrtifolia Urb., 7, 221, (123).
Borreria laevis (Lam.) Griseb., 380.
* Casasia clusiaefolia (Jacq.) Urban, "Sea bob", 6, (58).
Catesbea parviflora Sw., 107, 292.
* Chiococca alba (L.) Hitchc., "Piss the bed", 210, 313, 417, (48).
C. pinetorum Brit., 524.
* Erithalis fruticosa L., "Black torch", 15, 220, 421, (3).
* Ernodea littoralis Sw., 3, 397, 555, 556, (87).
* Exostema caribaeum (Jacq.) Roem & Schult., "Prince-wood", 223, (51).
* Guettarda elliptica Sw., 232, 400, 401, (27).
* G. scabra (L.) Lam., (26).
* Hamelia patens Jacq., 467, (28).
* Phialanthus myrtilloides Griseb., "Candlewood", 441, 532, (95).
* Psychotria ligustrifolia (Northrop) Millsp., "Wild coffee", 209, (72).
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* Randia mitis L., "Fever bush", 122, 139, 278, 493, (20)/
Spermacoce confusa Rendle, 331.
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Strumpfia maritima Jacq., 1, 219.

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* Amyris elemifera L., "White torch", (57).
Citrus aurantifolia (Christm.) "Swingle lime".
C. aurantium L., "Bitter orange", 188.
C. limon (L.) Burm. f. "Lemon".
C. sinensis (L.) Osb."Sweet orange".
Fagara flava (Vahl.) Krug & Urban. "Satinwood".
* F. pterota L., "Wild Lime". 477, (73).
* Spathelia bahamensis Marie Victorin, 9, 225, 308, (99).

* Zanthoxylum coriaceum Rich. "Hercules Club", 420, (105).

SAPINDACEAE

* Exothea paniculata (Juss.) Radlk., 583, (19).
* Hypelate trifoliata Sw., "Soapbush", 230, (96).
Melicoccus bijugatus L. "Genip".
Serjania diversifolia (Jacq.) Radlk., 130, 157, 291.
* Thouinia discolor Griseb., "Three finger", 218, (69).

SAPOTACEAE

* Bumelia retusa Sw., 303, 338, 340, (6).
* Chrysophyllum oliviforme., "Wild saffron", 361, (102).
* Dipholis salicifolia (L.) A.DC., "Cassadawood", 186, 481, (13).
* Manilkara jaimiqui (Wright) Dubard, "Wild Dilly" 355, (101).
* Manilkara zapota (L.) V. Royen, "Sapodilly" 42, (113).
* Sideroxylon foetidissimum Jacq., "Mastic" 339, (40).

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Bacopa monnieri (L.) Pennell, 579.
Buchnera elongata Sw., 521.
Capraria biflora L., "Goat weed", 7, 542.

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* Alvaradoa amorphioides Liebm., 376, (76).
* Picramnia pentandra Sw., "Bitter bush", 584, (45).
Picrodendrom macrocarpum (A.Rich) Britton, "Olive", 323, 364.

SOLANACEAE

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Datura inoxia Mill, 594.
D. stramonium L., 585.
Nicotiana tabacum L., "Tobacco".
* Solanum bahamense L., "Canker berry", 28, 236, (61).
* S. erianthum D. Don., 81, 259, (62).
S. nigrum L., 150.

STERCULIACEAE

* Helicteres jamaicensis Jacq., 258, (30).
* H. semitriloba Bert., 349, (31).
* Melochia tomentosa L., 74, 285, (93).

Waltheria americana L., 68.
W. bahamensis Britton, 118, 374.
W. indica L., 375, 527.

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Suriana maritima L., 11.

THEOPHRASTACEAE

* *Jaquinia keyensis* Mex., "Joewood", 5, 274, (109).

TILIACEAE

* *Corchorus hirsutus* L., "Soapbush", 68, 226, (10).
C. siliquosus L., 403.
Triumfetta semitriloba L., 180.

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* *Turnera diffusa* Willd., 237, (63).
* *T. ulmifolia* L., 4, 8, 156, (117).

TYPHACEAE

Typha domingensis Pers.

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Trema lamarckiana (R. & S.) Blume, 286 (71).

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Anethum graveolens L., 449.
Centella erecta (L.) Fern., 548.

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Avicennia germinans (L.), "Black Mangrove", 179.
* *Callicarpa hitchcockii* Millsp., "Boarhog bush", 125, 279, (79).
* *Citharexylum fruticosum* L., 433, (84).
* *Duranta repens* L., 346, 411, (16).
* *Lantana bahamensis* Brit., "Goldenrod", 75, 263, 309, (24).
* *L. involucrata* L., "Sweet sage", 12, 261, 470, (54).
Lippia nodiflora (L.) Michx., 71, 572.
L. stoechadifolia (L.) H.B.K., 264.
* *Petetia domingensis* Jacq., "Banana wood", 125 (44).
Priva lappulacea (L.) Pers., 280.
Stachytarpheta fruticosa B.L. Robinson, 314.

S. jamaicensis (L.) Vahl., 190.

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Guaiacum sanctum L., "Lignum vitae", 370, (91).

APPENDIX II.

Index to common names of plants mentioned in the text.

Australian pine	Casuarina equisetifolia
Avocado	Persea americana
Bamboo	Agave americana
Barbados pride	Poinciana pulcherrima
Bay cedar	Suriana maritima
Bay geranium	Ambrosia hispida
Bay lavender	Mallatonia gnaphaloides
Bay marigold	Borrichia arborescens
Beans, bonavist	Dolichos lablab
Beans, colored	Phaseolus vulgaris
Beans, lima	Phaseolus lunatus
Beefwood	Torrubia longifolia
Black mangrove	Avicennia germinans
Black torch	Erithalis fruticosa
Boarhog bush	Callicarpa hitchcockii
Bowstring hemp	Sansevieria sp.
Boxwood	Buxus bahamensis
Brasiletto	Caesalpinia vesicaria
Breadfruit	Arctocarpus communis
Broom bush	Evolvulus squamosus
Brown ebony	Dalbergia ecastophyllum
Buffalo top	Thrinax microcarpa
Burr Grass	Cenchrus spp.
Buttonwood	Conocarpus erecta
Caribbean pine	Pinus caribea
Cashew nut	Anacardium occidentale
Cassada	Dipholis salicifolia
Cassava	Manihot esculenta
Cassina	Acacia choriophylla
Cattail	Typha domingensis
Coconut	Cocos nucifera
Coco plum	Chrysobalanus icaco
Coral tree	Erythrina corallodendrum
Corn	Zea mays
Cotton	Gossypium barbadense
Cow peas	Vigna unguiculata
Custard apple	Annona reticulata
Dildo	Cephalocereus millspaughii
Dilly	Manilkara zapota
Divi-divi	Caesalpinia coriaria
Dollen plum	Reynosia septentrionalis
Elephant grass	Pennisetum purpureum
Fever bush	Randia mitis
Five finger	Tabebuia bahamensis
Frangipani	Plumiera rubra

Genip	*Melicoccus bijugatus*
Ginger	*Zingiber officinale*
Granny bush	*Croton linearis*
Green ebony	*Brya ebenus*
Grease bush	*Corchorus hirsutus*
Guava	*Psdium guajava*
Hog cabbage	*Pseudophoenx vinifera*
Hog plum	*Spondias mombin*
Horsebush	*Gundlachia corymbosa*
Horseflesh	*Lysiloma latisiliqua*
Horseradish tree	*Moringa oleifera*
Indian almond	*Terminalia catappa*
Indigo	*Indigofera suffruticosa*
Ironwood	*Krugiodendron ferreum*
Jerusalem thorn	*Parkinsonia aculeata*
Joewood	*Jaquinia keyensis*
Johnson grass	*Sorghum halepense*
Jumbay	*Leucaena leucocephala*
Kamalamay	*Bursera simaruba*
Lemons	*Citrus limon*
Lignum vitae	*Guiacum sanctum*, G. *officinale*
Lime	*Citrus aurantifolia*
Logwood	*Haematoxylum campechianum*
Love vine	*Cassytha filiformis*
Madeira	*Dipholis salicifolia*
Mahoe	*Thespesia populanea*
Mahogany	*Swietenia mahogani*
Mango	*Mangifera indica*
Manroot	*Vallesia antillana*
Mastic	*Mastichodendron foetidissimum*
Melon, musk	*Cucumis melo*
Melon, water	*Colocynthis citrullus*
Milkberry	*Bumelia retusa*
Milkweed	*Chamaesyce mesembrianthemifolia*
Morning glory	*Ipomoea pes-caprae*
Nickers	*Guilandina bonduc*
Onion	*Allium cepa*
Otaheite gooseberry	*Phyllanthus distichus*
Pangola grass	*Digitaria decumbeus*
Para grass	*Panicum muticum*
Paw paw	*Carica papaya*
Pigeon berry	*Rhacoma crossapetalum*
Pigeon peas	*Cajanus cajan*
Pigeon plum	*Coccoloba diversifolia*
Pineapple	*Ananas comosus*
Poinciana	*Delonix regia*
Poisonwood	*Metopium toxiferum*
Pomegranate	*Punica granatum*
Pond apple	*Annona glabra*
Pond top	*Sabal palmetto*
Pride of India	*Melia azaderach*

Princewood	Exostema caribaeum
Ramshorn	Pithecellobum keyense
Red mangrove	Rhizophora mangle
Rhodes grass	Chloris gayana
Sail needle	Acacia farnesiana
Salve bush	Pluchea rosea
Sandbox tree	Hura crepitans
Sawgrass	Mariscus jamaicensis
Sea bean	Canavalia maritima
Sea bob	Casasia clusiaefolia
Sea grape	Coccoloba uvifera
Sea lily	Hymenocallis declinata
Sea oats	Uniola paniculata
Sea pork	Sesuvium portulacastrum
Silver top	Coccothrinax argentea
Simon finger	Tabebuia bahamensis
Sisal	Agave sisalina
Soap bush	Corchorus hirsutus
Sorghum	Sorghum vulgare
Sours	Citrus aurantium
Spanish bayonet	Yucca aloifolia
Squash	Cucurbita sp.
Star grass	Leptochloa plechtostachya
Strong back	Bourreria ovata
Sugar apple	Annona squamosa
Sweet gale	Myrica cerifera
Sweet margaret	Eugenia longipes
Sweet orange	Citrus sinensis
Sweet potato	Ipomoea batatas
Sweet sage	Lantana involucrata
Sweetwood bark	Croton eluteria
Tamarind	Tamarindus indica
Tobacco	Nicotiana tabacum
Tomatoes	Lycopersicon esculentum
Wattle	Eugenia spp.
White mangrove	Laguncularia racemosa
White torch	Amyris elemifera
Wild cinnamon	Canella alba
Wild lime	Fagara pterota
Wild locust	Lysiloma bahamensis
Wild tamarind	Lysiloma bahamensis
Wild tobacco	Pluchea rosea
Yellow wood	Fagara flava

APPENDIX III

Data Sheet used during Analysis of Oldfields

CAT OLD FIELD DATA

Field Number____________

Photo Reference__________

Age Class_______________

Habitat-Type_____________

Height Class_____________

Soil-Type_______________

Moisture Class___________

Grazing Class____________

Species No.	Area	Species No.	Area	Species No.	Area	Species No.	Area	Species No.	Area
001		026		051		076		101	
002		027		052		077		102	
003		028		053		078		103	
004		029		054		079		104	
005		030		055		080		105	
006		031		056		081		106	
007		032		057		082		107	
008		033		058		083		108	
009		034		059		084		109	
010		035		060		085		110	
011		036		061		086		111	
012		037		062		087		112	
013		038		063		088		113	
014		039		064		089		114	
015		040		065		090		115	
016		041		066		091		116	
017		042		067		092		117	
018		043		068		093		118	
019		044		069		094		119	
020		045		070		095		120	
021		046		071		096		121	
022		047		072		097		122	
023		048		073		092		123	
024		049		074		099		124	
025		050		075		100		125	

APPENDIX IV.

A list of the minor species encountered in each habitat-type and each age-class. Species are listed in order of importance.

WHITELAND

Maximum cover value in age-class 1 (less than 5 years).

1. _Croton linearis_
2. _Turnera ulmifolia_
3. _Wedelia trilobata_
4. _Croton eluteria_

Maximum cover value in age-class 2 (5-14 years).

1. _Salmia petrobiodes_
2. _Cassia lineata_
3. _Cordia bahamensis_
4. _Chamaesyce lechiodes_
5. _Ernodia littoralis_
6. _Melochia tomentosa_
7. _Amyris elemifera_
8. _Phyllanthus epiphyllanthus_

Maximum cover value in age-class 3 (15-29 years).

1. _Piscidia piscipula_
2. _Caesalpinia ovalifolia_
3. _Calliandra formosa_
4. _Bursera simaruba_
5. _Gossypium barbadense_
6. _Bursera inaguensis_
7. _Bunchosia glandulosa_
8. _Solanum bahamense_
9. _Agave americana_
10. _Helicteres semitriloba_
11. _Scaevola plumierii_
12. _Cassia bahamensis_
13. _Fagara pterota_

Maximum cover value in age-class 4 (30-50 years).

1. _Sabal palmetto_

Maximum cover value in age-class 5 (more than 50 years).

1. _Jaquinia keyensis_
2. _Antirrhoea myrtifolia_

FLATLAND

Maximum cover value in age-class 1 (less than 5 years).

1. *Guettarda scabra*
2. *Lantana involucrata*
3. *Corchorus hirsutus*
4. *Cassia lineata*
5. *Wedelia trilobata*
6. *Cordia bahamensis*
7. *Guettarda elliptica*
8. *Trema lamarckiana*
9. *Psychotria ligustrifolia*
10. *Solanum eriathum*
11. *Croton eluteria*
12. *Thrinax microcarpa*
13. *Chrysophyllum oliviforme*
14. *Helicteres semitriloa*
15. *Duranta repens*
16. *Anthacanthus spinosus*
17. *Petitia domingensis*
18. *Solanum bahamense*
19. *Hamelia patens*
20. *Caesalpinia ovalifolia*
21. *Colubrina ferruginosa*
22. *Banara reticulata*
23. *Ficus jacquinifolia*

Maximum cover value in age-class 2 (5-14 years).

1. *Coccoloba krugii*
2. *Tabebuia bahamensis*
3. *Leucaena leucocephala*
4. *Eugenia monticola*
5. *Randia mitis*
6. *Erithalis fruticosa*
7. *Eugenia buxifolia*
8. *Malphigia polytricha*
9. *Eupatorium villosum*
10. *Phyllanthus epiphyllanthus*
11. *Turnera ulmifolia*
12. *Calliandra formosa*
13. *Torrubia obtusata*
14. *Croton lucidus*
15. *Croton bahamensis*
16. *Neobracea bahamensis*
17. *Picramnia pentandra*
18. *Callicarpa hitchcockii*
19. *Opuntia dillenii*

Maximum cover value in age-class 3 (15-29 years).

1. *Reynosia septentrionalis*
2. *Maytenus buxifolia*
3. *Diospyros caribaea*
4. *Fagara pterota*
5. *Exostema caribaeum*
6. *Ernodea littoralis*
7. *Gymnanthes lucida*
8. *Lantana bahamensis*
9. *Cassia bahamensis*
10. *Turnera diffusa*
11. *Agave americana*
12. *Nectandra coriacea*
13. *Crossopetalum rhacoma*
14. *Melochia tomentosa*
15. *Casasia clusiaefolia*
16. *Bernardia dichotoma*
17. *Evolvulus squamosus*
18. *Helicteres jamaicensis*

Maximum cover value in age-class 4 (30-50 years).

1. *Bourreria ovata*
2. *Dipholis salicifolia*
3. *Thouinea discolor*
4. *Piscidia piscipula*
5. *Conocarpus erecta*
6. *Cassia biflora*
7. *Coccoloba uvifera*
8. *Erythroxylon rotundifolium*
9. *Grimmeodendron eglandulosum*
10. *Coccothrinax argentea*
11. *Sabal palmetto*
12. *Manilkara emarginata*
13. *Spathelia bahamensis*
14. *Jaquinia keyensis*
15. *Erythroxylon areolatum*

Maximum cover value in age-class 5 (more than 50 years).

1. *Byrsonima lucida*
2. *Swietenia mahagoni*
3. *Amyris elemifera*
4. *Chiococca alba*
5. *Savia bahamensis*
6. *Plumiera obtusa*
7. *Pseudophoenix vinifera*
8. *Drypetes diversifolia*
9. *Jacaranda coerulea*
10. *Exothea paniculata*
11. *Krugiodendron ferreum*
12. *Brumelia retusa*

13. *Ateleia gummifera*

BLACKLAND

Maximum cover value in age-class 1 (less than 5 years).

1. *Leucaena leucocephala*
2. *Fagara pterota*
3. *Corchorus hirstus*
4. *Eugenia monticola*
5. *Lantana bahamensis*
6. *Cassia bahamensis*
7. *Randia mitis*
8. *Cordia bahamensis*
9. *Wedelia trilobata*
10. *Phyllanthus epiphyllanthus*
11. *Melochia tomentosa*
12. *Psychotria ligustrifolia*
13. *Cassia biflora*
14. *Anthacanthus spinosus*
15. *Exothea paniculata*
16. *Trema lamarckiana*
17. *Malphighia polytricha*
18. *Jacaranda coerulea*
19. *Indigofera suffruticosa*
20. *Calliandra formosa*
21. *Solanum bahamense*
22. *Turnera ulmifolia*
23. *Croton eluteria*
24. *Evolvulus squamosus*
25. *Croton bahamensis*
26. *Vallesia antillana*
27. *Haematoxylum campechianum*
28. *Banara reticulata*
29. *Coccothrinax argentea*
30. *Neobracea bahamensis*

Maximum cover value in age-class 2 (5-14 years).

1. *Lantana involucrata*
2. *Croton linearis*
3. *Maytenus buxifolia*
4. *Exostema caribeum*
5. *Eupatorium villosum*
6. *Chiococca alba*
7. *Croton lucidus*
8. *Guettarda elliptica*
9. *Agave americana*
10. *Sabal palmetto*
11. *Atelia gummifera*
12. *Nectandra coriacea*

13. *Cassia lineata*
14. *Heliotropium parviflorum*
15. *Bunchosia glandulosa*

Maximum cover value in age-class 3 (15-29 years).

1. *Tabebuia bahamensis*
2. *Piscida piscipula*
3. *Erithalis fruticosa*
4. *Diospyros caribaea*
5. *Thrinax microcarpa*
6. *Crossopetalum rhacoma*
7. *Petitia domingensis*
8. *Citharexylum fruticosum*
9. *Turnera diffusa*
10. *Eugenia longipes*
11. *Caesalpinia bahamensis*
12. *Bumelia retusa*
13. *Helicteres jamaicensis*
14. *Helicteres semitriloba*
15. *Spathelia bahamensis*

Maximum cover value in age-class 4 (30-50 years).

1. *Dipholis salicifolia*
2. *Thouinea discolor*
3. *Gymnanthes lucida*
4. *Eugenia buxifolia*
5. *Bursera inaguensis*
6. *Lysiloma latisiliqua*
7. *Savia bahamensis*
8. *Solanum erianthum*
9. *Casasia clusiaefolia*
10. *Conocarpus erecta*
11. *Erythroxylon areolatum*
12. *Polygala obovata*
13. *Plumiera obtusa*

Maximum cover value in age-class 5 (more than 50 years).

1. *Amyris elemifera*
2. *Coccoloba kruggii*
3. *Sideroxylon foetidissimum*
4. *Manilkara zapota*
5. *Torrubia obtusata*
6. *Guettarda scabra*
7. *Pseudophoenix vinifera*
8. *Ficus jaquinifolia*
9. *Coccoloba uvifera*
10. *Erythroxylon rotundifolium*
11. *Chrysophyllum oliviforme*
12. *Rapanea guyanensis*
13. *Krugiodendron ferreum*
14. *Picramnia pentandra*

15. *Zanthoxylum coriaceum*
16. *Guaiacum sanctum*
17. *Byrsonima lucida*

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