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A REVIEW OF THE NATURAL HISTORY OF THE MARSHALL ISLANDS

BY

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This review was prepared on very short notice, to provide a summary of what is known to the reviewer at the time, June 1988, about the natural phenomena of the Marshall Islands. This was for the use of the members of the survay team sent to the Marshalls by the Environmentand Policy Institute of the East-West Center, Honolulu. Their mission was to investigate the remaining relatively natural areas and the extent of biodiversity in the new Republic of the Marshall Islands.

The Marshall Archipelago has been the habitat of Aboriginal man for many hundreds, perhaps even thousands, of years. Hence there is very little, if any, undisturbed land remaining.

Since the coming of the Europeans, in the 19th Century, and especially in the years 1940 to the present, the disturbance and change have been greatly intensified. On four of the Atolls, namely, Eniwetok, Bikini, Kwajalein, and Majuro, the alteration has been catastrophic. Change is so rapid that even a superficial account of what was observed during the early and mid 1950's seems worth placing on permanent record.

This account is definitely not the results of a systematic literature search, but merely what is stores in the reviewer's head and in his notebooks, with such additions as are acknowkedged in the text. The account has been slightly, but not thoroughly, edited for more general publication, but its semi-popular level has not been changed, nor have all references to the Survay been deleted.

ACKNOWLEDGEMENT

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Contents

INTRODUCTION

This compilation is intended to summarize the physical geography and natural history of the Marshall Islands, explaining the natural features and diversity in these islands as they form the environment of the human populations found there - the Marshallese people.

Emphasis is on the natural environment, only briefly describing those environmental features resulting from human activities. The purpose is to explain the natural diversity in this environment and make possible an understanding of the influence of this diversity on the evolution and nature of the indigenous Marshallese culture, and to indicate such areas as still show viable examples of these features, after perhaps several thousand years of changes wrought by this culture, itself, and a hundred and fifty years of accelerated change under the increasing influence of Western European (including American) influence. In the past few years there has been an abrupt popular awakening of the importance of preserving and maintaining as much as practical of the natural diversity in the human environment.

Realization of this importance has led to a request for scientific advice as to the location and nature of the remaining areas of relatively unaltered environments in the Marshalls. This summary is intended to serve as background data to guide field investigations to determine the present extent and status of areas that may be worthy of selection as protected areas.

In order to serve both the field investigators sent out by the Environment and Policy Institute of the East-West Center, and perhaps cooperating agencies, and the Marshallese policy-makers, the language is deliberately less technical than might be necessary for strictly scientific communication and background information. It also may include material that might seem obvious and unnecessary to the scientific users. Its scope is perhaps overly limited by the extent and knowledge of and familiarity with the islands and the intention of the compiler. If this results in omission of material of importance, the users have his apologies. Certain geographical items, peripheral to the main purposes of this compilation, and the names of some animals that may be rare or endangered are not readily available, or would necessitate time-consuming research. Hence there may be gaps that would not be tolerable in a paper originally intended for scientific publication. The details in the descriptions of Wotho Atoll, transcribed with some editing, from the compilers field notes may seem excessive, but since it amy be the only available detail description of moist, semi-natural coral atoll

the skeletons, form vast quantities of calcareous debris which fill the interstices of the reef-lattice and depressions in the surfaces. Consolidation by cementation and by growth of encrusting organisms, of these lattices and sediments forms what are known as coral-reefs, and which are seen as spectacular and often incredibly beautiful phenomena in shallow tropical seas. These also form habitats and hiding places for myriads of softer species of plants and animals which are also members of these living communities.

The term atoll, strictly speaking, refers to a usually irregularly ring-shaped reef with one to many "islets", areas above high tide level, lying on it. This reef-ring encloses a (usually) sea-water lake or "lagoon," connected, in most cases, with the sea by one or more deep channels or "passes" and/or by small shallow channels called (in the Tuamotu language) "hoa."

On most islets just inland from the top of a beach or hard-rock shore, lies a low (usually 1-2 m) ridge of sand or gravel called a beach ridge. These ridges are much less well-developed, or even absent, on lagoon-sides of islets. Occasional stretches of beach-ridge, have cobbles and even boulders of coral limestone, in some places piled up forming higher ridges to even 5-8 (-10) m, considered to have been thrown up by storms or hurricanes. In some places there are several concentrically parallel such ridges, the older ones inland, the newer or fresher ones seaward, representing several storms. Occasional huge blocks or boulders are found well-inland, apparently thrown there by tsunamis ("tidal waves") or by hurricane waves.

The interior of most islets is low, flat and sandy. Seaward the texture may become coarser, and areas of exposed lithified breccia or conglomerate occur, probably formed during a post-glacial warm period with higher sea-level. The material of this structure, reef plus islets, is entirely of calcium carbonate, except for occasional pebbles of pumice, thrown up on the beaches by waves after floating from far-away volcanoes, perhaps such as Krakatau. Occasional bones of turtles and even whales may be found, buried or exposed.

The terms "coral," "coral-sand," "coral-rock," or "coral limestone" are general ones, referring to limestone materials of various textures and degrees of lithification, of organic origin, and comprising in addition to true corals, calcareous algae, foraminiferal tests, mollusk shells, sponge spicules, and fine unidentifiable triturated, precipitated, or crystalline calcium - or calcium magnesium carbonate. Inland, in addition to such carbonate materials, are occasionally found beds of lithified calcium phosphate

or "atoll phosphate rock" (discussed at greater length below).

GEOLOGICAL ORIGIN OF ATOLLS

The curious ring-shaped arrangement of atoll reefs has long excited the curiosity of observers - geographers, geologists, biologists, and interested laymen, alike. Much has been written on the subject, a literature far too extensive to summarize here. Suffice it to say that an idea first suggested by Charles Darwin well over a century ago, and gradually confirmed since amid much controversy, has developed to a concensus among qualified workers in all of the above scientific disciplines. This, expressed here very briefly, maintains that oceanic coral atolls began as volcanic islands, around which fringing coral reefs formed. This was followed by extremely slow subsidence, either isostatic or tectonic of the volcano or its remnants. Coral and algal growth is much more rapid in the turbulence zone on the seaward edges of the reefs, resulting in these outer edges keeping up with the rate of subsidence, while the slower growing inner areas become submerged. Such shallow water areas are termed "lagoons.* This slowness of growth may be contributed to by fresh water and silt draining from the land, not favoring many of the organisms living in lagoons. Many lagoon organisms, such as sea-grasses, also do not have calcareous skeletons, hence do not contribute material for upward growth of lagoon floors.

The loose sediments that occur on reef surfaces, especially in rough weather, and especially in storms and hurricanes, tend to be piled up as sand-bars on the reef surfaces. These tend to shift with waves and currents, but some surfaces are exposed above high-tide level. Also, in the inter-tidal zones of beaches not-altogether-understood process forms consolidated, outward sloping beds of rock called "beach-rock." This tends to stabilize these bars. Terrestrial plants gain footholds, forming salt-resistent vegetation, which holds the loose sediments together, lessening both wind and water erosion. Sand islets or cays are thus formed. Another process, formerly subject of much controversy, is eustatic (world-wide) fluctuation of sea-level. It seems well established that a few thousand years ago during a post-glacial warm period, melting occurred on the world's ice-caps and glaciers, resulting in a 2-meter or more rise over the present sea-level. This allowed reefs to grow to somewhat above their present elevation. Sand cays would have formed on these higher surfaces. With world-wide cooling, or other conditions leading to increase in ice-caps and glaciers, the sea-level receded downward. This not only favored the persistence of the sand-islets but left consolidated reef-rock and beach-rock lying as much as 2

meters above present sea level. Many islets in Marshall Island atolls are partly constructed of platforms of limestone as well as loose sediments.

There is even a suggestion, by traces of still higher limestone on atolls, mostly elsewhere in the world, but also in one locality on Pokak (Taongi), northernmost of the Marshalls, that there may have been an even higher, to 3.5 meters, earlier sea-level. This may have been post-glacial, but the traces may be remnants from higher reefs formed during a warm inter-glacial period before Wisconsin Glacial time.

If the above scenario is well-founded, there may have been a period, not too many millenia ago, when the Marshall Islands were mainly shoals over-washed by waves of the sea. Anyhow, there seems little doubt that the Marshalls were formed by subsidence of ancient volcanoes. Deep drillings, down 1,000+ meters to volcanic bedrock under coral-limestone on Bikini and Eniwetok atolls in the northern Marshalls, have confirmed Darwin's subsidence theory beyond a doubt.

GEOLOGY

A summary of the geology of these atolls will not be attempted here, as such features are covered by geography, soils and hydrology. Geology has only an indirect, though not unimportant, influence on biogeography. Much of what is known is contained in the enbrmous series of accounts in the great series of monographs included in U.S. Geological Survey Professional Paper 260 A-II (Emery et al. 1954 to 1969), in the Military Geography of the Northern Marshall Islands (Fosberg et al. 1956), and in Terrestrial Sediments and Soils of the Northern Marshall Islands (Fosberg and Carroll 1965). Summarizing these and related papers is far beyond the scope of this compilation.

CLIMATE

An account of the Marshall Islands climate adequately dealing with how it fits into and results from the global and Pacific atmospheric circulation, temperature and evaporation patterns, is beyond the scope of this summary. This discussion will be confined only to the tangible or observable results of these patterns which have direct influences on the occurrence and behavior of the organisms that live in and around the islands. And even this much is on a rather superficial level. To do anything further would require a major chapter or even a book-length account, and would delay this summary until its purpose would not be accomplished.

A major restriction on what may be said locally is a

scarcity and spottiness of meteorological records. On only a few atolls these are ample, if not adequate or of long duration. Much of what can be said about the climatic pattern is inferred from the vegetation, and this is limited by the human-caused alteration of the vegetation during the post-European time, essentially the last hundred years. Coconut plantations are not very sensitive indicators of climatic differences.

The striking feature of the regional Marshallese climate is a north-south gradient of increasing rainfall. The northern tier of atolls can be said to have an effectively semi-arid climate. Pokak, the northernmost shows a physiognomy that elsewhere might be considered semi-desert, though its rainfall (unmeasured as yet) may approach that of U.S. western prairie or even Middle Atlantic states. Two or perhaps three factors may contribute to this appearance. Almost perfect drainage due to the porosity of the soil, salt spray and saline ground-water, and probably high evapo-transpiration (generally about 200 mm/year) due to continuous tropical temperatures, and wind are jointly responsible.

Luxuriance, indicating higher and less seasonal rainfall, increases southward to Ebon, southernmost atoll, less than 5o N latitude, which may have had, before alteration, almost a rain forest physiognomy. It is in the equatorial high-rainfall belt. Hence the effects of other climatic variables may be damped or obscured.

A second important climatic feature is the position of the archipelago in the Northeast Trade Wind belt. During the greater part of the year the prevailing winds are from the north-east to the east, and are moisture-laden, though there is no high physiographic relief to bring about orographic dumping of this moisture. Trade-wind showers are frequent except in the northernmost atolls. These winds are also strong enough to carry quantities of salt-spray across the flat expanses of the islands from turbulence at the windward reef margin.

Salinity is an important factor in any atoll situation, especially in drier places where the salt is not washed down into the ground water and flushed out. This salinity has a strong bearing on many natural and human phenomena.

The constantly high, not strongly variable tropical temperatures, influence evaporation, and cold is scarcely a limiting factor on biological activity here.

Finally, tropical storms and hurricanes (locally called typhoons) occur, though not as frequently as farther west. When they occur, they sweep up from the south, exerting

their force from all directions, and pour down great quantities of rainfall. They are strong enough to uproot or break trees and to defoliate and often kill trees that are left standing. No one has even estimated their effects on animal life. Among their conspicuous effects are those caused by their generation of powerful waves that may sweep completely across narrow islets and carry tremendous loads of limestone sediments from the ocean margins onto the land, greatly influencing micro-topography and soil textures, and may completely wash away some islets. Damage to human structures and crops may be complete.

As yet, there seem to be no discussions of "El Niño" effects specifically on the Marshall Islands, but it seems likely that the occasional droughts, especially in the northern atolls, may be results of this phenomenon. Exceptionally high rainfall does not result this far west. Typhoons may be generated farther east during El Niño years because of increasibg sea surface temperatures in the equatorial eastern Pacific.

SOILS

Taking as the definition of a soil "loose or soft materials on the earth's surface capable of supporting plant growth," atoll islets are mostly covered by soils. Even in bare platform surfaces there are crevices and sand-pockets where plants find a foothold. We can exclude the intertidal zone of beaches where the combination of movement and salinity seems to prevent establishment of plants. However, shallow mud and sand supports mangrove vegetation, rocky intertidal shores are covered by algae, reef-flats have a felt of green algae, and lagoon bottoms support sea-grass beds and certain algae, especially Caulerpa and expanses of Halimeda. No one seems to have treated these marine substrata as soils, excepting perhaps mangrove peat. They do cover substantial areas in the Marshalls, but have not been classified or described in soils terminology. Here we afford them only this brief recognition.

Terrestrial soils have had more attention (Stone 1951a, b, c; 1953a,b), (Fosberg 1954, 1957a,), (Fosberg, Arnow & MacNeil 1956), (Fosberg & Carroll 1965), (Hatheway 1952), (Sachet 1955). Modern specialized nomenclature has not been applied to the simple assortment of atoll soils and will not be attempted here. Several soil series have been described and named in the Marshalls, and will be briefly enumerated.

The simplest soil frequently found on Marshall Island coral islets apparently has no series name. It is almost pure white or pink coral sand, with no darkened A horizon nor any trace of a B deposition-horizon. This is, of

course, the youngest of all the atoll soils, deficient in most nutrient elements except calcium. It is found on beach-ridges and dunes.

The Shioya Series is of slightly altered coral sand and small gravel, with a somewhat darkened thin A horizon, with circum-neutral reaction. This is the most generally distributed and least differentiated soil series in the Marshalls, as well as in most other coral atolls and back-beach flats on high islands. It may be recognized by its generally light brownish-gray color, sandy texture and complete lack of coherence or structure.

The Arno Atoll Series is a comparatively well-developed soil with a friable usually fine-textured black A horizon, with a circum-neutral reaction, lacking a B horizon, and with light brownish-gray to buff colored C horizon not sharply set off from the coral sand or gravel, or consolidated platform parent limestone material. This series is found in the interior of larger moist to wet islets. The type locality is on Arno Atoll.

The Jemo Series is a rather localized, remarkable soil found only in association with Pisonia forest vegetation. It is characterized by a conspicuous A-0 horizon of pure mor-like raw humus with a definite acid reaction, variable in thickness to as much as 30 cm, no well-developed A-1 horizon but usually a transition to either a B or a C horizon, a notable but discontinuous B horizon which is either a crumbly highly phosphatic mixture of humus and coral sand or a hardpan of indurated "atoll phosphate rock," usually 5-20, rarely to 60 cm thickness, overlying a C horizon transitional to parent material of coral sand or gravel. The hardpan is found where there are or have been sea-bird rookeries and nesting colonies in Pisonia forest. It is formed by cementation of coral-sand particles by a brown calcium-phosphate precipitate, from acidified and dissolved phosphatic guano, washed down through the acid mor and neutralized by the coral sand. Subsequent leaching by percolation of acid solution of calcium phosphate gradually replaces the carbonate radicle in the lime sand particles by phosphate radicle, until in extreme old samples an almost pure calcium phosphate or hydroxyl-apatite remains. This process, at least in the Marshall Islands, only takes place under a pure or practically pure stand of the tree Pisonia grandis, which produces an acid raw humus which forms faster than it decomposes, thus accumulates to form an A-0, or humus horizon. In places where in pre-European time there were such stands of Pisonia forest, but which have been destroyed and replaced by coconut plantations, there often remain areas of truncated Jemo soils with the A-0 horizon missing and the phosphatic hardpan, in a weathered

condition, exposed on the surface. Known occurrences of Jemo soils, outside the Marshalls, are found even as far away as the Seychelles, in the Western Indian Ocean.

In the dry northern islands, such as Rongerik and Ailinginae, there apparently exists another soil series, unnamed and not yet described in print. This has never been studied and is only known from one or two poor manuscript profile descriptions and field observations on soil pits dug for other reasons. It has a brown granular A horizon. Its description and localization awaits investigation of these poorly known uninhabited northern atolls. It seems to be associated with a scrubby poor mixed forest, perhaps semi-deciduous in extreme dry seasons. Perhaps it may be a very attenuated Arno Atoll Series variant.

In all of the above-described soils, test pits frequently show "buried profiles" or at least buried traces of A horizons, sometimes even more than one in the same pit. A relatively recent example of such burial, exposed in a pit dug on Bikar Islet, suggests that these buried profiles result from storm waves or tsunamis sweeping vast amounts of coral-sand and debris over existing soils to such depth that a new soil development is initiated above the old buried one. The fact that huge coral-rock boulders are occasionally found well inland shows that waves carrying much suspended coral debris are not too unusual to account for known buried horizons.

Apparently no detailed soil mapping has been done in the Marshalls.

HYDROLOGY

Standing fresh-water is a rarity in the Marshall Islands. Running water is totally lacking except briefly during heavy rain-storms. Fresh ground-water does exist on most islets of any extent except in the very driest northern extremes of the archipelago. The ancient Marshallese, in all probability, knew of this and utilized it. Certainly they did in historic times, digging shallow wells, and making depressions down to the water table, close to mean tide-level, for taro cultivation.

In recorded geographical literature Charles Darwin, in an usually unnoticed passage in his Journal of Researches (new ed. pp. 452-453), was probably the first person to note the existence of fresh-water lenses of ground-water on coral atoll islets. Nothing much further was said about this phenomenon until the later 1940's (Fosberg 1948, 1949) and early 1950's (Cox 1951, 1953), (Cox, Davis & Wentworth 1951), (Fosberg, Arnow & MacNeil 1956) when extensive

investigations were carried out in various of the Marshall atolls.

It is now well-known that shallow Herzberg (or Ghyben-Herzberg) lenses of fresh-water float on the heavier sea-water in the porous interiors of atoll islets, except the very smallest and very driest. This diffuses out at beach level and is replenished by rainfall. This fresh-water is certainly responsible for the continued existence of deep-rooted plants such as trees on atolls. It can be reached by digging a few feet down into the interior of almost any atoll islet except those that have the soils underlain by platform rock. The water encountered is normally potable, though "hard" (limey).

VEGETATION

(See also Fosberg, F. R., 1953, Vegetation of Central Pacific atolls, a brief summary, A.R.B. 23.

The obvious present day vegetation of the Marshall Islands, as of most other coral atolls, is a forest of coconut palms (Cocos nucifera L.). This, of course, is a planted forest, and it has replaced most of the original natural vegetation of the islands. In addition to the area now occupied by the coconut plantations, the Marshallese brought other areas under cultivation. Pits for taro cultivation were dug down to below the fresh-water table in the interiors of the larger islets. Filled with muck, created from decomposing vegetable matter, they are planted to Colocasia and Cyrtosperma, the principal and most edible taro genera, as well as minor bits of sugar cane and a few marsh plants useful as food and medicines. Still other areas were cleared and occupied by villages and associated human sites. Western man has come and replaced or altered large areas of vegetation with his military, commercial and government installations. His war and weapons testing activities have altered entire atolls. Areas seriously altered, especially those now occupied or utilized by man are generally characterized by low biodiversity. This is because most of the native plants and animals have been eliminated, replaced by a relatively few planted or naturalized species, most of them not especially well adapted to the saline, highly calcareous atoll environment. Most are pioneer species, widely distributed weeds and "tropical tramps", or domesticated species dependent on the presence and protection of man. These, even though making up a significant part of the biota, and present in some cases in enormous numbers, are not the primary subject of this compilation, and in most cases will not be mentioned except as they may have a significant effect on the ecosystems described.

The object of the present effort is to indicate the nature and present location of such remnants of native ecosystems as may still exist. It is largely based on observations made 20 to 40 years back, hence some of what will be mentioned may now be gone. By describing them and indicating where they were and in what kinds of places, either the same examples may be relocated or similar other ones may be located. By revisiting and restudying some of these sites change may be documented and the dynamics of atoll ecosystems be better understood. Methods of protecting those set aside as natural areas may be better designed.

No record remains of the true original Marshall Islands vegetation. The Marshallese have been in the region for several thousands of years. Although they unquestionably altered the biota and environmental conditions, they probably had reached an equilibrium with the environment and most of the original species likely survived. Change has been more drastic since Europeans, Japanese and Americans have been in charge.

By studying what still remains we may mentally reconstruct something resembling the original ecosystems, except for components now extinct. By understanding and reestablishing favorable environmental conditions, we may rescue and redevelop some of the biodiversity with which the Marshallese lived in some measure of harmony.

Since vegetation is the most obvious and visible portion of most terrestrial, and some aquatic and marine, natural ecosystems, they will be characterized by their vegetation. And other components, when known, will be mentioned or discussed as appropriate.

The Mixed Broadleaf Forest is, as in most tropical areas, the most common and most obvious type of vegetation in undisturbed places in the Marshalls. On small tropical islands this is usually a low to medium stature forest with a closed canopy. In the Marshalls, as in other low coral atolls, it is composed of varying proportions of a small number of tree species, a few shrubs and a sparse to dense herb layer, again of a few species. Epiphytes are present in the wetter southern atolls, but there are very few species.

One of the principal situations in which the mixed broad-leaf forest survives is in the "wind-breaks." There are crescent shaped strips of forest on the windward sides of islets, especially those on windward parts of the reef, left more or less intact to protect the coconut plantations

and taro-pits from wind-blown salt spray. This cultural practice is a very beneficial one, both as a reservoir of natural diversity and in facilitating food and copra production in the difficult atoll environment.

Where the strip of vegetation left as a wind-break is fairly wide, the inner part may be reasonably typical broad-leaf forest of Tournefortia argentea, Guettarda speciosa, Pisonia grandis, Pandanus tectorius, Allophylus timoriensis, Cordia subcordata, Hernandia sonora and a few other less common species. Lepturus repens, Thuarea involuta, Fimbristylis cymosa and Polypodium scolopendria are common herb species. The outer fringes of these strips are mostly wind-sheared scrub of Scaevola sericea, Suriana maritima, and Tournefortia, sloping from the forest down to the top of the beach.

Birds are seen around these areas, especially reef-herons and occasional white terns and noddies. Birds are more common in inverse proportion to the closeness of human habitations and activities. Of course, the insects snails and other invertebrates associated with the plant species may survive here as well as their plant hosts.

The relative abundance of the tree species varies a great deal locally and in places single species may dominate or even form pure stands. Such forests which are completely dominated by one species are here treated as distinct vegetation types and described as such. Such mono-specific forest types, though common in temperate and colder climates, are not usual in the tropics. They are here probably a response to stressful environments and to the fewness of species in the atoll floras. In the case of forests of Neisosperma oppositifolia, the pure stands may be final stages in succession. The dense shade created by the Neisosperma and the ability of its seedlings to survive in its shade may give the species a crucial advantage, leading to its eventually succeeding the mixed forest in certain habitats.

Neisosperma forest was a fairly frequent type in the interiors of islets, at least in the somewhat moist northern atolls. It may also have existed in wetter southern atolls but has not been observed there by us. The trees are tall, with clear trunks up to several dm diameter, and have dense rounded crowns of large dark green leaves. The ground is commonly covered by a dense stand of seedlings of this species 1-2 dm tall, apparently in a state of arrested or at least slowed-down development. Here and there in such stands of these trees, we have observed spots where the canopy is thin and chlorotic. Here a few shrubs suoh as Allophyllus timoriensis may gain a foothold, but no reason

for these areas has come to our attention.

Pisonia grandis forest is another pure-stand type, formerly very common and wide-spread in the Marshalls and throughout the Indo-Pacific coral islands. The trees reach enormous size to 30 m tall and with trunks to 2 m diameter, and even larger; pale and smooth-barked, of very soft brittle wood. Very little or no undergrowth and practically no herbs exist here. The ground is covered by a brown spongy layer of "raw-humus" or "mor" of semi-decomposed leaf-litter, acid in reaction, as described above under soils, Jemo Series. This is indeed an uncommon phenomenon in lowland tropics and not found under Pisonia grandis in mixed forest, where the litter is not pure Pisonia. The shade here is almost as dense as in the Neisosperma forest. The Pisonia, though capable of reproducing from seed, does not produce a layer of seedlings in a Pisonia stand, but large fallen branches and trunks strike root where they touch ground, if sufficient moisture is available, and give rise to new young trees. This forest is favored as a roosting and nesting site by several tree-nesting sea-birds.

Although Pisonia forest may have been the most frequent and widespread forest type on Indo-Pacific atolls, ease in clearing and fertile soils made it the most susceptible to alteration to coconut plantation. Now it is one of the more rare types and in most parts of the Marshalls has disappeared, leaving behind traces in the nature of truncated Jemo soils, indicated by weathered bedded phosphate rock.

Tournefortia argentea dominates areas especially on narrow islets in the drier northern atolls. This species is one of the principal pioneers on new sand and gravel bars, denuded islets, and abandoned clearings. The trees reach a large size, and stands of it tend to be of only one generation, replaced by other species of trees and the vegetation changing to mixed broad-leaf forest. In climatically dry areas there are open stands of Tournefortia of scrub-forest stature, with an herb-layer of Lepturus and locally, Sida fallax, Portulaca spp. and Fimbristylis cymosa.

On hard limestone platform areas Pemphis acidula forms very dense pure forests of rather low stature. The trees are often close together, tangled and difficult to traverse. Fringes of this species line rocky shores along passes and other places where the sand and gravel may have been washed away.

Stands of Suriana maritima scrub line certain sandy shores, forming narrow strips of this one species,

resembling Pemphis in habit but greener in color and with more flexible, less rigid branches.

Sandy shores and berms are, however, much more likely to support stands of Scaevola sericea. Pure bright green-leafed tangled scrub of Scaevola 1-2 m tall, and much interlaced, are also found on narrow ends of islets and in places where storms may have destroyed former vegetation.

Other species that occasionally form small stands are Barringtonia asiatica, Cordia subcordata, and Dodonaea viscosa. These will be pointed out, where known, in the accounts of individual atolls.

Mangrove vegetation is not very extensive in the Marshall Islands, but does occur. Poorly developed and impoverished mangrove swamps are known on Jaluit, Arno, and Ailinglapalap atolls in the southern and wettest parts of the group. Northward mangroves, especially Bruguiera, are found mostly in inland low wet spots, termed "mangrove depressions." These are, at least in some cases, probably the result of planting of the propagules of Bruguiera by the Marshallese, who had uses for the trees. They form dense pure stands, but do not spread where there is no connection with the sea. Various scrub types occur, pure stands and mixtures of various shrub species and juveniles of tree species. Scaevola sericea is the most ubiquitous, followed by juvenile Tournefortia. Allophylus timoriensis is widespread but less common, as also Dodonae viscosa. Sida fallax dominates certain open drier areas, but is easily shaded out.

Most of the herbaceous species occur principally as herbaceous components of forest or scrub types, but several may form pure or mixed usually small stands in openings and in theinterior of dry northern islets. Lepturus repens is the only one to dominate sizeable areas, especially on Pokak Atoll. It is a bunch-grass that also produces loose tangles of wiry stolons or runners. It is one of the earliest pioneers on bare sand and gravel, and its seeds are carried by floating on water, wind, and birds.

Boerhavia, of several ill-distinguished species, is common on both open and shaded ground, and especially where birds are nesting. Similarily, Tribulus cistoides is most frequent in sea-bird colonies, its long runners, grayish leaves, bright yellow flowers and "puncture-vine" fruits are characteristic.

Tacca leontopetaloides, a tall herb with dissected leaves, fistulose stems and petioles, potato-like tubers, and leathery greenish flowers in umbels on top of long

peduncles, forms open stands here and there both in open sunny places and in coconut plantations.

Small patches of several Portulaca (purslane) species are common, especially in openings.

Fimbristylis cymosa is very common in open or crowded pure stands in pioneer situations, such as back-beaches, sand flats, and even in coconut plantations.

Sea-grasses are very rare in the Marshalls, only two stands of Thalassia hemorichii being known from shallow water in Ujelang and Ailinglapalap Atolls. Other stands probably exist, but have not been reported. This seems to be the eastern limit of Thalassia in the Pacific.

Several cryptogamic formations should be mentioned, three of them terrestrial and three marine, though many more marine algal communities might be defined if serious attention were directed to the problem.

The identifiable terrestrial formations are three.
(1.) An algal crust, of several Myxophyta, almost universally found on undisturbed loose coral sand, the sand grains, to a few mm depth, stuck together by the gelatinous sheaths of the algal cells and filaments. The crust is gray and friable when dry, soft and flexible greenish gray when wet. This may be a source of fixed nitrogen for the various pioneer ecosystems in which these crusts occur.
(2.) On pebbles, cobbles, boulders, and lithified limestone surfaces exposed to light is a layer of the limestone penetrated to up to 5 mm or more by endolithic, boring Myxophyta. These appear as a graying or blackening of the limestone surfaces (upper surfaces only, of pebbles, cobbles, and boulders), and a greenish zone on broken edges. This layer seems universal on these coral-limestone surfaces above high tide level.
(3.) On coral sand flats, and also on flat exposuras of lithified limestone, after rain or heavy dew, abundant colonies of Nostoc appear, abundant enough to cover the ground by large hollow pads or bubble-like dark brownish-green masses, gelatinous in nature, drying black when exposed to the sun. Nostoc is known to fix nitrogen, suggesting another nutrient source for pioneer ecosystems on atolls.

The algal ridge on the outer edge of windward exposures of fringing and barrier reefs is composed principally of stony species of Porolithon, smooth or rough, depending on the species. This is the actively growing, wave-resisting part of the reef, and contributes perhaps a preponderant part of the calcium carbonate of a windward reef.

The algal felt which covers the smooth almost imperceptibly sloping surface of the reef-flat on the windward side of windward islets, at or just below mean low-tide level, is a dominant stand of branching filamentous green algae of several genera, Microdictyon okamurae, Neomeris vanbosseae, Cladophoropsis zollingeri, and red algae of the genera Laurencia and Jania. Many other small algae are less common components of this wide-spread formation. This algal felt is the home of several abundant genera of foraminifera which are principal contributors to the pink sand so abundant in Marshall Island beaches.

Another recognizable, but poorly studied algal vegetation type is the "meadow" of Halimeda spp. on lagoon bottoms. The flake-like segments of this segmented calcareous green alga are the most abundant components of many, if not most, lagoon-bottom sediments, and of some fossil limestone facies.

Many other communities of marine algae remain to be studied and defined in recognizable terms (perhaps some have been in literature that I have not seen). A proper algal flora, or at least an annotated check-list of Marshall Islands algae is much desired. With such a basis, meaningful marine synecology could be arewarding enterprise.

LIST OF THE INDIGENOUS, POSSIBLY OR PROBABLY INDIGENOUS VASCULAR PLANTS KNOWN FROM THE MARSHALL ISLANDS, AND THOSE BELIVIED TO BE ABORIGINAL INTRODUCTIONS

Low coral islands, generally, have very small floras, compared with even moderately elevated islands. The reasons for this are a bit complicated and some of them are matters of some disagreement, as well as their relative importance. I will give, very briefly, my own views on this.

First, and most obvious, is that the plants must be able to tolorate considerable salinity, from salt spray and the occasional flooding by storm waves. This restricts the possible floras considerably. There is also the considerable likelihood that all low coral islands without any elevated limestone (feo in the Tuamotus), were completely submerged during the "post-glacial xerothermic period," when the world-wide sea-level was several meters higher than at present. If this is the case, the present floras are the results of colonizations within the last few thousands of years. The Marshall Islands have little or no elevated limestone of more than 1-2 meters. The third factor is isolation. Many atolls, including the Marshalls, are separated from continents and high islands, source areas of insular floras, by hundreds, often many hundreds, of

miles. Long-distance dispersal and successful establishment is, statistically, an infrequent occurrence. Low nutrient status (Fosberg and Carroll 1965) is another limiting factor. The soils of coral islands, derived from almost pure calcium carbonate, with some added guano, are generally very low in some of the minor nutrients, such as iron. Many plants do not thrive in such nutrient-poor situations.

One of the difficult problems in determining the number of native species is how to know that a species is or is not indigenous. Seldom do we have records of when a widespread species arrived. Many are obviously not native, but early collections show that some such have been in the Marshalls for a long time. In this compilation we have indicated the species as indigenous [I], of probably aboriginal introduction [A], and probably or possibly introduced by natural means, or doubtful [D]. Species marked [D] should be disregarded in estimating real natural diversity.

This compilation lists the species by the names that I consider correct. Some of these names may be unfamiliar, but to list all the synonyms would unduly extend the time the compilation required. Further information may be found in the three installments of our Geographical Checklist of Micronesian Plants (Fosberg, Sachet, and Oliver 1979, 1982 and 1987). The following additional symbols or abbreviations for habit and occurrence are indicated as appropriate:

Te - terrestrial
Ep - epiphytic
Aq - aquatic
Tr - tree
Sh - shrub
Vi - vine or creeper
Gr - grass
He - herb
Fe - fern
A - abundant
C - common or frequent
L - local
0 - occasional
R - infrequent or rare

Application of some of these categories may be somewhat subjective, matters of judgement or opportunity for observation.

The genera are listed in the Dalle Torre & Harms sequence (slightly modified) familiar in most of American floras.

Psilotum nudum (L.) Beauv.
Eniwetak, Kwajalein, Majuro, Jaluit, Arno, Mejit.
(I] He, Tr, Fe, 0-L

Ophioglossum pendulum L.
Namorik, Mili, Jaluit, Ebon.
[I] He, Ep, Fe, 0-L

Asplenium nidus L.
Ailinginae, Kwajalein, Ailinglapalap, Majuro, Jaluit, Namu, Ebon.
[I] He, Te, Exp, Fe, L-A

Nephrolepis acutifolia (Desv.) Christ
Ailinglapalap, Majuro, Arno, Jaluit, Ebon, Namu.
[I] He, Ep, Fe, 0-L

Nephrolepis biserrata (Sw.) Schott
Ebon.
[D] Fe

Nephrolepis hirsutula (Forst. f.) Presl
Kwajalein, Jaluit, Kili.
[D] He, Te, Fe, L

Polypodium scolopendria Burm. f.
Ailinginae, Taka, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Likiep, Aur, Ailinglapalap, Majuro, Arno, Jaluit, Ebon, Eniwetak, Namorik, Wotje.
[I] He, Te, Fe, C

Pteris tripartita Sw.
Namorik, Jaluit, Ebon.
[I] He, Te, L

Thelypteris interrupta (Willd.) Iwatsuki
Arno, Jaluit, Ebon.
[I] He, Te, Fe, L-A

Vittaria incurvata Cav.
Namorik, Mili, Jaluit.
[I] He, Ep, Fe, L

Pandanus tectorius Parkinson (sens. lat.)
Bikar, Eniwetak, Bikini, Rongelap, Rongerik, Ailinginae, Taka, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likiep, Aur, Majuro, Ailinglapalap, Namu, Arno, Kili, Jaluit, Ebon, Wotje, Mejit.
[I, A] Tr, Te, C
Edible varieties planted, propagated vegetatively.

Thalassia hemprichii (Ehrenf.) Aschers.

Ujelang, Ailinglapalap, Jaluit, Ebon.
[I] He, Aq, L-R

Centosteca [Centotheca] lappacea (L.) Desv.
Jaluit
[D] He, Te, Gr, R

Digitaria ciliaris (Retz.) Koel.
Rongelap, Kwajalein.
[D] He, Te, Gr, L

Digitaria radicosa (Presl) Miq.
Taka, Utirik, Kwajalein, Arno.
[I] He, Te, Gr, 0

Digitaria setigera

Cyperus odoratus L.
Eniwetak, Lae, Jemo, Likiep, Ailuk, Kwajalein, Namu, Jaluit, Mejit, Wotje, Ailinglapalap, Ebon.

Digitaria setigera Roth
Eniwetak, Bikini, Ailinginae, Rongelap, Wotho, Lae, Utirik, Ujae, Kwajalein, Ailuk, Jemo, Likiep, Majuro, Arno, Jaluit.
[I] He, T, Gr, C

Lepturopetium marshallense Fosb. & Sachet
Eniwetak.
[I] He, Te, Gr, R
The only Marshallese endemic plant.

Lepturus gasparricensis Fosb.
Pokak.
[I] He, T, Gr, L-C
Endemic to Pokak and Wake Island.

Lepturus repens (Forst. f.) R. Br.
Pokak, Bikar, Eniwetak, Bikini, Ailinginae, Rongelap, Rongerik, Taka, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likiep, Aur, Ailinglapalap, Majuro, Arno, Jaluit.
[I] He, Te, Gr, A
The commonest, most ubiquitous plant in the Marshalls.

Oplismenus hirtellus (L.) Beauv.
Majuro, Eniwetak.
[D] He

Oplismenus compositus (L.) Beauv.
Majuro, Arno, Jaluit, Ebon.
[D] He, Te, Gr, L

Growing in shade away from sea.

Setaria pallide-fusca (Schum.) Stapf. & Hubb.
Eniwetak
[D] He, Te, Gr, L-A

Stenotaphrum micranthum (Desv.) Hubb.
Ujelang, Arno, Jaluit.
[D] He, Te, Gr, L-A

Thuarea involuta (Forst. f.) R. Br. ex R. & S.
Eniwetak, Bikini, Ailinginae, Rongelap, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Likiep, Aur, Ailinglapalap, Majuro, Arno, Jaluit, Namu, Wotje, Mejit, Ebon.
[I] He, Te, Gr, C

Zoysia matrella (L.) Merr.
Jaluit.
[D] He, Te, Gr, L

Cyperus javanicus Houtt.
Likiep, Majuro, Jaluit, Mejit, Ebon, Eniwetak, Namu.
[I] He, Te, L

Cyperus kyllingia Endl.
Arno, Jaluit.
[D] He, Te, L

Cyperus odoratus L.
Wotho, Lae, Kwajalein, Ailuk, Likiep, Ailinglapalap, Majuro, Arno, Jaluit, Namu.
[D] He, Te, L-C
Common in wet places.

Cyperus polystachyos Rottb.
Kwajalein, Majuro.
[D] He, Te, L

Eleocharis geniculatus (L.) R. & S.
Kwajalein, Ailuk, Likiep, Arno, Jaluit, Mejit, Ebon.
[I] He, Te, L-A
Locally abundant in wet places.

Fimbristylis cymosa R. Br.
Eniwetak, Bikini, Rongelap, Taka, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Likiep, Mejit, Aur, Ailinglapalap, Majuro, Arno, Namorik, Jaluit, Ebon, Namu.
[I] He, Te, A

Cocos nucifera L.
Bikar, Eniwetak, Bikini, Rongelap, Rongerik, Taka,

Utirik, Ujelang, Ujae, Lae, Kwajalein, Jemo, Ailuk, Likiep, Wotje, Maloelap, Aur, Ailinglapalap, Majuro, Arno, Kili, Jaluit, Ebon, Ailinginae, Mejit, Erikub, Namu.
[A] Tr, Te, A
Principal economic plant.

Alocasia macrorrhiza (L.) G. Don
Ujelang, Kwajalein, Ailuk, Mejit, Majuro, Arno, Kili, Jaluit, Ebon, Namu.
[A] He, Te, 0

Colocasia esculenta (L.) Schott
Lae, Likiep, Aur, Jabwot, Ailinglapalap, Majuro, Arno, Kili, Jaluit, Ebon.
[A] He, Te, L
Formerly a very important food plant, grown in muck-filled marshy pits or depressions.

Cyrtosperma chamissonis (Schott) Merr.
Wotho, Ailuk, Likiep, Majuro, Arno, Kili, Jaluit, Ailuk, Wotje Mejit.
[A] He, Te, L
Formerly an important food plant, grown in muck-filled marshy pits or depressions.

Cordyline fruticosa (L.) Chev.
Kwajalein, Likiep, Jaluit, Ebon.
[A] Sh, Te, L-C

Crinum bakeri K. Schum. (or Engler ?)
Rongelap, Utirik, Wotho, Likiep, Ailinglapalap, Majuro, Mili, Jaluit.
[A] He, Te, L
Cultivated, known only from the Marshalls but probably brought by the Marshallese, but possibly a cultivar of local origin from Crinum asiaticum L.

Tacca leontopetaloides (L.) 0. Ktze.
Eniwetak, Bikini, Ailinginae, Rongelap, Rongerik, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likiep, Aur, Ailinglapalap, Majuro, Arno, Kili, Jaluit, Namu.
[A] He, Te, C
Tubers used as food but not or rarely planted, spontaneous.

Dioscorea alata L.
Jaluit
[A ?] He, Vi, Te, L
Cultivated only?

Dioscorea bulbifera L.
Majuro

Musa sapientum L.
Ujae, lae, Kwajalein, Ailuk, Maloelap, Aur, Ailinglapalap, Majuro, Arno, Kili, Jaluit, Namu.
[A] He, Te, C
A series of sterile clones, planted for food, grown in sheltered places only.

Curcuma longa L.
Jaluit.
[A] He, Te, L-R

Casuarina equisetifolia L.
Kwajalein, Likiep, Jaluit
[A ?] Tr, Te, 0

Peperomia gibbonsii C. DC.
Ailinglapalap
Same as P. ponapensis?

Peperomia ponapensis C. DC.
Lae, Ailinglapalap, Mili, Jaluit, Ebon.
[I] H, Te, L-0

Peperomia volkensii C. DC.
Ebon.
Same as P. ponapensis?

Ximenia americana L.
Eniwetak, Bikini, Ujae, Lae, Arno.
[I] Tr, Sh, Te, R

Artocarpus altilis (Park.) Fosb.
Eniwetak, Bikini, Rongelap, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likiep, Mejit, Aur, Ailinglapalap, Maloelap, Majuro, Arno, Mili, Namorik, Kili, Jaluit, Ebon, Wotje.
[A] Tr, Te, C
An important food plant, many cultivars.

Artocarpus mariannensis Trec.
Eniwetak, Rongelap, Utirik, Ujae, Lae, Ailuk, Likiep, Arno, Jaluit, Ebon, Majuro, Namorik, Bikini, Mejit, Wotje, Ebon, Jemo.
[A] Tr, Te, C
Many hybrids with A. altilis.

Ficus microcarpa L.f.
Kwajalein (possibly introduced)
[D] Tr, Ep, Te, R

Ficus tinctoria Forst. f.
Ailinglapalap, Majuro, Jaluit.

[I] Tr, Te, 0
On Majuro said to have been brought from the Gilbert Is.

Laportea interrupta (L.) Chew
Jaluit.
[D] He, Te, R

Laportea ruderalis (Forst. f.) Chew
Eniwetak, Bikini, Ailinginae, Rongelap, Taka, Utirik, Ujelang, Ujae, Lae, Ailuk, Jemo, Likiep, Wotje, Ailinglapalap, Majuro, Arno, Jaluit, Kili, Mejit, Jwajalein, Namu.
[I] He, Te, C

Pipturus argenteus (Forst.f.) Wedd.
Ujelang, Ujae, Lae, Kwajalein, Wotje, Mili, Ailinglapalap, Majuro, Arno, Jaluit, Namu, Ujelang.
[I] Tr, Sh, Te, C

Procris pedunculata (Forst.) Wedd.
Jaluit, Ebon
[I] He, Te, Ep, L-0

Achyranthes canescens R. Br.
Bikini, Rongelap, Taka, Uterik, Jemo
[I] He, Te, L

Boerhavia albiflora Fosb.
Eniwetak, Bikini, Rongelap, Rongerik
[I] He, Cr, Te, C

Boerhavia repens L. (s. 1.)
Bikar, Eniwetak, Bikini, Rongerik, Taka, Utirik, Ailuk, Likiep, Jaluit
[I] He, Vi, Te, 0

Boerhavia tetrandra Forst. f.
Eniwetak, Bikini, Ailinginae, Rongelap, Rongerik, Taka, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Jemo, Likiep, Mejit, Aur, Arno, Namorik, Jaluit, Ailuk, Majuro, Wotje
[I] He, Vi, Te, C

Pisonia grandis R. Br.
Pokak, Eniwetak, Bikini, Ailinginae, Rongelap, Rongerik, Taka, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likiep, Ailinglapalap, Kili, Arno, Jaluit, Majuro, Namu, Wotje
[I] Tr, Te, C-L-A
Probably formerly dominant on many islands, now very locally so.

Sesuvium portulacastrum (L.) L.

Kwajalein
[D] He, Vi, L-0

Portulaca australis Endl.
Eniwetak, Bikini, Rongelap, Rongerik, Utirik, Ujelang, Kwajalein, Ailuk, Likiep, Majuro, Arno, Jaluit, Mejit, Wotho, Ebon, Wotje
[I] He, Te, 0

Portulaca johnii v. Poelln.
Mejit, Wotje
Doubtfully distinct from P. lutea.

Portulaca lutea Sol. ex Forst. f.
Pokak, Bikar, Eniwetak, Bikini, Ailinginae, Rongelap, Utirik, Wotho, Likiep, Ailuk
[I] He, Te, L-C

Portulaca oleracea L.
Eniwetak, Bikini, Rongelap, Taka, Ujae, Kwajalein, Majuro, Arno, Jaluit, Wbtje
[D] He, Te, C

Cassytha filiformis L.
Eniwetak, Bikini, Ailinginae, Rongelap, Rongerik, Taka, Utirik, Mejit, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likiep, Aur, Ailinglapalap, Majuro, Arno, Jaluit, Namu, Wotje
[I] He, Vi, Ep, C-A
Parasite on many host plants.

Hernandia sonora L.
Bikini, Ujelang, Lae, Kwajalein, Likiep, Ailinglapalap, Majuro, Arno, Jaluit, Ebon, Namu, Wotho
[I] Tr, Te, L-C

Rorippa sarmentosa (Forst. f. ex D.C.) Macbride
Arno, Jaluit
[I] He, Te, L-0

Caesalpinia bonduc (L.) Roxb.
Ujae, Jaluit, Ailuk, Mejit, Wotje
[I] Vi, Te, L-R
All or mostly seedlings from drift seeds.

Caesalpinia major (Medic.) Dandy & Exell
Lae, Kwajalein, Arno
[I] Vi, Te, L-R
All or mostly seedlings from drift seeds.

Canavalia cathartica Thou.
Eniwetak, Rongelap, Ujelang, Ujae, Wotho, Lae,

Kwajalein, Jemo, Likiep, Ailinglapalap, Arno, Jaluit, Majuro
[I] Vi, Te, C

Canavalia rosea (Sw.) DC.
Majuro, Mejit, Ebon, Eniwetak
[I] Vi, Tr, R

Canavalia sericea A. Gray
Wotje, Ailinglapalap, Majuro, Arno
[I] Vi, Te, 0

Entada phaseoloides (L.) Merr.
Jaluit, Eniwetak
[I] Vi, Te, R
Drift seeds, one germinated.

Erythrina variegata L.
Kwajalein, Likiep, Jaluit
[D] Tr, Te, 0

Intsia bijuga (Colebr.) 0. Ktze.
Ujae, Wotho, Lae, Kwajalein, Ailinglapalap, Majuro, Jaluit, Ebon
[I] Tr, Te, L-0

Mucuna urens Medic.
Ailuk, Ebon
Drift seeds that sometimes germinate but do not survive.

Sophora tomentosa L.
Bikini, Ujelang,.Ujae, Likiep, Kwajalein, Ailinglapalap, Majuro, Arno, Jaluit, Wotje, Ebon
[I] Sh, Te, 0

Vigna marina (Burm.) Merr.
Ujelang, Ujae, Wotho, Lae, Kwajalein, Likiep, Aur, Ailinglapalap, Majuro, Ebon, Arno, Jaluit, Namu, Mejit, Wotje
[I] He, Vi, Te, C
Bears nitrogen-fixing nodules.

Tribulus cistoides L.
Eniwetak
[I] He, Vi, Te, L-R
Often found in terrestrial sea-bird rookeries elsewhere, rarely seen in Marshalls.

Suriana maritima L.
Eniwetak, Bikini, Ailinginae, Rongelap, Rongerik, Taka, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Likiep, Aur, Ailinglapalap, Arno, Kili, Jaluit, Mejit, Wotje
[I] Sh, T, C-L-A

Often dominant in shore vegetation, especially on sandy shores.

Soulamea amara Lam.
Bikini, Rongerik, Utirik, Ujae, Wotho, Lae, Kwajalein, Ailuk, Ailinglapalap, Arno, Likiep, Wotje, Ebon
[I] Sh, Tr, Te, 0

Euphorbia chamissonis (Kl. & Gke.) Boiss.
Eniwetak, Bikini, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Likiep, Aur, Ailinglapalap, Arno, Majuro, Jaluit, Namu, Mejit, Wotje
[I] He, Te, C-L-A

Allophylus timoriensis (DC.) Bl.
Bikini, Ailinginae, Rongelap, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Aur, Ailinglapalap, Majuro, Arno, Mili, Jaluit, Mejit, Wotje, Ebon, Likiep
[I] Sh, Te, C

Dodonaea viscosa L.
Bikini, Likiep, Wotje
[I] Sh, Te, L-C

Triumfetta procumbens Forst. f.
Bikar, Eniwetak, Bikini, Ailinginae, Rongelap, Rongerik, Taka, Utirik, Mejit, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likiep, Aur, Ailinglapalap, Majuro, Arno, Jaluit, Wotje, Ebon, Namu, Kili
[I] He, Vi, Te, C

Hibiscus tiliaceus L.
Bikini, Ujelang, Ujae, Lae, Kwajalein, Likiep, Aur, Ailinglapalap, Majuro, Namu, Arno, Jaluit, Mejit, Ebon, Kili, Eniwetak, Ailinglapalap
[D] Tr, Te, L-C

Sida fallax Walp.
Pokak, Eniwetak, Bikini, Rongelap, Rongerik, Taka, Ailuk, Likiep, Utirik, Ujelang, Ujae, Wotho, Lae, Mejit, Aur, Mili, Namorik, Majuro, Arno, Jaluit, Wotje, Mejit, Ebon
[I] Sh, Te, C

Thespesia populnea (L.) Sol. ex Correa
Kwajalein, Jaluit
[D] Tr, Te, L-0

Calophyllum inophyllum L.
Bikini, Rongelap, Rongerik, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likiep, Aur, Ailinglapalap, Namu, Majuro, Arno, Jaluit, Mejit, Ebon
[I] Tr, Te, C

Mammea odorata (Raf.) Kosterm.
Arno
[D] Tr, Te, R

Pemphis acidula Forst.
Eniwetak, Bikini, Rongelap, Taka, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Likiep, Wotje, Ailinglapalap, Majuro, Arno, Kili, Jaluit, Namu, Mejit, Ebon.
[I] Sh, Tr, Te, C-L-0

Barringtonia asiatica (L.) Kurz
Lae, Kwajalein, Likiep, Ailinglapalap, Arno, Jaluit, Namu, Mejit, Ebon
[I] Tr, Te, 0

Rhizophora mucronata var. stylosa (Griff.) Schimper
Ailinglapalap, Ebon, Arno
[I] Tr, Aq, L
Found in mangrove swamp.

Bruguiera gymnorhiza (L.) Lam.
Bikini, Rongelap, Utirik, Lae, Ailuk, Likiep, Aur, Ailinglapalap, Aur, Ailinglapalap, Majuro, Arno, Jaluit, Ebon, Namu, Kwajalein, Wotje
[I] Tr, Aq, L
Found in mangrove swamps and depressions, distribution extended by planting by Marshallese.

Sonneratia alba J. E. Sm.
Ailinglapalap, Arno, Jaluit, Lib, Wotje
[I] Tr, Aq, L
Found in mangrove swamps.

Lumnitzera littorea (Jack) Voigt
Ailinglapalap, Arno, Jaluit
[I] Tr, Aq, L
Found in mangrove swamps and depressions.

Terminalia samoensis Rech.
Eniwetak, Bikini, Ailinginae, Rongelap, Rongerik, Taka, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likiep, Majuro, Arno, Ailinglapalap, Jaluit, Ebon, Mejit, Wotje, Kili
[I] Tr, Sh, Te, C

Ludwigia hyssopifolia (G. Don) Exell
Likiep
[D] He, Te, L-R
Found in wet places.

Ludwigia octovalvis (Jacq.) Raven
Likiep, Majuro, Arno, Jaluit, Kili
[D] He, Te, L
Found in wet places, taro pits, eto.

Centella asiatica (L.) Urb.
Utirik, Ujae, Kwajalein, Ailuk, Likiep, Aur, Ailinglapalap, Majuro, Arno, Jaluit, Mejit, Namu, Wotje
[D] He, Vi, Te, C

Neisosperma oppositifolia (Lam.) Fosb. & Sachet
Eniwetak, Bikini, Rongelap, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Likiep, Aur, Ailinglapalap, Arno, Jaluit, Wotje, Utirik, Majuro, Ebon
[I] Tr, Te, C-L-A
Locally pure-stand dominant, now less frequent.

Ipomoea littoralis Bl.
Ujelang, Lae, Ailinglapalap, Majuro, Arno, Jaluit
[D] He, Vi, Te, C

Ipomoea macrantha R. & S.
Pokak, Eniwetak, Bikini, Ailinginae, Rongelap, Rongerik, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likiep, Mejit, Aur, Ailinglapalap, Majuro, Arno, Kili, Jaluit, Ebon, Wotje, Namu
[I] Vi, Te, C

Ipomoea pes-caprae var. brasiliensis (L.) v. Ooslstr.
Eniwetak, Lae, Kwajalein, Likiep, Majuro, Jaluit
[D] He, Vi, Te, L

Heliotropium anomalum H. & A.
Eniwetak
[I] D Sh, R

Cordia subcordata Lam.
Eniwetak, Bikini, Ailinginae, Rongelap, Rongerik, Utirik, Ujelang, Uaje, Mejit, Wotho, Lae, Kwajalein, Jemo, Likiep, Ailinglapalap, Arno, Majuro, Jaluit, Kili
[I] Tr, Te, C

Tournefortia argentea L. f.
Pokak, Bikar, Eniwetak, Bikini, Rongelap, Rongerik, Taka, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likiep, Aur, Ailinglapalap, Majuro, Arno, Kili, Jaluit, Ebon, Namu, Wotje
[I] Tr, Sh, Te, C-L-A

Clerodendrum inerme (L.) Gaertner
Eniwetak, Bikini, Ailinginae, Rongelap, Utirik, Ujelang, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likicp,

Ailinglapalap, Majuro, Arno, Jaluit, Mejit, Wotje, Ebon
[I] Sh, Te, C-0

Premna serratifolia L.
Utirik, Ujelang, Ujae, Wotho, Lae, Ailuk, Likiep, Ailinglapalap, Majuro, Arno, Jaluit, Mejit, Wotje, Kwajalein
[I] Tr, Tc, C

Vitex trifolia L.
Kwajalein
[D] Sh, Te, R

Ocimum sanctum L.
Utirik, Ujae, Lae, Ailuk, Ailinglapalap, Majuro, Arno, Jaluit, Aur, Mejit
[A] He, Te, 0
Planted and naturalized.

Solanum nigrum L.
Kwajalein, Arno, Jaluit
[D] He, Te, L-0

Hemigraphis reptans (Forst.) T. Anders.
Kwajalein, Majuro, Arno, Jaluit, Ebon
[I] He, Te, 0

Aidia cochinchinensis Lour
Arno, Jaluit
[I] Tr, Te, 0

Hedyotis biflora (L.) Lam.
Likiep, Majuro, Arno, Ailinglapalap, Jaluit, Wotje, Mejit
[D] He, Te, 0

Guettarda speciosa L.
Eniwetak, Bikini, Ailinginae, Rongelap, Rongerik, Taka, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likiep, Mejit, Wotje, Aur, Ailinglapalap, Kili, Majuro, Arno, Jaluit, Ebon
[I] Tr, Te, C

Ixora casei Hance
Kwajalein, Likiep, Ailinglapalap, Majuro, Arno, Jaluit, Ebon
[A] Sh, Te, 0
Probably intorudced as an ornamental and naturalized.

Morinda citrifolia L.
Eniwetak, Bikini, Ailinginae, Rongelap, Rongerik, Taka, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likiep, Ailinglapalap, Majuro, Arno, Jaluit, Aur, Namu,

Wotje, Ebon, Kili
[I-A?] Tr, Sh, Te, C
Widely used for many purposes.

Scaevola sericea Vahl
Pokak, Bikar, Eniwetak, Bikini, Ailinginae, Rongelap, Rongerik, Taka, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likiep, Wotje, Aur, Ailinglapalap, Majuro, Arno, Kili, Jaluit, Namu, Ebon
[I] Sh, Te, C-L-A
Dominant shore plant.

Adenostemma lanceolatum Miq.
Lae, Ailinglapalap, Majuro, Arno, Jaluit
[D] He, Te, 0

Wollastonia biflora (L.) DC.
Eniwetak, Bikini, Ailinginae, Rongelap, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Likiep, Aur, Ailinglapalap, Majuro, Arno, Namorik, Jaluit.
[I] He, Sh, Vi, Te, C-L-A

LIST OF INTRODUCED AND PROBABLY OR LIKELY TO BE NATURALIZED SPECIES OF VASCULAR PLANTS.

This list includes such species as I consider, with reasonable certainty, to be of human, post-aboriginal, introduction and which are known or suspected to be naturalized, that is, spontaneously reproducing themselves, in the Marshall Islands. Islands where they have been collected or reliably observed are listed for each.

The genera are listed in the Dalla Torre & Harms sequence.

Cenchrus echinatus L.
Utirik, Jemo, Kwajalein, Likiep, Ujae, Eniwetak, Majuro.

Chloris inflata Link
Eniwetak, Kwajalein, Bikini

Chrysopogon aciculatus (Retz.) Trin.
Jaluit, Kwajalein

Cynodon dactylon (L.) Pers.
Eniwetak, Kwajalein, Majuro

Dactyloctenium aegyptium (L.) Willd.
Kwajalein, Eniwetak, Jaluit

Eniwetak

Eleusine indica (L.) Gaertn.
Eniwetak, Kwajalein, Majuro, Namu, Likiep, Utirik, Mejit, Kili, Jaluit, Lae, Ujelang, Wotho, Ujae, Jemo

Eragrostis amabilis (L.) W. & A.
Eniwetak, Rongelap, Rongerik, Utirik, Ujelang, Ujae, Wotho, Lae, Kwajalein, Ailuk, Jemo, Likiep, Aur, Ailinglapalap, Majuro, Arno,
Jaluit

Eragrostis scabrifolia Swallen
Eniwetak

Paspalum conjugatum Berg.
Arno

Paspalum distichum L.
Likiep, Kwajalein, Ailuk, Arno

Paspalum setaceum var. ciliatifolium (Michx.) Vasey
Kwajalein, Jaluit

Setaria verticillata (L.) Beauv.
Majuro, Eniwetak

Cyperus compressus L.
Kwajalein, Eniwetak

Cyperus rotundus L.
Jaluit, Kwajalein, Majuro, Eniwetak

Commelina undulata R. Br.
Jaluit

Rhoeo spathacea (Sw.) Stearn
Likiep

Canna indica L.
Kwajalein, Arno, Jaluit

Peperomia pellucida (L.) HBK.
Jaluit

Pilea microphylla (L.) Liebm.
Kwajalein, Ailinglapalap, Jaluit, Ujelang

Coccoloba uvifera L.
Jaluit, Eniwetak

Mirabilis jalapa L.

Eniwetak, Utirik, Kwajalein, Ailuk, Likiep, Ailinglapalap, Majuro, Jaluit, Mejit, Wotho

Achyranthes aspera L.
Eniwetak

Amaranthus dubius Mart. ex Thell.
Eniwetak, Kwajalein, Majuro, Jaluit

Amaranthus spinosus L.
Kwajalein

Amaranthus viridis L.
Eniwetak, Kwajalein, Arno, Jaluit, Majuro

Gomphrena globosa L.
Ujae, Kwajalein, Ailinglapalap, Majuro, Arno, Jaluit, Likiep, Mejit, Ebon

Lobularia maritima (L.) Desv.
Kwajalein

Kalanchoe pinnata (Lam.) Pers.
Kwajalein, Likiep, Arno, Jaluit

Cassia occidentalis L.
Ujelang, Jaluit

Crotalaria incana L.
Kwajalein, Jaluit

Crotalaria longirostata H. & A.
Jaluit

Crotalaria pallida Ait.
Jaluit

Desmodium adscendens (Sw.) DC.
Eniwetak

Desmodium incanum DC.
Kwajalein

Dolichos lablab L.
Kwajalein

Leucaena leucocephala (Lam.) deWit
Utirik, Bikini, Kwajalein, Ailuk, Likiep, Jaluit, Eniwetak

Mimosa pudica L.
Kwajalein

Euphorbia cyathophora Murr.
Utirik, Bikini ?, Kwajalein, Ailuk, Likiep, Majuro, Arno, Jaluit, Wotje, Ebon

Euphorbia glomerifera (Millsp.) Wheeler
Kwajalein, Majuro, Jaluit

Euphorbia hirta L.
Eniwetak, Bikini, Utirik, Kwajalein, Jemo, Likiep, Jaluit, Wotje

Euphorbia maculata L.
Kwajalein

Euphorbia prostrata Ait.
Bikini, Ujae, Kwajalein, Jemo, Likiep, Ailinglapalap, Majuro, Arno, Jaluit

Euphorbia rubicunda Steud.
Bikini, Ujelang, Kwajalein, Jaluit, Likiep, Utirik, Wotje, Eniwetak

Phyllanthus amarus Schum.
Eniwetak, Bikini, Utirik, Ujelang, Ujae, Lae, Kwajalein, Jemo, Likiep, Ailinglapalap, Majuro, Arno, Jaluit

Ricinus communis L.
Eniwetak, Bikini, Ailinglapalap, Jaluit

Gossypium barbadense L. (or G. hirsutum L.)
Utirik, Kwajalein, Majuro, Arno, Jaluit, Likiep, Mejit

Malvastrum coromandelianum (L.) Garcke
Jaluit, Eniwetak ?

Sida acuta Burm. f.
Rongelap, Ujelang

Sida rhombifolia L.
Jaluit

Carica papaya L.
Bikini, Rongelap, Taka, Utirik, Ujelang, Ujae, Lae, Kwajalein, Ailuk, Jemo, Aur, Ailinglapalap, Majuro, Arno, Kili, Jaluit, Likiep, Namu, Mejit, Wotje, Ebon

Terminalia catappa L.
Kwajalein, Likiep, Arno, Jaluit

Polypremum procumbens L.
Eniwetak

Catharanthus roseus (L.) G. Don
Kwajalein, Ailuk, Likiep, Ailinglapalap, Arno, Jaluit, Majuro, Aur, Mejit, Eniwetak

Cerbera manghas L.
Jaluit

Asclepias curassavica L.
Bikini, Lae, Utirik, Ailuk, Ailinglapalap, Majuro, Arno, Jaluit, Namu, Mejit
Often cultivated, rarely established.

Ipomoea triloba L.
Kwajalein, Jaluit

Heliotropium procumbens var. depressum (Cham.) Fosb. & Sachet
Kwajalein, Majuro

Lantana camara L.
Ailinglapalap, Jaluit, Likiep

Lippia nodiflora (L.) Michx.
Eniwetak

Stachytarpheta indica (L.) Vahl
Jaluit

Stachytarpheta jamaicensis (L.) Vahl
Kwajalein, Majuro

Stachytarpheta urticaefolia Sims
Eniwetak

Plectranthus scutellarioides (L.) R. Br.
Kwajalein, Jaluit

Capsicum frutescens L.
Arno

Nicotiana tabacum L.
Jaluit

Physalis angulata L.
Eniwetak

Scoparia dulcis L.
Kwajalein

Plantago major L.
Kwajalein

Asystasia gangetica (L.) Anders.
Kwajalein

Blechum brownei Juss.
Jaluit

Pseuderanthemum carruthersii (Seem.) Guill.
Bikini, Rongelap, Utirik, Ujae, Wotho, Lae, Kwajalein, Ailuk, Ailinglapalap, Arno, Jaluit, Majuro.
Usually planted, but occasionally naturalized or persisting.

Dentella repens Forst.
Majuro, Jaluit, Kwajalein

Dentella serpyllifolia Wall. ex Airy Shaw
Kwajalein

Hedyoti corymbosa (L.) Lam.
Kwajalein, Jaluit

Hippobroma longiflora (L.) G. Don
Likiep, Arno, Jaluit

Ageratum conyzoides L.
Jaluit

Bidens alba (L.) DC.
Kwajalein

Bidens pilosa L.
Eniwetak

Conyza bonariensis (L.) Cronq.
Eniwetak, Bikini ?, Kwajalein

Conyza canadensis (L.) Cronq.
Kwajalein, Majuro

Coreopsis basalis (Dietr.) Blake
Jaluit

Eclipta alba (L.) Hassk.
Kwajalein, Majuro
Possibly not to be distinguished from E. prostrata (L.) L.
Eclipta prostrata (L.) L.
Kwajalein, Majuro

Emilia fosbergii Nicolson
Kwajalein, Majuro

Emilia sonchifolia (L.) DC.
Kwajalein

Pluchea X fosbergii Coop. & Gal.
Kwajalein
Spontaneous sterile hybrid between P. indica and P. symphytifolia

Pluchea indica (L.) Less.
Eniwetak, Kwajalein, Majuro

Pluchea symphytifolia (Mill.) Gillis
Eniwetak, Kwajalein, Majuro

Sonchus oleraceus L.
Kwajalein, Majuro, Arno

Spilanthes iabadicensis A. H. Moore
Jaluit

Synedrella nodiflora (L.) Gaertn.
Kwajalein, Majuro, Jaluit

Tridax procumbens L.
Kwajalein, Eniwetak

Vernonia cinerea (L.) Cass.
Eniwetak, Bikini, Kwajalein, Likiep, Ailinglapalap

Wedelia trilobata (L.) Hitchc.
Kwajalein, Eniwetak

Zinnia elegans Jacq.
Kwajalein, Jaluit

MARSHALL ISLAND BIRDS

Birds are the most conspicuous group of animals in the Marshall Islands fauna, and will certainly be a major object of attention during the Biodiversity Survey and of almost any scientific visit. Because of the enormous concentration of birds on Pokak Atoll, a special list of birds observed there in our visit in 1952 is included in our description of that atoll; the same for Bikar Atoll. A complete list of Marshallese birds is given here, copied from Atoll Research Bulletin 127 (Amerson 1969).. Notes on the birds of Wotho are also included in the account of that atoll, given here. A account of Marshall Island birds seen on the U.S. Geological Survey expedition in 1951-1952, was published as Atoll Research Bulletin 114 (Fosberg 1966).

AVIFAUNAL DISTRIBUTION

GENERAL

Seventy-nine species of birds have thus far been recorded from the 50 atolls which make up the Marshall and Gilbert Islands and from the ocean surrounding them. Of these 79 species, 37 are seabirds (Table 37) and 42 are land and fresh-water birds (Table 38).

Seventy bird species have been recorded from the Marshall Islands; 43 species have been recorded from the Gilberts. Thirty-five species are found in both island groups; 35 are known solely from the Marshalls; 9 are known solely from the Gilberts.

SEABIRDS

Thirty-one seabird species have been recorded from the Marshall Islands; 25 have been recorded from the Gilberts (Table 37). Nineteen seabird species are recorded from both island groups; 12 are known solely from the Marshalls; 6 are known solely from the Gilberts.

Seven seabird species are resident breeders on both island groups; in addition, three species that are resident breeders in the Marshall Islands are possible breeders in the Gilbert Islands. Seven others (including two in question) are resident breeders solely on the Marshall Islands, while only two (including one in question) are resident breeders solely on the Gilbert Islands.

The resident, including probable and possible, breeding seabirds in the Marshall and Gilbert Islands all regularly occur at sea within their respective areas. Some are more common than others, mainly due to species feeding habitat preference (also interaction of surface water zonation and abundance of food). The three major feeding habitat categories, for Marshall-Gilbert seabirds, are coastal (beaches, recfs, lagoons), offshore (near islands or atolls), and pelagic. Some species may overlap or their ranges may vary at different times during the year. Table 39 shows which Marshall-Gilbert breeding species generally occur in the three feeding habitats.

Seven seabird species are known to migrate annually through the Marshall-Gilbert area from breeding grounds elsewhere in the Pacific. These migrant species are usually entirely pelagic and pass through the area quickly. Occasionally, due to storms, injuries, or sickness, individuals may occur on the islands; these are then considered accidental to the island avifauna.

One seabird species is vagrant in the Marshall-Gilbert area. Such birds are so classified because they are away from their normal migration routes. If these stop on an island, they are also known as accidentals to the island avifauna.

Seabird occurrence in the Marshall and Gilbert Islands.

- none recorded.
* none recorded, but probably vagrant in the area.
# none recorded, but probably migrant in the area.
& none recorded, but probably a visitor in the area.
+ none recorded, but probably occurs.

Species	Marshall Island	At Sea	Gilbert Islands	At Sea
1) Black-footed Albatross		Visitor		
2) Laysan Albatross	Accidental	&		
3) Phoenix Petrel		Visitor		
4) Kermadec Petrel		Migrant		#
5) White-necked Petrel	Accidental	#		
6) Black-winged Petrel		#		Migrant
7) Bulwer's Petrel	Resident breeder ?	Uncommon		Visitor
8) Pale-footed Shearwater		Migrant		+
9) Wedge-tailed Shearwater	Resident breeder	Uncommon		
10) Sooty Shearwater	Accidental	Migrant		Migrant
11) Slender-billed Shearwater	Accidental	Migrant		Migrant
12) Christmas Shearwater	Resident breeder	Uncommon		Visitor
13) Little Shearwater	Accidental			
14) Audubon's Shearwater				Visitor
15) Leach's Storm Petrel		Migrant		Migrant
16) White-throated Storm Petrel			Resident breeder ?	+
17) Red-billed Tropicbird				Vagrant
18) Red-tailed Tropicbird	Resident breeder	Common	Resident breeder ?	Uncommon
19) White-tailed Tropicbird	Resident breeder	Uncommon		Visitor
20) Blue-faced Booby	Resident breeder	Uncommon	Visitor	Visitor

21)	Red-footed Booby	Resident breeder	Common	Resident breeder	+
22)	Brown Booby	Resident breeder	Uncommon	Resident breeder ?	Uncommon
23)	Great Frigatebird	Resident breeder	Uncommon	Resident breeder ?	Uncommon
24)	Lesser Frigatebird	Visitor	&	Resident breeder	Common
25)	Great Skua		#		Migrant
26)	Jaeger	Accidental			
27)	Common Tern	Accidental	*		

Seabird occurrence in the Marshall and Gilbert Islands.

		Marshall		Gilbert	
	Species	Island	At Sea	Islands	At Sea
28)	Arctic Tern	Accidental	*		
29)	Black-naped Tern	Resident breeder	Rare	Resident breeder	Rare
30)	Gray-backed Tern	Resident breeder ?	+	Visitor	Uncommon
31)	Sooty Tern	Resident breeder	Common	Resident breeder	Uncommon
32)	Brown-winged Tern	Accidental	*		
33)	Crested Tern	Resident breeder	Rare	Resident breeder	Rare
34)	Blue-gray Noddy	Resident breeder	Uncommon		
35)	Brown Noddy	Rasidcnt breeder	Common	Resident breeder	Common
36)	Black Noddy	Resident breeder	Common	Resident breeder	Common
37)	White Tern	Resident braeder	Common	Resident breeder	Common

Land and fresh-water bird occurrence in the Marshall and Gilbert Islands.

Speoies	Marshall Islands	Gilbert Islands
1) Reef Heron	Resident breeder	Resident breeder
2) Snow Goose	Accidental	
3) Mallard	Accidental	Accidental
4) Common Teal	Accidental	
5) Gadwall	Accidental	
6) European Widgeon	Accidental	
7) Pintail	Uncommon Migrant	

8)	Northern Shoveler	Uncommon Migrant	Migrant
9)	Canvasback	Accidental	
10)	Tufted Duck	Accidental	
11)	Muscovy Duck	Introduced breeder	
12)	Duck sp.	Accidental	Accidental
13)	Domestic Chicken	Introduced breeder	Introduced breeder
14)	White-browed Rail	Accidental	
15)	Golden Plover	Common Migrant	Common Migrant
16)	Black-bellied Plover	Uncommon Migrant	
17)	Semipalmated Plover	Uncommon Migrant	
18)	Ring-necked Plover	Uncommon Migrant	
19)	Mongolian Plover	Uncommon! Migrant	
20)	Plover sp.	Accidental	
21)	Whimbrel	Common Migrant	Common Migrant
22)	Bristle-thighed Curlew	Common Migrant	Common Migrant
23)	Bar-tailed Godwit	Common Migrant	Common Migrant
24)	Greater Yellowlegs	Accidental	
25)	Spotted Sandpiper	Accidental	
26)	Polynesian Tattler	Uncommon Migrant	Uncommon Migrant
27)	Wandering Tattler	Common Migrant	Common Migrant
28)	Ruddy Turnstone	Common Migrant	Common Migrant
29)	Japanese Snipe	Accidental	
30)	Sanderling	Common Migrant	Uncommon Migrant
31)	Pectoral Sandpiper	Uncommon Migrant	
32)	Sharp-tailed Sandpiper	Common Migrant	Common Migrant
33)	Buff-breastcd Sandpiper	Accidental	
34)	Stilt sp.		Accidental
35)	Ground Dove		Introduced breeder
36)	Friendly Ground Dove		Introduced, breeder?
37)	Crimson-crowned Fruit Dove	Extinct breeder	
38)	Micronesian Pigeon	Resident breeder	Resident breeder ?
39)	Parrot sp.	Probably introduced	
40)	Long-tailed New Zealand Cuckoo	Common Migrant	Common Migrant
41)	House Sparrow	Probably introduced, possible breeder	
42)	Indian Myna	Introduced breeder	

At-sea feeding habitat classification of seabirds that breed in the Marshall and Gilbert Islands.

Species	Coastal	Offshore	Pelagi
Bulwer's Petrel		x	x
Wedge-tailed Shearwater		x	x
Christmas Shearwater		x	x
White-throated Storm Petrel		x	x
Red-tailed Tropicbird			x

White-tailed Tropicbird			x
Blue-faced Booby		x	x
Red-footed Booby		x	x
Brown Booby		x	
Great Frigatebird		x	x
Lesser Frigatebird		x	x
Black-naped Tern		x	
Gray-backed Tern		x	x
Sooty Tern		x	x
Crested Tern	x		
Blue-gray Noddy	x	x	
Brown Noddy		x	
Black Noddy	x	x	
White Tern	x	x	

Accounts of Individual Atolls and Islands of the Marshall Archipelago

This section will provide a usually brief summary of available information for each member of the Marshall Group, roughly in order north to south in the Radak and Ralik chains. In each account there is a paragraph on location and general geographical features, then it mentions, or usually briefly describes, where possible, areas of special interest from the viewpoints of natural diversity and remnants of unaltered, unoccupied or unexploited land. These accounts are limited by the ready availability of appropriate information and the personal knowledge of the compiler. For some islands there is practically nothing on record. These are pointed out as possible objectives of field study. We offer apologies for the limitations, and for possible omissions of important sources. With the practical limits on time, it has not been possible to go much farther than our own files and library. The references listed may give clues to other pertinent information.

POKAK ATOLL

Pokak (Pokaakku, or Taongi) Atoll, 140° 43' N, 168° 57' E, is the northern-most of the Marshalls, lying about 150 miles NNW of Bikar, next of the Radak Chain. It is the least disturbed atoll (exception possibly Bikar) of the Marshall Group, uninhabited by humans, and, from some viewpoints, one of the most interesting. Climatically it is the driest, though no rainfall measurements are known, and presents almost a semi-desert aspect. Because of its interest as an important natural area it will be described here in more detail than will be devoted to any of the other 28 atolls and islands. This is especially necessary as it

usuallynot be practical to visit it or Bikar, because of distance and landing difficulties. The enormous bird populations also give Pokak special interest as a possible preserved area. Pokak and Bikar were set aside by administrative decree as protected areas by the administrator of the Marshalls District in 1962, which status probably still remains. Hopefully this status will be recognized and sustained by the new Marshallese Government. The following information is mostly from observations made on a visit by C. G. Johnson, geologist, and F. R. Fosberg, from July 20 to 27, 1952. (Fosberg 1955 a & b, 1965).

The atoll is roughly crescent-shaped, about 11 miles by 5, oriented north - south, convex side to the east. A single narrow boat-passage, passable at slack water for small boats, empties the lagoon through the reef on the west side. Water, driven by the Northeast Trade Winds, pours in over the reef on the east and northeast sides, filling the lagoon to a constant high tide level. During ebb tide the water rushes out through this passage almost like a waterfall. The lagoon is shallow, probably not exceeding 30 m depth, and has many coral heads and patches, some reaching the surface. A massive algal ridge lines the outer edge of the windward reef, while the south and west reefs are coral-covered narrow flats where landings can be made at high tide in quiet weather. An interesting feature, perhaps unique to Pokak Atoll, is the presence on lagoon shores of the westernmost islets, on east facing lagoon reef-fronts, and on the windward edges of coral patches in the lagoon, of a tiny algal-rim, a miniature algal ridge 10 15 cm high probably a response to wind-generated turbulence in the lagoon.

Not much is known of the marine fauna and flora, but superficially they seem rather rich. Turbo lajonkairi seems to replace T. setosa as the common turban shell and provides the principal housing of the large red hermit-crab, Coenobita perlat.

Ten islets lie on the southern part of the eastern reef and on the part that curves westward. The rest of the reef lacks dry land and has not been well-studied. The largest islet is called Sibylla, about 2-1/2 miles long and up to 300 m wide. Kamome Islet, northeast of Sibylla, is also quite large. High boulder ridges and sand ridges are a feature of these islets that indicates a history of severe storms. Large boulders are also scattered inland, obviously carried by typhoon waves. The seaward sides of most of the islets have boulder and cobble ridges, sometimes 2 or even more concentrically parallel, their outer margins lining or somewhat back from the actual shore. Inland on the wider

islets are sand flats and rubble flats. Back from the lagoon shores are low sand and gravel ridges. On both seaward and lagoon sides are stretches of exposed rock platform, of coral conglomerate, its surface flat, about 1 m above mean high tide level, their outer edges sloping down, forming a rough erosion ramp, to the level of the reef flat, near mean low tide level. Outside of this on the inner edge of the leeward reef flat on Sibylla Islet are three low stacks, one of them with a huge boulder perched on top of it, with a visible crack or seam between the top of the stack and the boulder. The top of the stacks are about on a level with the upper surface of the ledge of reef conglomerate that protrudes from under the beach ridges opposite the stacks. Clearly these stacks and the ledge are parts of the same former reef surface, on which boulders were thrown by storm waves. This situation is similar to that described by MacNeil (1950) in Okinawa, and interpreted by him as evidence of a post-glacial higher than present sea-level. The northern two-thirds of the seaward shore of Sibylla is backed by an enormous boulder-ridge, up to practically 6 m high.

On Bokdik (or South) Islet, the last of the series to the southwest, is what seems to be evidence of a still higher, perhaps 4 m, former sea level. On both sides of the islet are beach-rock series, sloping in opposite directions, with between them a platform of reef-rock, above high tide level, forming the body of the islet. On this, running lengthwise north-east to south-west, are many huge boulder-like masses of limestone, apparently remnants of a surface about 2 m above that of the platform. The rock seems clearly to be continuous with the platform, no crack or suture separating the two at any of the places free from debris and available for observation. They seem, without doubt, to be erosion remnants of a former limestone surface almost 4 m above present mean low tide level, corresponding to the 11-1/2 foot notch seen in coastal limestone in various places in the world.

On the lagoon side of several of the islets a deep notch is cut in the low (1 m) cliff formed by the projecting platform, the overhanging edge broken off here and there.

The soils of Pokak are mostly very immature, in general belonging to the Shioya Series, characterized by very little humus accumulation. Large areas of fine sand show little development beyond the stage of unaltered coral sand. Since these sandy areas are inhabited by large numbers of shearwaters, burrowing beneath the surface, they may have some phosphate, from the excrement, though visible guano was only very local, under trees, and not characteristic of the fine sand. Most of the Shioya soils are mixtures of coarser

coral sand and gravel of various textures.

Other than exposures of bare limestone conglomerate, mostly around the peripheries of islets, the only extensive substratum beyond those mentioned above is surface covered by a rubble of loose broken coral, from pebble to boulder size, with no sand showing in the surface layer, at least. It is usually stained gray from presence of endolithic blue-green algae. This frequently has little or no vegetation.

Botanically, along with Bikar, it is the most impoverished of the Marshalls, each having only nine species of flowering plants. The following list comprises the entire vascular flora of Pokak as of 1952:

List of vascular plants.

Lepturus gasparricensis Fosb.
Lepturus repens (Forst. f.) R. Br.
Boerhavia repens L. (s. %.)
Pisonia grandis R. Br.
Portulaca lutea Sol.
Sida fallax Walp.
Ipomoea macrantha R. & S.
Tournefortia argentea L. f.
Scaevola sericea Vahl

The vegetation is comparatively simple, but interesting. The following generalized description is a somewhat edited version of one prepared in the field in July 1952, during a rather extreme dry period. The ground-water, sampled at the center of the widest place on Pokak Islet, and at two places on widest part of Sibylla, was at least half as saline as sea-water, the only such instance found in many pits in a number of others of the Northern Marshall Atolls, in all of which were found potable water, hard, but usually no more saline than the Honolulu city water supply.

There are, basically, six vegetation types on Pokak, each dominated by a single species. Various combinations of these occur, as well as different aspects with regard to height, density, luxuriance, etc.

The type that gives the atoll its character is a sparse low scrub forest of Tournefortia. This is from two to six m tall, with occasional trees that may be taller. It is rarely so dense as to greatly impede walking. It may be found in almost any substratum, but is usually not on sand or only in patches. Locally it has an understory of Scaevola. This in places closed so as to make progress difficult without a machete. Ordinarily, where there is no Scaevola, the spaces between the trees may be occupied by sparse Lepturus, Portulaca, Sida or Boerhavia, the latter more abundant on pure broken coral substratum (this likely

because of lack of competition, as it does very well in sand in some spots).

The other forest type is a pure Pisonia forest, represented only by several patches on Kamome Islet. This is not over 6-8 m tall at most. The trees not over 2.5-3 dm in diameter are set rather closely, with complete canopy, but this was sparse at when examined because of smallness and fewness of leaves. Doubtless it may be dense in a moister season. In the greater part of this, root sprouts are so thick as to effectively crowd out anything else, but locally there are patches of grass, Boerhavia, etc. Judging from the presence of Tournefortia logs inside this, it is probably increasing. Comparison of 1945 and 1951 photos shows that the Pisonia forest patches are gradually enlarging. Also that the relation of Sida to grassy areas in the open part is not a constant but a shifting one.

A prominent type is a scrub, 1-2 m tall, of Scaevola sericea, either pure or with scattered Tournefortia trees. This is commonly so dense as to impede walking through it. It is also of a characteristic bright green or yellow green color. It generally covers the ground completely. It is often on rock or broken coral, but by no means always. The low spreading branches, when covered by wind-blown sand, send out roots and form new plants. It rarely has any ground cover of other species.

The other woody type is a usually low, thin scrub of Sida fallax. This varies from 0.5 to 2 m tall, and from rather sparse to so dense as to be unpleasant to walk through, but offers no real obstacle because of the weak nature of the shrubs. This may be a practically pure stand, but more often has scattered Tournefortia trees. Often it is accompanied by Lepturus, Portulaca, or Boerhavia, or any combination of these.

This may grow on either gravel or sand, rarely on broken coral. An extensive aspect of it is on sandy stretches, usually on the lagoon sides of the broader islets, occupied by rookeries of shearwaters, with numerous burrows. Here the Sida is usually mixed with one or more of the herbaceous species.

This type grades imperceptably into a bunch-grass savanna with one or both species of Lepturus. In its more luxuriant aspects this is on sand and is also occupied by shearwater burrows. On thin gravel deposits on rock, or on recently available gravel habitats it is very sparse and composed usually of very small tufts of grass.

The limits between this and the remaining type, a pioneer community of Portulaca lutea, are hard to define.

In sandy places on the lagoon side, especially around reentrants, and on rubble or even pure broken coral, Portulaca may exist in pure stand. Everywhere it tends to grade into the Lepturus type. On rooky places, or even some sandy ones, it may have appreciable Boerhavia. It may, and frequently does, form a thin ground cover under Sida scrub and Tournefortia forest. It usually is sparse, under any circumstances, and does not completely cover the ground.

A prominent feature of the landscape is open broken coral, usually the tops of boulder ridges or boulder flats, commonly on the seaward side or on the north ends of islets, absolutely devoid of macroscopic vegetation. These are of a blue-gray color, due to the presence, in the surface of the limestone, of microscopic algae (Chroococcus?).

Also a prominent feature are exposures of old reef-rock, just above high tide level, on both seaward and, especially, lagoon sides. These, also, are colored blue-gray, darker than the boulder ridges, by microscopic algae.

The vegetation of the shallow edges of the lagoon is, so far as observed, sparse nodular lithothamnion (encrusting fragments of coral, shells, etc.) and patches of Caulerpa. In the passages, also, Cauleroa, Lithothamnion, and Turbinaria occur.

The leeward reef and detached small reef platforms inside it are covered with a luxuriant growth of various species of Porolithon. The surface of these reefs is at about constant high tide level. Around their edges is found an irregular rim of a few inches, resembling a miniature lithothamnion ridge. In holes in this platform two species of Caulerpa are abundant and several other green algae much less so. Microdictyon forms conspicuous tufts on the surface.

The windward reefs were not examined closely. A rather irregular algae ridge of Porolithon is evident.

Patches of reef just inside the windward reefs are reported (by C. G. Johnson) to be essentially similar to those inside the leeward reef.

An outstanding feature of all the land vegetation at the time of these observations was the appearance of extreme dryness. The Tournefortia had lost all but terminal tufts of very small leaves much less than half normal size. Scaevola had also lost its lower leaves, but still presented almost normal sized leaves but fewer of them. In most places, it was flowerless and fruitless. The Sida bushes were practically all partially dead, some completely

so. The Pisonia leaves were only a fraction of their normal size. Boerhavia was generally purplish in color and had mostly lost the leaves from all but the most distal parts of the branches. Ipomoea macrantha had died back to short scandent branches with short leafy side branches. A striking thing about this species here is its forming a short thick trunk, about a 3-4 dm high, with short living branches, surrounded by dead long radiating twining stems. Both species of Lepturus were mostly gray-brown tufts, with all culms and most leaves dead. Only the crowns and small sheltered leaves were still alive. Portulaca showed less effect of the dryness than any other plants but even this was obviously wilted at the tips, and in many areas, flowerless.

An interesting fact in this connection was that the effects of drought were less obvious in the most sandy areas, such as the lagoon side of Kamome Islet and the lagoon ridge of Pokak Islet.

The Tournefortia trees on most parts of the atoll were partly dead, or at least had dead branches. Judging from the guano deposits under the trees, the dead limbs were the habitual roosting-places of boobies and frigate birds. Whether the limbs were dead from this cause, or whether the birds chose the dead limbs to sit on was not obvious. Because of the prevalence of dead parts of trees the vegetation had a very bedraggled appearance. This, of course, was intensified by the general sparseness of foliage on the trees and other plants, and the gray-brown color of the dry tufts of grass.

The Sida, at this time, also presented a very unluxuriant appearance. Practically all of the plants were partly dead, and the general aspect of the Sida scrub was one of dead gray sticks.

Terrestrial animal life is most evident in the form of birds, but the Polynesian rat, Rattus exulans, is common at least on the larger islands. A lizard, Emoia sp. small in size, is common. The other obvious animals are principally large hermit crabs, mostly Coenobita perlata, the principal scavenger organism in the terrestrial ecosystem. Insects and other small terrestrial arthropods are common, but not very obvious. Collections made on the 1952 expedition have mostly not been reported on, so it is not possible to list them.

The bird fauna of Pokak is perhaps the most important feature of the atoll from the standpoint of preservation of natural diversity. The incredible abundance of seabirds and shorebirds there may be some indication of the conditions on

the other atolls, and of atolls in general, before the arrival of human immigrants. There now seems to be almost a negative correlation between the abundance of birds and of humans on atolls and atoll islets.

Following is a list of the birds seen on Pokak during a week in July, 1952; annotations concerning abundance, habitats and behavior, are given in a quotation in the General section of this report.

Diomedea nigripes (offshore only)
Puffinus pacificus
Phaethon lepturus
Pluvialis dominica
Arenaria interpres
Numenius tahitiensis
Heteroscelus incanum
Phaethon rubricauda
Sula sula
Sula dactylatra
Sula leucogaster
Sterna lunata
Sterna fuscata
Thalasseus bergii
Procelsterna cerulea
Fregata minor
Egretta sacra
Anous stolidus
Anous tenuirostris
Gygis alba

Pokak Atoll is by no means the most luxuriant of the group -- in many respects it may be the most impoverished. It exhibits less diversity, in terms of numbers of species (except of birds), but it is a relatively undisturbed, almost unaltered island ecosystem, a rare thing, indeed, in these times. It does show enough diversity to serve as an interpretive base-line for estimating change in relatively dry coral islands. It also may serve as a reservoir from which colonization, at least of birds, might take place if in the future more favorable conditions are established for rebuilding natural communities in other atolls in the drier northern part of the archipelago.

It is perhaps not too extravagant to suggest that it would be an appropriate "crown jewel" in a system of natural areas in the Marshall Islands, should such a system be developed. It should be helpful that both Pokak and Bikar were declared protected reserves in the early nineteen sixties by the then District Administrator, Mr. Maynard Neas, Trust Territory of the Pacific Islands. According to Mr. Jack Tobin, former Trust Territory anthopologist, (conversation 1964), prior to annexation by Europeans, Pokak, along with Bikar and Jemo, were regarded by the Marshallese as a bird (and turtle) reserve. Birds, their eggs, and turtles could be taken, after proper ceremonies, during the one visit made during the year.

BIKAR ATOLL

Bikar is the second most northern of the Marshall Group, 12° 15' N, 170° 07' E, its reef is oval in shape 6-7 miles long, about 4.5 miles wide. In August 1952 there were 3 islets and 2 small gravel bars, though Firth, et al. 1945, says there were 8 small islands. Evidence of a relatively recent typhoon is abundant on the atoll and such

a storm may have swept away some small islets. On the west side is a single boat-passage, forked, Y-shaped, with a patch reef just inside, as is frequent with narrow reef-passages.

The largest islet, Bikar, is oval-shaped, with projections north and south, the wider central portion with a high sand ridge along the west side and the greater part covered by Pisonia forest, surrounded by a narrow zone of Tournefortia.

Almeni Islet, smaller, also has Pisonia forest, but lower in stature and much wind-sheared, in its interior; Jaliklik Islet, also has Pisonia.

Jaboero Islet, a gravel bar, not more than half meter or so above high-tide level, has only Portulaca lutea vegetation, but has a large nesting colony of sooty terns.

The Pisonia forests, especially on Bikar Islet, have thick layers of raw-humus and phosphatic hardpan. One buried occurrence of phosphate is as much as half a meter thick. These Pisonia forests have in most areas a notable shrub-layer of Pisonia root sprouts. Some large trees have been uprooted by storms, prying up slabs of phosphate. Some of the holes thus created were being filled by Pisonia root sprouts, others not.

A small clump of coconut palms, planted at the north edge of the forest on Bikar Islet, by people from Likiep, persists, producing nuts, but these were very small and with bitter water in 1952. Larger shells were on the ground.

Only 9 species of flowering plants were found, list given below. The low vegetation on the rocky open areas is generally sparse.

Pandanus tectorius Park.
Lepturus repens (Forst. f.) R. Br.
Cocos nucifera L.
Boerhavia repens L. (s. 1.)
Pisonia grandis R. Br.
Portulaca lutea Sol.
Triumfetta procumbens Forst. f.
Tournefortia argentea L. f.
Scaevola sericea Vahl

Birds are abundant, 18 species listed below. Annotations are given in the part on Marshallese birds in the General section of this report. Red-footed boobies and noddy terns nest abundantly in the Pisonia trees.

noddy terns nest abundantly in the Pisonia trees.

Phaethon lepturus	Pluvialis dominica	Sterna fuscata
Phaethon rubricauda	Arenaria interpres	Thalasseus bergii
Sula dactylatra	Numenius tahitiensis	Procelsterna coerulea
Sula leucogaster	Heteroscelus incanum	Anous stolidus
Sula sula	Sterna sumatrana	Anous tenuirostris
Fregata minor	Sterna lunata	Gygis alba

The outstanding feature of Bikar is the nesting of green turtles, Chelonia mydas, especially on Bikar Islet. During three nights of observation in August 1952 over 300 female turtles came ashore to lay their eggs. The entire coastal sandy part of the islet is churned up by the nest-building, excavation of holes, egg-laying, and covering and concealing the nest-sites.

The turtle-nesting, intact Pisonia forest, Jemo phosphate soils, and large bird populations make this atoll a primecandidate for preservation as a natural area. This also would preserve the ancient Marshallese custom mentioned above.

TAKA ATOLL

This small uninhabited atoll lies at 11° 07' N, 169° 46' E, about 4 miles southwest of Utirik. There are 8 islets on the reef, the largest being Taka Islet, about 1/2 mile long, and not very wide.

In 1951 the lagoonward part of Taka Islet was planted to coconuts, denser near the lagoon, sparse and mixed with native vegetation toward the center. The soil in the plantation is sandy, Shioya type. In the center was a small Pisonia grove, trees about 20 m tall, at that time, battered by a typhoon earlier in the year, rather open but choked by Pisonia root sprouts. The soil here is black. Scattered Pisonia occurs on most parts of the islet. The outer half of the islet is covered by mixed scrub of Guettarda, Pisonia, Tournefortia, some Suriana and Pemphis, and Scaevola is common.

Lojiron Islet is small, has a low but rather dense Pisonia grove in the center, with Jemo soil with raw humus. This is surrounded by an interrupted scrub of Scaevola, Terminalia, Guettarda and Tournefortia. In openings are stands of Achyranthes caneseans and of Sida fallax. Openings in and near the Pisonia grove are choked with Pisonia sprouts. Large areas were apparently swept clean by the typhoon and are beginning to revegetate.

Wotwerok Islet is partially wooded with a scrub or scrub forest of Tournefortia, Scaevola, and Pisonia, rather

battered by the typhoon. Only 4 coconut palms were seen. The opener parts of the islet are one vast sooty tern rookery, the ground being covered by nesting birds, their eggs laid on the bare gravel, so numerous that one had to be careful not to step on them. When scared up the birds filled the sky, with a deafening clamor.

Some other birds were seen, but the sooty terns dominated the islet.

Taka Atoll has a rather impoverished fauna and flora, but was relatively undisturbed in 1951. A study of its recovery from the typhoon would be rewarding. All or large parts of it could well be preserved to document revegetation and colonization processes over long periods of time.

UTIRIK ATOLL

Utirik (also called Wutrok) Atoll, the third southward of the Radak Chain, lies at 11o 14° N, 169° 51' E, about 60 miles SSW of Bikar. It and south reefs.

Utirik Islet is the largest, about 1-1/2 by 3/4 miles, and is the location of the village. In 1951 it was recovering from a severe typhoon earlier in the year. This islet is almost completely planted to coconuts. A number of long-abandoned taro pits are in the interior. The only reasonably unaltered parts are a long narrow spit extending from the southwest corner; with interesting small dunes and much beach-rock. This after 45 years, should show the results of a long period of recovery from denudation by the typhoon. The other area is on the east side, with thickets of Cordia, Guettarda and Pisonia tangled with Ipomoea macrantha, and farther east, Lepturus grassland and then broken coral rock with a dense scrub of Scaevola sericea with old battered trees of Tournefortia, Cordia, Guettarda and Pisonia.

Bigarak Islet is partly planted to coconuts, the southern part, with a small mangrove depression with Bruguiera gymnorhiza. The rest of the island is mostly broken coral rock with a mixed scrub of Scaevola, with occasional trees, 5 to 8 m tall, mostly Pisonia, but with some Tournefortia and Guettarda.

Eeluk Islet, next to the north, had a sparse planting of coconuts on the lagoon side, with Pandanus trees very common. The outer part, eastward, is covered by a mixed scrub of Pisonia and Scaevola, with an outer cobble ridge with Suriana maritima scrub.

The smaller islets, probably less disturbed, were not visited. Bird populations on the islets visited were not prominent. Probably the other islets may still have better faunas.

A short visit to Utirik in 1956 showed an increase in weed establishment, and an interesting phenomenon of coconut trees felled by the 1951 typhoon but not completely uprooted, prostrate on the ground, then making a right angle and growing erect.

Utirik would justify a visit by a field party, especially to study the smaller islets. This could conveniently be combined with visiting Taka.

LIKIEP ATOLL

Likiep is one of the more populated, hence more altered atolls in the northern part of the archipelago. It lies at 9° N, 169o 18' E. It is a large atoll, about 23 miles long and at most 9 miles wide, with 44 islets, practically all planted to coconuts. Even the tiny islet just inside the south passage, which except for the few palms, had, in 1951, some woods.

Not much information on areas in anything like natural condition is available. Of some interest is the strip of natural scrub and scrub forest along much of the seaward coast of the islets visited which serves as a wind break, protecting the coconut plantations from wind-blown salt spray. This is mainly typical mixed broad-leaf forest and scrub, with a fringe of Scaevola on its outer edge. The profile typically slopes from the edge of the plantation down to the top of the beach.

The eastern point of Likiep Islet is of particular interest. At 200-300 m from the point the coconut plantation is replaced by mixed forest, which attenuates eastward. This point has a most intricate pattern of series of beach rock, dipping in various directions. A study of these might provide information on the geomorphological history of this part of the islet, and of coral islet geoparphic dynamics generally.

JEMO ISLAND

This fragment of a former atoll (?) lies at 10° 06' N, 169° 30' E, about 27 miles SW of Ailuk. Its reef extends about 5 miles to the east. The island is oval in shape, about 3/4 mile long, oriented slightly west of north. Landing is only possible on SW beach in quiet weather (party

landed Dec. 10, 1951, with no difficulty). In 1951 there was a small house near the landing. At that time the terrestrial aspects of the island were studied rather carefully and it was described in detail, and specimens of all plants and invertebrates seen were collected. It was here that the Jemo series of phosphatic soils was described and an interpretation of its origin was worked out. It is said, also, that Jemo was, in pre-European times, considered a turtle sanctuary, only infrequent visits being permitted, with turtles and eggs being taken in limited numbers, under close supervision by priests (Tobin, conversation 1964).

Around almost the entire island beds of beach-rock dip seaward. Above this, on the west, north and much of the east sides is a high sand ridge, 4-5 m above high tide level. This is lacking on the S and SE exposures, where the beach is made up of rounded cobbles and pebbles. On the SW side, about 15 m inland are large boulders, including a slab of beach-rock fully 18 square meters and 3 dm or more thick, which must indicate a powerful typhoon, responsible also, perhaps, for the cobble beach.

On the sand ridge on the west side is a magnificent grove of Pisonia grandis 20 m or more tall, trunks up to 3.5 m diameter, with closed canopy, no undergrowth except Pisonia root sprouts, a thick raw-humus and phosphate hardpan layer on the ground beneath. At the south end, this forest becomes mixed with large Tournefortia trees, some of them almost as tall as the Pisonia. and with trunks to 0.5 or more m diameter.

Around the house, in a small clearing, in 1951 was a veritable weed patch, with a few cultivated trees and shrubs, and many exotics, some of which, especially Carica papaya, had begun to spread into the coconut plantation. Pandanus trees were occasional.

Inland from the Pisonia zone was a very luxuriant and healthy coconut plantation, on a level area of black soil with some phosphate fragments, extending about half-way across the island. Eastward from this the soil changed abruptly to fine sand, probably blown inward from the dune ridge. Here the coconut trees became sparse, and mostly dead or dying, some topless trunks still standing, others fallen. Around some of these were abundant coconut seedlings, and a few young trees, healthy enough. In this area, and becoming very dense, is a mat-like layer of Triumfetta procumbens with Boerhavia and Casaytba. eastward being invaded by Scaevola, and locally, Tournefortia.

Along the east side the sand ridge, and southward, the level terrace, somewhat lower than the coconut area, is a

dense tall scrub or scrub-forest, or even taller forest of Scaevola on the outer edges gradually changing to Pisonia inland to the edge of the decadent coconut plantation. This forest, where well-developed, is rather clear beneath, in areas of lower stature toward the beach, it is dense and tangled. Inland, the old coconut plantation is patchily being replaced by young coconuts.

A more detailed description of the island, with suggestions of the succession taking place, is available. If a field party were able to visit Jemo, it would be desirable to prepare a careful description of the present vegetation, to compare with that of 1951.

Birds were common, many red-footed boobies and common noddies nesting in the trees, white terns, also, other birds less common.

AILUK ATOLL

Ailuk Atoll, about 15 x 7 miles oriented north-south, lies at 10° 13' N, 169° 59' E, 41 miles SSE of Taka. It has a deep lagoon, and a continuous reef the length of the straight eastern side. On this reef are all but two of the many small islets, with the largest, Ailuk Islet, at the southern end. On Ailuk islet is the village, home of all or most of the inhabitants.

On the westernmost point is Akilwe (Aglue) Islet, differing notably from the others. The lagoon side is planted to coconuts, rather open with grass and scattered native trees. The north and southwest sides, from lagoon to about two-thirds of the way to the west point, are lined with a dense mixed scrub of stunted examples of Scaevola, Tournefortia. Pandanus, Terminalia, Neisosperma, Soulamea, which on the windward islets make up most of the predominant mixed forest. The western point, from about two-thirds the distance from the lagoon, is lined by an enormous boulder-cobble ridge, evidence of a terrific typhoon in the not too distant past. Huge boulders are scattered some distance inland from this. The ridges are partly bare, partly covered by mixed scrub-forest, extending well inland, to where it is replaced by open grassland, of Lepturus, Digitaria and Fimbristylis. with scattered patches of scrub and trees.

The many islets on the eastern side show the effects of almost continuous exposure to strong trade winds. The coconut trees, planted on all the suitable sandy lagoonward areas, are protected by broad zones of mixed forest. Some islets are too small or too rocky for coconuts to succeed. These are bare or covered by scrub, especially of Pemphis, bare rock exposures on many of the islets support patches of

dense scrub forest of Pemphis acidula.

The following generalized description, prepared in the field after at least brief visits to most of the islets in 1952, will give an idea of the pattern on these eastern islets. The constant wind-exposure seems to be the controlling ecological factor. Birds, of at least 13 species, are fairly common, but not really abundant. This is not surprising, considering the presence of a large human population on the atoll.

These islets vary in details of their vegetation, obviously because of size, shape, and substratum, but do conform as variations around a general pattern.

The portion toward the lagoon beach is planted to coconuts. This is surrounded by a crescent of mixed forest, very dense, often of Pandanus on the inner edge and in the outer part of the coconut grove. Guettarda, Pandanus, Tournefortia and Scaevola make up the taller part, next to the Pandanus and coconuts. This slopes seaward (and windward) becoming more and more a scrub, largely of Scaevola. The horns of this crescent extend along the passage beaches. There is usually a margin of Suriana or Pemphis or both here. The outermost convexity is usually a very sparse beaten-down scrub often of gnarled bushes of Pemphis and Suriana, sometimes Tournefortia and Scaevola. This extends onto the denuded part of the islet.

Practically all of the islets seem to have had their outer parts denuded of soil by a typhoon or typhoons. Some still show bared root systems clinging to cracks in rock. Crowns and crown sprouts of Pemphis, gnarled and beaten down, submerged in sea water at high tide, persist here with small tufts of Fimbristylis between them.

Plants observed growing where bases are covered at high tide were:

Pemphis acidula	Scaevola sericea
Fimbristylis cymosa	Tournefortia argentea
Lepturus repens	Guettarda speciosa

The slope from true forest at edge of coconuts to scrub to the windward is very characteristic of these islets on the windward side.

The islets are characteristically separated by expanses of flat solution-pitted and exfoliated reef rock, of conglomeratic or brecciated nature, cut back in deep embayments from lagoon side, these often surrounded by low undercut cliffs, tops at about high tide level. Channels

from seaward reef flat run into these with a very swift current on rising and high tides. Much fine material is carried lagoonward in these. Many of the intervening flats are covered by irregular sharp boulders. Some of these may have been deposited here, but mainly they seem to be formed here by the sea dissolving away weaker beds and dissolving along bedding cracks until weakened sections of beds collapse and break into boulders and smaller fragments, which are gradually moved lagoonward by inflowing currents at high tide. In edges of the lagoon this debris, with that from outer reef flats, characteristically forms large deposits at inner ends of passages, bars across channel mouths, and debris trains extending inward from corners of islets. This undermining and breaking process seems to be one of the most important ways by which the rock between tides and above is being removed, at least where there is much agitation of water.

The explanation of the cutting away of the rock from the lagoon side in passages is not obvious.

The windward side of Ailuk seems to have been a continuous platform of reef-conglomerate and confused series of beach-rock, frequently but not always outlining the present islets but at various angles within these outlines. The series outlining the islets usually dip away from the islets toward the passages and lagoon.

This platform is being cut away by solution, abrasion, and under-cutting and collapse at present, except where protected by loose material and vegetation.

The leeward reef, on the other hand, seems to have its surface below low tide, with coral masses growing up to about mean low tide, and abundant scattered boulders of all sizes strewn over surface, exposed at low tide. Corals are abundant, varied, and beautiful here, algae not very important.

MEJIT ISLAND

This is a small island, lying 53 miles east of Ailuk, 10o 17° S, 170° 53' E, surrounded by a very broad reef. It lacks a lagoon, though there is a "shallow inlet" or pond. The island is said to be "well cultivated and wooded with coconut and breadfruit trees.* There was in 1935 a population of 424, certainly large for such a small island. We have little information of any kind, and none on possible undisturbed areas. The broad reef and the "inlet" might be of interest for aquatic diversity.

WOTJE ATOLL

Wotje (or Romanzov or Otdia) is a large atoll with about 56 islets on its reef. It is about 26 x 11 miles, oriented east-west, lying on 9° 28' N, 170° 15' E, with a large deep lagoon and several ship passages. It was the first of the Marshall atolls to be scientifically studied, visited in 1815-1818 and 1823-1826 by Kotzebue's two Expeditions with A. von Chamisso and F. Eschscholtz as naturalists. It is the atoll frequently mentioned as "Radack" in scientific literature, given as the locality for many cited collections by Chamisso and Eschscholtz.

EBON ATOLL

Ebon is the southernmost, 04° 38' N, 168° 43' E, and one of the wettest of the Marshalls. It is roughly circular and has about 22 islets, the larger ones on the southern half of the reef, where is also the only boat passage. Ebon Islet is over 5 miles long and at one end is also quite wide. Some collections have been made of its flora, almost none of the other organisms. Only three bird species were known from there in 1969. Nothing is on record as to the condition of the vegetation, or whether any undisturbed areas remain, but not much can be expected, as there is a large human population. Since it is about the most luxuriant, climatically, a visit would be worth-while.

KILI ISLAND

A small island lying at 05° 34' N, 169° 04' E, about 1 mile long, a third of a mile wide, land area about 1/3 square mile. It has no lagoon, only a brackish pond and a fresh-water marsh or depression. It is totally planted to coconuts and breadfruit, and is the present home of the Bikini people, exiled because of radioactive contamination from nuclear weapons testing on their home atoll of Bikini. The beaches are mostly cobble and boulder, with two stretches of sand. Densely inhabited, there is not likely any remaining native vegetation or native terrestrial animal life, and nothing of interest to a biodiversity field party.

NAMORIK ATOLL

This small trapezoidal-shaped atoll, lying at 05° 36' N, 168° 07' E, 3.75 x 3.50 miles, in the southern, wet belt of the group, is interesting in having the greater part of the reef occupied by two relatively wide islets, with relatively narrow reef-flats and over a square mile of land area. There is no passage into the lagoon, even for small boats.

Apparently no scientist has visited this atoll, and no useful information is available. This atoll might merit a visit to determine if any areas of native vegetation survive, and to collect specimens and information on current diversity status.

LAE ATOLL

This rather small atoll lying at 08° 56' N, 166° 14', E, is about 40 miles SW of Kwajelein, roughly triangular in shape, 5 x 3.5 miles, with 17 islets on the north and south reefs. The one shallow boat passage is on the west reef. Some of the islets are very close together and most of them are broad enough to hold an effective fresh-water lens. The rainfall is high enough to support a luxuriant vegetation and a diverse flora for a coral atoll. There is a relatively small human population.

Apparently a considerable proportion of the land area is too rooky to be suitable for coconut culture. At least, except for the two largest islets, Lae and Loj, only the lagoon ward half or third of each islet was planted to coconut trees when the atoll was studied in 1952. What would be, on other northern Marshall islets, a narrow crescent-shaped windbreak belt of broad-leaf scrub and scrub-forest, is on most of the islets on Lae a substantial area of forest reaching 20-25 m in height, and with a fair number of tree species and several forest types. The proportions of the common species in these forests vary greatly, locally. The common tree species are Pisonia grandis, Intsia bijunga, Neisosperma oppositifolia, Allophylus timoriensis, Guettarda speciosa, Pandanus tectorius, and Tournefortia argentea. The Tournefortia trees are all large old trees, suggesting, because this is a pioneer tree on bare substrata, that these forests are not older than the life-span of a Tournefortia tree.

One of the more interesting and unusual forest types here is a pure stand of Neisosoerma oppositifolia, which seems at least potentially a climax forest type. The ability of Neisosperma to reproduce in its own shade, and the shade of other trees, even of Pisonia, makes it likely that if it gains a foothold, over the long haul it will replace its competitors. Pisonia grandis, with its strong tendency to root-sprouting, seems similarly able to maintain dominance, but invasion of Pisonia forest by Neisosperma has been observed, but not vice versa.

A curious phenomenon observed in mature Neisosperma forests is an occasional very small area where the trees are chlorotic and in some such places the stand thin and somewhat open. Where open there may be large shrubs of

Allophylus timoriensis. These spots seem to be more than just temporary, as the same spots showed in 1952 on 10-year-old air photos. There is no obvious explanation for this phenomenon, and it would be very desirable to locate such spots and examine them carefully during the diversity field investigation.

The general pattern of the vegetation on the islets of the north reef at Lae may be described as follows:

Coconut groves are small in relation to sizes of islets, on or near inner side of islet, semi-circular with the straight side toward the lagoon, convex side reaching to the middle or less of the islet. Outside this is a crescent-shaped area of natural vegetation conforming to outline of island and that of convex side of coconut grove.

Undergrowth in coconut groves is of Wedelia, Ipomoea, Tacca, etc., ground cover of Lepturus, Fimbristylis, etc. State of undergrowth is dependent on how recently it has been cleared out. Burning of trash is commonly practiced.

The mixed forest which usually is just outside the coconut grove is largely of Pisonia and Intsia, with isolated Neisosperma trees or small groups, occasional Guettarda, Pandanus, and isolated large old Tournefortia trees, no young ones. This forest has sparse undergrowth, mainly of young trees of the same species, with Ipomoea and Canavalia vines, etc. On most of these islets are patches, large or small, of pure stands of Neisosperma, more or less even in age, with pure Neisosperma seedling stands beneath. Sometimes these forests extend practically to the beaches.

Seaward and passageward the mixed forest changes to a belt of scrub, widest toward the sea, there usually almost pure Scaevola, more mixed and more luxuriant along passage beaches.

The lithified conglomerate exposures may have small stands of Pemphis acidula scrub or scrub-forest.

Lae IsIet, the largeat one, site of the village, occupies the entire eastern point of the triangle, extending both east and northwest. It is largely planted to coconuts and breadfruit, but has an area of native vegetation occupying the easternmost point and another on the western extension. The latter is covered by a stand of Neisosperma along the west passage beach-ridge, and for a short distance east along the south side. Locally there is some admixture of Pandanus and Guettarda. The outer margins of this forest are lined with a dense scrub of Scaevola, Guettarda, Suriana with some Pemphis, and tangled with Ipomoea, Vigna, and

Canavalia.

In the center of the islet is an area of partly overgrown old taro pits, some still in use (in 1952), others with small trees growing in and around them, those in use more or less occupied by the not very useful Alocasia macrorrhiza.

East of this, the eastern peninsula for about one-third the distance to the lagoon shore, is not planted to coconuts or breadfruit, but is partly densely forested, partly open. The open areas were, in 1952, blanketed with a dense tangle of Wollastonia biflora to a depth of one meter or more. The soil here is a loose accumulation of small coral pebbles with a little dark soil well down between them.

Surrounding the open area is a broad zone of mixed forest, largely dominated by Guettarda speciosa, with Pandanus and Allophylus. Locally Pisonia forms pure colonies. This forest occurs on what seem to be a series of boulder and cobble ridges, the largest one around the east point. On the south side, on an enormous storm deposit of boulders, is a forest entirely made up of Barringtonia asiatica, mostly 3-10 dm trunk diameter, but some positively enormous, but the largest ones are usually hollow and partly decayed. The appearance of the boulder deposit suggests that the boulders may have been thrown up after the forest had attained nearly its present stature. The highest seaward edge of this ridge reaches at least 5 meters elevation. The forest is perhaps 20 m tall, and is tangled with lianas of Ipomoea macrantha with stems as much as 4 cm thick. Thc outer slope of the boulder ridge is covered by a strip of mixed forest. The whole east peninsula is fringed with Scaevola scrub.

Loj Islet, the westernmost, is almost entirely planted to coconuts, except the extreme points which have a fringe of Scaevola, and a depression in the center occupied by a pure stand of breadfruit. A mat of Vigna marina is the principal ground cover in the plantations.

Lae Atoll is one of the more luxuriant and least disturbed of the inhabited Marshalls. The trees have more epiphytic mosses, lichens, etc. than is usual on coral islands. It would seem to merit much time and attention by a field party.

AILINGINAE ATOLL

This is an elongate, narrowly rectangular atoll, lying at 11° 08' N, 166° 24' E, about 15 miles long, 4 miles wide, oriented N-S. There are 25 islets, and their arrangement

somewhat unusual in that they are almost all on the west and south reefs. The atoll is uninhabited, but several of the larger islets are planted to coconuts, and people, probably from Rongelap, are said to visit to make copra.

All too little is known of the natural history of Ailinginae, except for the birds, which were studied by a party from the Pacific Ocean Biological Survey Program in 1967, and the atoll was looked at casually, by Fosberg in February, 1956. On this latter brief visit a few plants were collected and notes made on the vegetation on Sifo Islet. Examination of oblique air photos, taken in 1955, shows that Knox Islet, Knobuen Islet, Ribinouri Islet, Mogiri Islet, Manchinikon Islet, and Sifo are densely wooded, with Enibuk Islet mostly planted to coconuts, some on Sifo, and Eniwetak Islet grassy with scattered trees.

An all too brief visit to Sifo Islet showed that the greater part is covered by a scrub forest, principally of Guettarda, Tournefortia, Scaevola, Pisonia, and Cordia, very little Pandanus. In openings there is a ground cover of Lepturus,Triumfetta, Boerhavia and Portulaca. Along the lagoon shore, and hooking around the ends of the islet, is a narrow zone of scrub, mostly Scaevola sericea, about 3 m tall, interlocked and dense. Locally there are some Guettarda and Suriana a few bushes of Terminalia samoensis.

On the seaward (west) side is a broad cobble-boulder flat, some of it open, some covered by a sparse mixed scrub. The east part of the seaward side, on the reef flat, somewhat separated from the shore, are two large series of beach-rock beds. West of this are large rocks. The lagoon shore is lined by beach-rock, being eroded.

Part of the interior of this islet is covered by a forest of Pisonia, up to 20 m tall and Cordia up to 10 m. Locally one or the other is more abundant. The Cordia, in addition to growing upward and forming a secondary canopy, sends out long twisted lower branches running over or near the ground, forming a tangle that is exhausting to penetrate and traverse. Ipomoea macrantha festoons the trees and in thin places is a thick tangle of Wollastonia biflora. In the interior of this is a pronounced ridge, to 3-4 m high, of sand and pebbles. The soil in this forest is a peculiar loose brown granular material, also noted on Rongerik, but in neither place was there time to study this carefully, or to describe a profile. It seems to be associated with Cordia and Pisonia. This, along with other features of Ailinginae, would justify much more careful study. The natural diversity is perhaps less than on most other atolls, but disturbance and alteration have been far less.

AILINGLAPALAP ATOLL

This is a large atoll, lying at 07° 23' N, 168° 46' E, in the southern portion of the Ralik Chain, roughly W of Majuro and N of Jaluit. It is triangular-crescent shape, convex to the east, about 27 miles by 19 miles, with many islets scattered on all sides, the larger ones mostly around curves and angles in the reef. There is a large resident human population and the larger islands are planted to coconuts. Little reliable information on vegetation is available except on Ailinglapalap and Bikajle (Bigatyelang) islets, which were studied briefly by Fosberg in 1946.

The two mentioned rather elongate islands on the south reef are mostly planted to coconuts, except on the rockiest shores, planted down to the top of the beach. A few bits of broad-leaf forest remained here and there in 1946, and several small rock bottomed mangrove depressions. One of these, on Ailinglapalap islet, part called Airik, was completely dominated by Lumnitzera littorea, with brilliant scarlet small flowers.

Other mangrove depressions have Bruguiera gymnorhiza with occasional Intsia bijuga and, rarely, Lumnitzera. The edges are lined with Pemphis acidula.

On Airik, and Ailinglapalap islet also, is one of the very few real mangrove swamps in the Marshalls. This has standing water in the central part, connected by a small channel with the lagoon at high tide. Sonneratia alba and Rhizophora mucronata var. stylosa are the principal trees, with occasional Bruguiera gymnorhiza. The bottom is a gray calcareous mud or marl. Epiphytic Nephroleois acutifolia occurs on some trees.

The flora, in general, is rich for a coral atoll, reflecting the high rainfall. This mostly occurs as undergrowth in the plantations and fringes around rocky beaches, in small wooded patches, and in the mangrove areas. About 100 species were collected during parts of two days, April 25-26, 1946.

The principal areas of natural history interest are the mangroves. However, it is likely that some of the smaller islets may remain relatively undisturbed and worth investigating. The known bird fauna is meager, 4 species only. This may reflect the long-time presence of a large human population, or it may likely result also from the almost complete lack of investigation and observation.

On the lagoon floor, in rather shallow areas, were

observed some of the finest displays of tall branching corals seen anywhere in the Marshalls. These merit detailed observation and perhaps protection as a marine park or preserve. They could be observed very well, even by snorkeling.

NAMU ATOLL

This is a large elongate atoll, lying at 08° 00' N, 168° 10' E, 32 miles long, NW-SE, 2-7 miles wide, NE-SW, with a large number of islets, mostly scattered along the east reef and around the two ends, a single islet beside the northern of 3 boat passages on the west side. The islets are said to be mostly sandy, some places with considerable humus and some exposed rock. Rainfall is high, and the flora, as indicated by St. John (unpubl. data) is fairly rich for an atoll. There is a fairly large human population. Only 6 species of birds are recorded, but probably more are present in small numbers.

No information on vegetation is available except that most islets are planted to coconuts.

WOTHO ATOLL

This atoll, lying at 10° 06' N, 165° 59' E, shaped like a bent triangle, 19 by 9 miles, has 18 islets, mostly on the east reef and at the angles, several on the west reef where there is a wide but shallow pass. For its size it has considerable land area, and, though populated, probably retains intact more of the total Marshall Islands biodiversity than any of the other atolls and islands. It is moderately wet and hence, has many more species and more diverse ecosystems than do the less-disturbed atolls at the north end of the group. This is known from studies made by the U.S.G.S. Expedition in 1952, when much detailed reconnaissance information was recorded on vegetation types and patterns, and relations between vegetation and substratum. If much of this natural vegetation still survives after 35 years, Wotho will be one of the most important atolls for preservation of indigenous biodiversity in the Marshall Archipelago. The following descriptive remarks, though written in the present tense, portray the atoll as it was in 1952. Because of the fact that this atoll may well be the one receiving most attention in the Biodiversity Project, the vegetation and geographical information notes made in 1952 will be copied with little editing from the field notebook. These notes cover most of the islets in clockwise order around the atoll, starting with Wotho Islet, the largest, in the northwest corner of the atoll. There is much repetition, but these detailed notes may make possible comparisons that could tell us much

about the dynamics of Marshall Islands vegetation and even geomorphology.

The western part of this islet is partially separated from the larger part by a large bay on the seaward side, running up into a sandy reentrant that extends in almost to the lagoon. Along the entire lagoon coast of the islet is a broad low ridge of sand, several feet above the general level. The reentrant tapers out into a narrow shallow channel which becomes fainter lagoon-ward and disappears shortly before reaching the ridge along lagoon shore. The reentrant is bare in center, with a belt of sparse scrub along each side. This is composed of Suriana, Scaevola, Guettarda, etc. on deep pink sand.

The north beach of the smaller north section of Wotho Islet is a boulder beach, running up into a well developed boulder ridge, backed by a broad boulder flat at slightly lower altitude. This flat has sparse mixed scrub of Scaevola, Guettarda, Suriana, etc. with scattered trees of Tournefortia and especially Pandanus, extending some distance in, merging with scrub forest. The boulder flat, as it gets further from the ridge, especially on the east side has some sand between the boulders. There are openings with Lepturus and Cassytha in the scrub.

The reef here has a layer of coarse breccia, well consolidated, being stripped by solution along bedding planes or unconformities and subsequent wave action, from a previous solution surface (?) in finar grained rock, exposing old solution basins (?).

Boulder beach hooks around the point and runs part way down the passage beach to the main curve in it.

The west point of the island has a sparse grove of coconuts with Pisonia, Scaevola, Tournefortia, Soulamea, Guettarda, Pandanus scrub forest second story, undergrowth of young coconuts and tree seedlings, with openings with Lepturus, some Fimbristylis and Cassytha. Same thing further in but lacking coconuts. No ground cover except in thinner places where it is similar to that in openings but sparser, and occasionally under Soulamea trees, where seedlings form a carpet. Tournefortia very soon drops out, Soulamea becomes more abundant. Finally scrub forest is Soulamea and Scaevola.

Soil from sand ridge along lagoon almost to the center is a fine gray silty material, quite deep.

Near the center is a patch of Neisosoerma forest, almost a pure stand but with small admixture of Pandanus and

Premna. Neisosperma seedlings abundant. Here the soil is a coral rubbla, pieces rather small. Beyond this, again a fine gray soil, with same mixed scrub forest as on west point, with Intsia added. This changes close to the channel on the east, becomes sparser and lower, with more coconuts, then becomes a scrub of Scaevola, Suriana, some Terminalia and Tournefortia. Outer fringe of this mostly Suriana. Gravel flat beyond this is bare, with a few Suriana seedlings close to scrub, many Scaevola seedlings further out in channel.

Enerikau islet beyond narrow channel has a small dry coconut grove, open beneath, surrounded by sparse scrub forest of Tournefortia, Guettarda, Pandanus, and Scaevola. Very rubbley soil.

Along sandy reentrant back of scrub the belt is a mixed forest of Premna, Morinda, Soulamea, Pandanus, Neisosperma, Scaevola, etc. varying locally to pure Neisosperma, on fine gray soil.

This changes, following up the reentrant, to coconut plantation, at first with much undergrowth of Scaevola, Guettarda, young coconuts, etc. At head of reentrant plantation it becomes sparse, with little undergrowth and a ground cover of Lepturus and Fimbristylis with Cassytha and some Ipomoea macrantha, on fine gray soil.

Along the lagoon, back from the sand ridge, is a large open area with Lepturus, some Fimbristylis and Cassytha. being invaded by Wollastonia, Scaevola and Guettarda, a few young coconuts which are very yellow. Fine gray soil. Back of this and of houses in village is coconut plantation with a mat of Wollastonia. Back of this is tangled undergrowth of shrubs of Morinda, Pandanus, etc. tangled with Wollastonia, Canavalia, Ipomoea macrantha, etc. In the village the ground cover is Vigna, Lepturus, Thuarea, Eragrostis amabilis, Fimbristylis, Cassytha, Canavalia, Ipomoea, etc. Here are 4 large breadfruit trees.

Village consists of a long stone-lined path with houses at very wide intervals on both sides. Those on lagoon side are up on the sand ridge.

Back, along the sandy reentrant is a scrub belt, as on the other side.

On the southwest shore of bay is a belt of small sand dunes. On the exact south side is a sandy belt with scattered small boulders, many of them of Porolithon. The beach here is somewhat shingly. Along the southeast side are a few boulders and much sand back of the beach, further

in fine gray soil but much small rubble in it. In the more rubbly places, the soil is blacker. The undergrowth in the plantation is tall, and near the beach is mainly Scaevola.

The two sides of the bay are lined with beach-rock, the head has none. About half way out on southeast side the directions of the strike and dip become very confused.

The hook at the outer corner of the bay is lined with a boulder ridge and boulder flat back of it. On this is a mixed scrub forest of Pisonia, Guettarda, Neisosoerma, Tournefortia, Pandanus, Morinda etc. Tangled with Wollastonia and Ipomoea it gradually changes to Scaevola scrub as the point and outer beach are reached.

Seaward beach is sand, behind a well developed cuesta of beach-rock. There is a broad belt of Scaevola scrub sloping to seaward, gradually changing to Tournefortia inland, with much Guettarda. The beach is about 10 m broad, and Scaevola roots run completely across this to the beach-rock. There are boulders scattered inland through the scrub and into the forest for at least a kilometer.

The leaves of the Scaevola exposed to the constant wind and spray are thick and twisted and distorted, locally chlorotic.

Back of the scrub belt is a belt of forest 50-100 m wide. In from the boulder flat along the bay shore this is a mixture of Neisosperma, Allophylus, Pandanus, small coconuts, etc. The soil becomes less rocky and the rubble becomes smaller and is occasionally piled up into low rounded mounds of small broken coral. Further in rubble becomes less abundant and fine soil more so. The undergrowth in this forest is largely tree seedlings with some Morinda and Wollastonia, Ipomoea is common in the canopy and its thick rope-like gray stems are common beneath.

The forest gradually changes, away from the boulder flat to an open forest of Tournefortia, Guettarda and Pandanus. Here are occasional sand dunes (boulders scattered in tops of dunes) as much as 2 m tall. Inside this is an enormous area of almost pure Neisosperma forest, locally varied with tall Pandanus. The Neisosperma trees are about 40-50' tall, seldom 1' in diameter, mostly about 0.5' with tall straight clean trunks, branched only near top, canopy complete, no undergrowth. A carpet of seedlings 6-12' tall, ground completely covered with fruits. Soil fine gray, varying to fine rubble.

Locally there are spots, light on photos, where the

Neisosperma is yellow, even dying. There is no evident reason for this. Where there is any hole in the canopy, the seedlings are much taller than elsewhere. Boulders are sparsely and irregularly scattered throughout this Neisosperma forest.

The center of the island is a series of long winding troughs and ridges, most likely ancient taro pits. Much breadfruit here, some trees even in bottoms of pits. Mostly the pits are dense tangles of Clerodendrum, Vigna, Wollastonia, Canavalia, Ipomoea, young Pandanus, etc. Locally spots have been cleared out and Cyrtosperma planted. The bottom is deep wet muck in these places. Cyperus and Fimbristylis tend to choke out the Cyrtosperma.

The Neisosperma forest seems to represent a remnant of the original vegetation. Otherwise it is hard to account for the pure stand. The trees are not large, but there is little else. To have produced such a stand after clearing would necessitate a means of close sowing of the seeds and of eliminating all competing species. Over long periods they might well be eliminated but it would take at least the lifetime of the longest-lived.

On Wotho islet the grass, and, especially, the Fimbristylis, show strongly the effect of the drought, by being brown and partly dried up. Beach rock, dipping lagoonward, extends for some distance along south end of lagoon beach. It is pitted with rounded edges, probably abraded by wave-washed sand. Toward the south end, perhaps 200-300 m north of the point, there is an abrupt change in the height of the coconut trees, those to the south being lower. The south point has only mixed scrub and back from point mixed scrub forest.

The north third of Bokanaetok, a sand spit on the east reef, was examined. The spit is a long low ridge of sand on platform rock that is generally marked with several series of beach rock, that showing along lagoon beach mostly dipping toward lagoon, that on seaward mostly dipping seaward. However, one stretch of a single series of beds, lying between the seaward dipping beds and the main sand ridge dips lagoonward, making it look as though a stretch of the sand ridge has moved into the lagoon. The denuded outer flats are generally rather wide.

There is very little vegetation, only a few scattered Tournefortia and Scaevola bushes, on the thin sand locally found on these seaward flats. On the main sand ridge is a mixture of Scaevola, Tournefortia and Terminalia, varying in density from scattered to continuous, some Tournefortia trees 5-6 m high and 2-3 dm thick, but these are uncommon.

Where there are scattered bushes low mounds of sand have accumulated under them. Where there is continuous scrub the sand ridge is several feet higher, with highest line usually nearest the lagoon side.

On seaward side is one tiny patch of Suriana, and about one third the way from the north end is a large and conspicuous clump of Pemphis acidula, quite dense. On the lagoon side the leaves are rather thin, on the seaward side very thick. At 9-9:30 a.m. insects of various sorts were common on the west side of this clump while none were seen on the sunny side. The Pemphis was flowering.

The sand where there is no vegetation tends to be flat on top. It is fine, white to pinkish, and the surface may locally be held firm by an incipient algal crust. There is a loose layer of dead leaves under the bushes. Here and there are thin patehes of Lepturus in the bushy vegetation, none in open.

There is a small group of ragged coconut trees at north end, and very ragged individual trees here and there along the islet.

From the lagoon the vegetation all along seems to be scrub with frequent Tournefortia 2-3 times as general level of scrub.

North of this spit are some small patches of sand on the reef.

Then there is a small islet with two patches of vegetation connected by a rock flat. The vegetation of both halves is sparse scrub and there is one coconut tree on the south half. (Seen only from boat.) Between this and the end of Wotho Islet is a small bar on a rock platform. From a boat two bushes are visible on this.

Lojwa islet was seen only from the boat in the lagoon. On the lagoon side appear to be high beach rock beds, possibly undercut by lagoon waves, extending above all but most extreme high tides. Vegetation is a sparse scrub and scrub forest mostly of Tournefortia with some Scaevola, a few coconuts on lagoon side.

Iroijemau, Ujiej and Jibnao islets were seen only from the boat in the lagoon. These are all wooded, possibly mostly with Pisonia, as defoliation is very noticeable, but from appearance on aerial photos, rather mixed. The ends, and in case of Iroijemau, the seaward projection tapers off to scrub. On Iroijemau, MacNeil reports a single Pemphis

bush on the extreme end of the seaward projection, the rest of the scrub being Tournefortia and Scaevola. This projection is bare rock. On each of these islets there is a small patch of coconuts on the lagoon side.

On the lagoon side of Iroijemau there is mixed forest of Pisonia, Tournefortia, and Guettarda. On this islet the lagoon beach is lined with beach rock with great slabs of it piled up on beach above. Some sand on the north end, this with scrub of Tournefortia and Scaevola.

On Enejelto islet the entire lagoon beach, except for a few short stretches, is lined by lagoonward dipping beach-rock, and above this, great slabs of beach-rock are piled up to the top of the beach. The unusually strong lagoon waves are dissolving the beach-rock along bedding planes, cracks, etc.' the cracks apparently reauIt of undercutting along bedding planes. A slight ridge is developed here and there along lagoon beach, but it is not conspicuous. Along the entire lagoon beach, except for a short stretch of coconuts with Scaevola between them, is a mixed forest of Guettarda, Tournefortia, Pandanus, Pisonia, Neisosperma and Scaevola, tangled with Wollastonia and Ipomoea pes-caprae. Here and there are small patches of Lepturus. Inward, Pisonia becomes dominant, but is being replaced by a layer of young Neisosperma trees.

In the center, at least of tha south end, is a solid forest of Neisosperma. In all of this forest sticks blackened by Xylaria are common. Rats are common. The soil in the forest is fine and blackish, with varying admixture of fine rubble. Toward the seaward beach it becomes more sandy and has on the surface boulders strewn into the forest. Near the south end is mixed forest similar to that described for the lagoon beach, with, also, some Canavalia tangled in it. This peters out into mixed scrub on the sandy extreme south end. The entire seaward beach is gravel, resting on flat reef conglomerate. Above it is a belt of Tournefortia forest with a Scaevola fringe.

Kabben Islet is a large triangular island with one lagoon coast and two seaward ones, an east and a southwest. There are also two passage beaches, one north, the other west, the latter not sharply marked off from the southwest seaward beach.

Most of the beaches are of sand or fine white gravel. Along the lagoon beach is a broad ridge of sand, broken into small dunes at the western end. The north passage beach is of pebbles, lying on beach-rock, changing to finer gravel seaward and around on seaward beach changing to sand. The pebble beach is backed by a low ridge of broken coral. The

south peninsula of the islet is surrounded by a pebble-cobble beach, high and steep, backed by a very broad ridge of boulders and rubble, 100-200 m wide. This beach rests on a pitted conglomerate platform, with remnants of a higher platform here and there not yet completely eroded away on the southwest side. The ridge and boulder beach extend around the point and to the beginning of the sparse scrub and the crescent of sand beach on the southwest side and a corresponding distance, perhaps 300 m or more, on the east side.

The southwest corner of the islet has a broad reef-rock platform, and three series of beach rock extend along the passage beach, dipping away from the islet, splaying out fan-wise toward the lagoon corner, but not reaching it. This part has a sand beach.

Along the top of the lagoon beach is a narrow belt or fringe of scrub of Scaevola with some Tournefortia, tangled with Wedelia. This is in the edge of the coconut plantation, on the sand ridge. The plantation, except immediately around an old hut, is choked with thickets. Near the lagoon these thickets are of Pandanus, Scaevola and Morinda, tangled with Wollastonia. Around the hut, where the thickets have been cleared, a thin tangled mat of Wollastonia covers the ground.

West of the center of the lagoon beach, Neisosperma becomes a component of the plantation thickets, with Guettarda and Pandanus; Neisosperma very locally forming almost pure stands, and with Neisosperma and Pandanus seedlings making up the undergrowth. From here westward the coconuts are very sparse, thickets dense. Back from the beach, in the region of the hut, Scaevola rapidly drops out. Guettarda, Morinda and Pandanus dominate the thickets and the whole becomes choked with young coconuts of all ages. Still further back the coconuts become sparse. There are large clumps of breadfruit, and Neisosperma becomes common.

Westward the plantation gradually changes to mixed scrub forest with a few coconuts. On the west end, behind the low dunes, there is open sand with a scattered scrub of Scaevola,Guettarda, Suriana and Tournefortia, with scattered trees of Pandanus and small coconut trees. On the sand is a well-developed algal crust.

On the north passage a belt of scrub, mostly Scaevola and very low on the seaward end, becoming mixed with Tournefortia and Guettarda, and taller toward the lagoon, occupies the ridge of broken coral. Back of this is a scrub forest of Tournefortia, Pandanus, Pisonia, Guettarda, Soulamea, with a little Scaevola and Terminalia. Locally

there is a ground cover of rather wilted Polypodium, and of Soulamea seedlings, these now mostly dead. A few saplings of the trees and a tangle of Wollastonia make up the undergrowth. In openings Lepturus and Triumfetta form the ground cover. The soil is small rubble, becoming finer inward.

Toward the edge of the plantation a few scattered coconuts, Cordia, Morinda and Allophylus are added to the scrub forest. The forest is generally not more than 10 m high, the canopy not dense, at least in the dry season. The undergrowth becomes thicker by addition of coconut seedlings. Wollastonia becomes more luxuriant. Conditions become slightly moister so that seedlings of Soulamea are able to survive. Probably this change to slightly moister conditions is due to lessened penetration of wind due to greater distance from the windward beach.

Inward from the east end of the lagoon beach, into sparse coconut plantation grown up to a scrub forest, Pisonia, Guettarda, clumps of Cordia, with Canavalia festooning everything. Inward a little way are several breadfruit trees, coconuts become scarcer. Locally Pisonia is dominant and makes very large trees. Under them is a well developed peat layer and no undergrowth. The soil of fine rubble soon becomes mixed with much dark gray-brown loam. This mixture is generally at least 3-4 dm deep, the rubble increasing downward. Soulamea becomes common, and further in, abundant. Guettarda is co-dominant with it, and Neisosperma appears, forming local patches. Inward these patches become more frequent and larger, until the large area of pure Neisosperma forest extending inward from the east coast is reached. The soil remains the same uneven mixture of loam and fine rubble. In the mixed forest around the pure Neisososerma, Wollastonia behaves as a liana, straight stems going up into the canopy, then forming tangles.

Extending from the east coast in for some distance is a great roughly triangular area of pure Neisosperma forest. This has a layer of fruits on the ground and a continuous layer of seedlings, varying locally in height from 2 dm to 1 m. The height of the forest varies from perhaps 20 m sloping down to the east to perhaps 4-5 m. There it gives way to a narrow belt of scrub, mainly Scaevola, which lines the beach. There is some admixture of Guettarda, and locally clumps of Tournefortia trees. A characteristic of this scrub belt on the windward beach is the effect of strong grooves or channels in the surface of the vegetation, parallel to the wind direction, starting at the beach and becoming shallower and disappearing inward. This scrub belt extends the full length of the east coast, typically wedge shaped in cross section, thin edge at the top of the beach.

Along the inner sides of the Neisosperma forest great Pisonia trees are mixed with the Neisosperma. Here, also, are many patches where the Neisosperma is very chlorotic, and even some trees have died. Just inland from the Neisosperma forest is a mixed forest of great Pisonia trees, Neisosperma and a few old Tournefortia trees, a few Pandanus and small Allophylus. Undergrowth is of saplings of Neisosperma and a few of Allophylus. There are occasional scattered groups of the low rounded mounds of broken coral previously described. One old Tournefortia had fallen. Paced off it was about 45 m tall. A few of the Neisosperma here are old, but there is mainly a stratum of young ones about 10 m tall. The undergrowth is of young Neisosperma saplings and a few young Pandanus.

Northward near center of this part of the island is a sparse stand of coconuts choked with Guettarda, Neisosperma, Pandanus, etc. with seedlings of these and of coconuts making walking difficult. Then there is a section of scrub forest of Guettarda, Soulamea, Pisonia, and Pandanus. Between this and the east end of the lagoon beach is more choked coconut plantation.

The east coast scrub belt sends a narrow hook around the south point. This is backed by mixed forest, the transition being gradual Guettarda and Tournefortia replacing more and more of the Scaevola. Along the boulder beach of the southwest coast of the south peninsula, mixed forest comes right to the top of the beach. It is made up of Pisonia, Tournefortia, Guettarda and Cordia. Inland on the broad boulder flat Pisonia becomes dominant in this mixed forest, some of the trees being enormous. Inland from these is a large opening on the rubble flat filled with a deep mat of Wollastonia. In the inner edge of this is a grove of coconuts. The boulder and rubble flat along this coast is 100-200 m wide.

Along the central part of the southwest side is a wide sand flat with very sparse scrub, much open sand, Scaevola predominant. In the mixed forest on the rubble and boulder flat there is little undergrowth except occasional seedlings of the component trees, and inland, of Neisosperma which is rare as a large tree but is actively invading.

The Cordias, abundant near the beach, are enormous low spreading trees with immense gnarled trunks and great writhing horizontal branches just off the ground. Penetration is difficult.

Enearik Islet, the surface of which is all sand along the lagoon beach, is a broad dune ridge from 2 to 4 m above

high tide level. The seaward part is lower. On top of a high rounded dune on the south end are scattered large boulders, about 2.5-3 m above high tide. On this dune there is a grove of Pisonia, surrounded by Tournefortia and Terminalia. Both the Pisonia and the Terminalia were practically leafless. North of this a large Cordia forms a broad low tangled thicket. In the center are three patches of coconuts, the middle one back from the beach. Between them is a patch of Neisosperma. Here there are, for a short distance, two dune ridges, but they are lower than at the two ends. The west end and parts of the east and center are covered by a mixed forest of Tournefortia, Pisonia, Terminalia and Guettarda. The edges of this and sparser spots are tangled with Wollastonia. Some of the Terminalia has lost its leaves, some has not.

The lower ground back of the dune ridge is covered by uneven scrub forest, mainly Tournefortia, Guettarda and Pisonia, of varying density. Toward the seaward beach, especially on the east and west ends, this thins out to a sparse scrub of Scaevola with some Tournefortia and some Guettarda. Much bare sand between the rounded bushes. A broad series of beach-rock, dipping seaward, lines the southeast beach, some beach-rock, also, on the south side, and along the southwest side. Drift seeds are unusually abundant on this island. The sand at about high tide level, and the beach sandstone beneath it, are curiously polished.

Ombelim Islet, a sand platform, somewhat uneven surface, 1.5-2 m, is covered by a single large grove of Pisonia, medium sized, perhaps 15 m tall, with undergrowth of root sprouts of Pisonia about 1 m tall forming a definite layer. This is surrounded on all but the southwest side by a narrow belt of Tournefortia. The only other vascular plant is Lepturus, which forms a small patch on seaward side in the Tournefortia belt, now dry. Peat layer is well developed in the central part only of the Pisonia forest, from 2 to 8 cm thick, underlain by partially consolidated layer of sand 3-5 cm thick, this lying on loose sand. On top is a loose layer of dry leaves covered by guano stains.

Near center is a broad sand dune about 4 m above high tide. Some sand is piled up around the edges, burying the lower parts of Tournefortia trunks. Waves cutting a low cliff in sand on north side, expose abundant Tournefortia roots 4-5 m from the plants. Birds are abundant and the dead leaves, roots, branches, etc. are strongly stained by guano, but no noticeable accumulation of guano was seen.

Biken Islet is a sand platform with high beaches, general surface about 2 m above the high tide level, but uneven, one large dune hill being about 2 m above general

surface. Lagoon beach is being cut away by waves, leaving a 2 m sand cliff, with a pile of slabs of beach-rock at base, one slab up in center of islet on sand.

Vegetation is rather open Pisonia forest in center, some fair sized trees, some bare, several still with last season's leaves. Occasional thin patches of Lepturus, scattered Boerhavia and Portulaca lutea, latter nearly leafless, the thick stems carrying it over tthe dry season. a sparse belt of Tournefortia runs around the periphery, with a few Scaevola bushes. Many white-capped noddy nests in trees.

Mejurwon Islet - east passage beach, seen from east, very long. Outer third is boulder beach, middle third seems to be gravel, inner third sand. A well-developed belt of Tournefortia extends along entire beach, backed by coconut plantation. Lagoon beach is all sand. In the eastern part there is no very noticeable sand ridge. In the middle the sand ridge along the back of the beach is broad and low, but very definite, actually appearing to be two ridges. Westward, about the west third of it develops into conspicuous dunes from 6 to 10 feet high. Back of the lagoon beach is a broad belt of open scrub, of Scaevola, Tournefortia, Guettarda, occasional Pandanus and Suriana. Between them is open sand. On this are scattered pumice and scoria pebbles with network of roots on their under sides. Here and there in this belt are great clumps of Calophyllum. Their leaves are browned on tips or edges where much exposed to weather.

On the dunes to the west the scrub is about the same composition as on the sand flats back of the beach to the east, but with much more Suriana. In openings Triumfetta is often found, half smothered by sand. In other openings Lepturus is common and Cassytha is common parasite both on Lepturus and on bushes.

To the west, near point the scrub becomes taller and denser, and may be termed scrub forest.

The islet is extensively planted to coconuts, on a fine sandy gray-brown soil. The part of the plantation near the lagoon beach is rather well cleared out, with scattered small bushes, the ground covered by a mat of Canavalia or Wollastonia. Large Calophyllum trees are found around old house site and elsewhere where there might have been a house, just back from the beach scrub. Calophyllum is more abundant on this islet than anywhere I have been in the Marshalls. Probably this accounts for the abundance of Calophyllum drift seeds on the beaches of various islets of Wotho.)

Away from the lagoon the woody second story becomes more abundant, forming thickets, composed of Pandanus, Morinda, Terminalia, Soulamea, a little Cordia, tangled with Ipomoea macrantha and Canavalia, and choked with coconut seedlings of all ages. Walking is difficult. There is some ground cover of Polyoodium and Lepturus, the latter especially in small openings. In thin places in the plantation Tournefortia and Guettarda are very common, with Wollastonia on the ground.

Natives visiting this islet had gathered a bundle of dry Pandanus leaves and some copra and turtle eggs, as well as 3 or 4 dozen coconut crabs. Some of these had been roasted and the large claws tasted very good. A large individual from this batch was preserved in a tank of alcoholic specimens otherwise collected by MacNeil (unnumbered). The color varied on different individuals, dull purple usually predominating, but certain ones largely light blue.

Enebarbar Islet's east end is surrounded by pebble or boulder beach, lagoon beach west of this, sand. Seaward beach, as seen from west, is a high steep boulder ridge. Most of the islet is covered by dense Pisonia forest, reaching out to the seaward edge. Surrounded, on lagoon side, by a broken fringe of Tournefortia. A clump of coconuts at west end. Seen only from boat in lagoon.

Eneobnak Islet. A belt toward lagoon a sand flat, forming 2 parallel ridges, especially toward the west, where there are two more ridges, separated from the two lagoonward ones by an interval in which there is locally a little rubble. These ridges are generally sandy.

On the sand flat and two lagoonward ridges is a sparse stand of scrub of Scaevola, Guettarda and Tournefortia, much bare sand and much Cassytha on the bushes. Pumice is scattered commonly on this sand. Some of the pieces have patches of a root network on the bottom.

The rest of the islet is wooded with a mixed forest, in most parts rather sparse, made up of Tournefortia, Guettarda, Pisonia, Cordia, and Scaevola, the Tournefortia most abundant near the edges, the Pisonia almost dominant in center. Three sparse patches of coconuts are found near the lagoon side. They show evidence of the drought in having the recent clusters of nuts dwarfed or abortive, some nuts small on some of the older clusters. Trees in the western-most clump mostly have no nuts. The forest is rather dense in center of widest part of island, where Pisonia is commonest, about 8-10 m tall, little undergrowth or ground

cover. To the west it thins out, becoming rather sparse, Tournefortia more abundant, Pisonia less, thin ground cover of Lepturus with some Boerhavia, Cassytha especially in open places. One can walk freely almost anywhere. More or less sand on east end near passage beach. Some Terminalia here.

The low rounded mounds of small broken coral perhaps betray their origin here. A little to seaward of center of islet, where the soil is generally rather rubbly, low mounds of small pieces have piled up around root systems of Pisonia trees, either surrounding them or on the seaward side. In a few cases the tree has fallen, leaving the mound, with the tipped up root system adjacent, lying toward the lagoon either contiguous or several feet away. There are examples in various states of preservation, one or two having sent up big sprouts from the fallen trunk, one having almost decayed away, and several lacking any root system, the mound alone surviving.

Around the peninsula that sticks out to seaward, from near the lagoon end of the east passage beach around to the concave bend in the west passage beach, is a well-developed boulder ridge, with Scaevola-Tournefortia scrub on the northeast side, this changing inward to the forest described above.

Back of the west end are several channels between rubble or reef conglomerate flats. Water runs swiftly through these from seaward, where they are narrow. They are much wider toward the islet, then the current sweeps westward from each of them around the west horn of the islet.

Wotho birds - In general, birds are abundant on the smaller islets, relatively scarce on the larger ones. Nesting is mostly seen on the smaller islets. Terns, as usual, are the most abundant birds.

Frigate birds - A colony of well over a hundred roost on Ombelim Islet. During the hot part of the day they are mainly resting, toward evening they soar in numbers above this and other islets, or out over the sea. Several individuals are all black beneath. Some also seen over Biken Islet.

Terns - Both noddies, white terns, and rarely black-naped terns may be found fishing together, flying excitedly over schools of fish, diving for them, either in lagoon or out in open sea. After they are full the noddies rest in the water.

Brown booby - One seen several times around Biken

Islet. An immature one seen at sea west of Biken. One adult seen at Ombelim Islet.

Common noddy - Seen in small or moderate numbers over lagoon and at sea, a few on the larger islets. Many on Enejelto Islet. Many birds and several nests seen on Enearik I., with downy young. One bird scared up here that had difficulty flying because it had Pisonia fruits stuck over its feathers. Several nests on Biken Islet. Many birds seen on the long sand spit on the east reef. Some birds and one nest on Eneobnak, this low in a Guettarda tree. Commonly seen, in middle of day, in groups on beaches.

White-capped noddy - Commonly seen fishing over lagoon or open sea, at any time of day. Some nests seen in Neisosperma trees on Enejelto I., also about 20 nests on Eneairik. Hundreds of nests and a multitude of birds on Ombelim, in Pisonia and also in Tournefortia, many seen holding a "conference" in Tournefortia trees on seaward side. On the seaward side of Kabben Islet were a small group of nests in Pisonia trees. Many nests in Pisonia and Tournefortia on Biken I.

White terns - To be seen generally almost anywhere, flying over lagoon or open sea in pairs or small groups, or fishing in flocks in company with other terns, or flying overhead on islets protesting intrusion into their privacy. Probably in most such cases there are eggs on the bare branches of the trees, but they are seen only with difficulty. Many terns seen on Ombelim Islet, where one egg was seen on a Tournefortia branch, also one half feathered and one fully feathered young. On Enejelto many were flying overhead, protesting as though they had eggs in the trees. Many were flying over the long-sand spit on the east reef, also over Eneobnak Islet.

Black naped tern - Small flocks on various islets, invariably on or over sand projections or beaches on inner corners of islets. On Enearik there were 8 on the east corner and 4 on the west. On Ombelim there were 10 birds on the inner beach - the islet is too short for the corners to be distinguished. Six were seen fishing over the lagoon near Wotho at 6:30 p.m., and one with a flock of other terns near Mejurwon at about 4 p.m.

Crested tern - Rare here, possibly only one or two pairs. One seen at sea west of atoll. Two seen on Ombelim Islet.

Pacific Golden Plover - Seen in small numbers generally, on inner and outer beaches, and in interior

wherever conditions are at all open, on most islets. Often with turnstones, tattlers, or curlews.

Wandering tattler - Seen one or two at a time, usually on outer beaches or reef flats, or passage beaches, on most islets. Often in company of plovers or turnstones, or more rarely, curlews.

Turnstone - In small flocks of two to five on most islets, on beaches or reef flats. Often with plovers and tattlers.

Bristle-thighed curlew - Seen singly, in pairs, or as many as three or four on beaches and reef flats of most islets. Here often fairly tame, allowing one to approach to within 15 or 20 m before flying.

Whimbrel - Rare; one seen on Enearik Islet.

BIKINI ATOLL

Bikini, northernmost of the Ralik Chain, 11° 35' N, 165° 23' E, is familiar as the site of a series of nuclear bomb-tests during the 1940's and 1950's. Its vegetation was greatly altered and largely destroyed, especially by the hydrogen bomb-test in 1954. During current investigations of the possibility of decontamination of Bikini, with the aim of permitting the return of the Bikini people to their homeland, a study of the present vegetation was carried out, and a descriptive report prepared (A.R.B.).

No original vegetation remains, but the recovery has been notable. It is of interest in our context as an illustration of the processes of revegetation after extreme disturbance. In the report are suggestions for preservation of a number of the smaller islets for long-term observation.

ENIWETAK ATOLL

Eniwetak, at 11° 30' N, 162° 15' E, is familiar as one of the two Marshall Atolls used for testing of nuclear weapons in the 1940's and 1950's. It is a large roughly circular atoll with 43 islets mostly on the north, east, and south reefs. Its vegetation and terrestrial natural features were completely altered during and after the testing period. A research laboratory was maintained there for a number of years and much research was carried out, making it one of the better-known of the Marshall Atolls. For the purposes of the biodiversity survey it is only of interest for its marine features and for studies of the recovery of vegetation after devastation.

MILI ATOLL

This is one of the larger atolls of the group, lying at 06° 08' N, 171° 55' E, 23 miles long, 13 miles wide, roughly rectangular, with over a hundred islets, well-distributed on the reefs. It has a substantial human population. A large number (22) of bird species are known from Mili, some collected by Japanese collectors, others recorded by non-scientific visitors. Nothing is on record about the vegetation of Mili, and relatively few records of plant specimens from the atoll. I would expect that some of the small islets might be relatively undisturbed, and might be considered for protection as natural areas, but this is merely a probability. No actual information is available.

AUR ATOLL

Aur is a medium sized rather wet atoll lying at 08° 16' N, 171° E. It is diamond-shaped, 15 x 9 miles, oriented NW-SE. About 42 islets are mostly on the east and northeast reefs, the largest are at the angles in the reef. Quite a number of species are known from the atoll, but there seems to be no recorded information on its vegetation. The island has had a considerable human population for a long time, so it can be assumed that at least all of the favorable habitats are planted to coconuts.

KNOX ATOLL

This small atoll, lying at 05o 55' N, 172o 09' E, just SE of Mili Atoll, is elongate, 4 miles long, oriented NW-SE, with broad reefs, very small lagoon, and about 10 islets. Almost nothing is known of it, scientifically. The coconut is the only plant on record, and not a single plant specimen from there is known to me. Sparse to dense vegetation has been mentioned. There are no permanent human inhabitants. There is said to be a boat passage on the west side.

ARNO ATOLL

Arno, lying at 07° 05' N, 171° 41' E, is a large, 21 miles long, 6-15 miles wide, irregularly crescent shaped atoll, with many (said to be 133) islets well-distributed around its reef, several of them, Ine, Ijen, and Rakaru quite elongate, occupying much of the southern reef. It contains approximately 5 square miles of land surface. The site of the 1950-1952 Pacific Science Board study, Arno is certainly the best studied of the Marshall Group, though perhaps more time has been devoted to Bikini and Eniwetak. Outstanding among the published results of the PSB study is the treatment of the vegetation by Hatheway (1953). This

multifacetted treatment should be consulted by all the members of the Biodiversity Project team. Here will be given some generalizations from Hatheway's work.

Arno has had a long history of human occupation and had a population of 1000 in 1952. Hatheway concludes that most of the vegetation is either presently planted coconuts and breadfruit, or secondary, or seriously altered stands of mostly native plants. However, in addition to the predominant secondary broadleafed mixed scrub-forest, he describes several restricted types of vegetation in particular habitats that may be not seriously altered, or even like original vegetation.

Storm ridges (boulder ramparts) on the seaward coasts of windward islets are covered by a dense scrub of Scaevola sericea, with some admixture of Tournefortia argentea, Guettarda speciosa, Terminalia samoensis, Pandanus tectorius, and Pemphis acidula. This scrub is wind-sheared, sloping upward from the beach-top to the forest inland. Stony flats, inland from the scrub zone support a belt of native mixed broadleaf forest of 14 species of native trees, 5 to 20 m tall, the zone to 100 m wide. Tree species present were Pandanus tectorius, Neisosperma oppositifolia, Guettarda soeciosa, Tournefortia argentea, Cordia subcordata, Intsia bijuga, Allophylus timoriensis, Pisonia grandis, Hernandia sonora, Barringtonia asiatica, and, in smaller numbers, Terminalia samoensis, Scaevola sericea, Pipturus argenteus, and Soulamea amara. Herbs on the ground were Asplenum nidus, Polypodium scolopendria and Peperomia ponapensis; epiphytes Asplenium nidus, Nephrolepis acutifolia; lianas or creepers Ipomoea macrantha and WollastonIa biflora.

The proportions of the tree species vary locally, with a tendency to form groves or small areas of single species. Scattered coconut trees indicate that this forest, though probably close to the pre-human predominant type, has been subject to some human influence. Cut stumps, usually sprouting, point in the same direction.

A third local habitat described by Hatheway is termed Saline Flats. These are shallow depressions, with salt water reaching the surface at highest tides. These occur at least on Bikarej, Badrbaren, Namwi and Enidr1@ islets. They are completely dominated by Pemphis acidula, or in places lacking plant life altogether. Pemphis surrounds them on slightly higher exposed rock. This shrub or small tree can stand having its roots temporarily covered by sea-water.

In saline areas that are filled or covered by sand, Scaevola sericea and Tournefortia argentea mingle to some

extent with the Pemphis.

Pemphis also forms dense scrub-forests in other areas where bare limestone is exposed. This is the normal habitat for Pemphis in most parts of its range.

Mangrove swamps and what we now call mangrove depressions, the latter usually rock-bottomed, are fairly frequent on Arno, perhaps more so than in other Marshall atolls. The principal species is Bruguiera gymnorhiza, with slight to considerable representation of Sonneratia alba, Lumnitzera littorea and Pemphis acidula. Such swamps occur on Tinak, Langau, Bikarej and Manwi islets, the first two completely enclosed by sand or gravel ridges, the latter two connected with the sea. Swamps also occur at Kinajong and Matoleu districts on Ine Islet. Nephrolepis acutifolia and Asplenium nidus occur epiphytically on the mangrove trees. Elsewhere on the atoll are small local mangrove depressions, usually pure stands of Bruguiera, locally some Lumnitzera. Some of these stands may have resulted from Marshallese introduction of Bruguiera to wet places.

Hatheway also described fresh-water swamps or bogs, dominated by the "wild,' or small fruited form of Pandanus tectorius, called "erdwan" or "erwan" by the Marshallese. These are found on Ulien, Tutu and Arno islets. They may have been formed by successive storm ridges cutting off sections of reef flat. They have bottoms of fibrous peat. Other species of trees found occasionally are coconut, Hibiscus tiliaceus, Intsia bijuga, Morinda citrifolia, and Allophylus timoriensis. Epiphytes are Polypodium scolopendria, Nephrolopis acutifolia and Asplenium nidus. In more open places a herbaceous ground layer of Eleocharis geniculata, Thelypteris interrupta, and Polyoodium scolopendria occurs. Some such fresh-water swamps or marshes may have been taro or yaraj (Cyrtosperma) pits that were abandoned and invaded by the swamp trees and herbs.

Hatheway discusses the origin and dynamics of the secondary vegetation of Arno at length, interpreting most of it as following abandonment or failure of coconut plantings on poor or worn out land.

Lib Island

This island or table reef lies at 08° 19' N, 167° 25' E, south of Kwajalein. It has a large fresh-water pond in the eastern half, apparently containing some mangroves (Bruguiera ?). No scientific information is available, but I examined the island briefly from the air in 1960. It is inhabited and partly planted to coconuts. However, there is considerable native forest remaining on the north side

and around the pond. Tournefortia, Scaevola, Calophyllum, Pandanus, Hibiscus tiliaceus, Bruguiera, Artocarpus and Cocos, could be identified with some confidence from the air. This island would well repay a visit and careful study. I know of no collections of plants, birds, or other scientific specimens from Lib.

KWAJALEIN ATOLL

An enormous, roughly crescent-shaped atoll, said to be the largest in the world, 75 miles from tip to tip, about 30 miles wide at widest part, lying at 09° 05' N, 167° 20' E. This has been the U.S. military Pacific headquarters, a target area, and Western Pacific Headquarters of the Pacific Missile Range.

The reef periphery is almost 200 miles, with the 92 islets well-distributed with 3 large gaps. Kwajalein Islet, at the southern extremity is the largest, and is completely covered by the airport and installations. Most of the Marshallese population of tha atoll live on Ebeye Islet somewhat north of Kwajalein Islet on the east reef. The other large islets - the Roi-Namur complex and Ebadon, at the northern and western points, respectively, are very much altered, Roi-Namur by military installations, Ebadon by coconut planting.

The other almost 90 islets, with a few exceptions, are scientifically almost unknown. I have examined them all from the air several timas, from very favorable altitudes, taking notes. These islets are diverse in size and shape, as well as vegetation and position with respect to orientation and exposure to Trade Winds and waves. Most of the largest ones are more or less planted to coconuts, some partly wooded. A few of the smaller ones have some coconut trees, but most of the smaller ones seem to be in fairly natural condition, at least with spontaneous vegetation. Most are wooded or scrubcovered, or with grassy openings and open scrub. Much of the forest seems to be Pisonia, but with occasional patches of Neisosperma. Almost any of them seem well worth investigating. A very few of them have been visited by me many years back.

Perhaps the most important of these is Eniwetak Islet, not on the reef, but in the lagoon just inside the second passage from the south end of the east reef. This islet was in 1952 a magnificent forest of giant Pisonia grandis trees. On the ground was a thick layer of raw humus or mor, underlain by a continuous or somewhat fragmented layer of brown, white-speckled atoll phosphate rock. The only sign of disturbance was a small grove of coconuts on a slightly lower projection on the southeast side. I was told in 1965

that a small tower had been erected on this islet by the U.S. Pacific Missile Range personnel. Their commanding officer agreed to stop further use of the islet when its uniqueness and scientific importance were explained to him. In 1952 the islet was home of a very large sea-bird population. It seems possible that this was, in pre-European times, a Marshallese bird sanctuary, and that this tradition has protected it. If it is still intact, it should have the highest recommendation for a protected natural area.

Information was collected on several short visits to islets on the west reef, north of Kwajalein islets which may be of some interest.

Ligan Islet: This is really two islets connected by two dry land strips enclosing a fair-sized pond. The lagoonward side is convex and is a large rubble flat as long as the entire islet. Its outer 20 meters or so is consolidated rubble. The inner part is lower and not consolidated, scarcely dry at low tide. The seaward side of the isthmus is a double anticline-like series of beach-rock beds. The seaward sloping component extends along the entire seaward coast, but was partly destroyed by the Japanese construction of a seaplane ramp.

The north one of the two islets was briefly examined. There is a seaward fringe of Scaevola, then a strip planted to coconuts. In from this is a zone of Neisosperma forest, then old large Pisonia forest, being invaded by young Neisosperma. Between this and the lagoon is a tall scrub of Pemphis, Scaevola, Guettarda, Tournefortia and Terminalia. Birds of several species were common.

Enelapkan Islet is a north-west-southeast oriented islet, the central part planted to coconuts, but with a strip cleared for radio towers. The SE end is thickly wooded. The eastern extremity is a Pemphis forest of large trees (large for Pemphis), closed canopy, lower branches dead but persistent. This changes to a mixed forest of Guettarda, Pisonia, Neisosperma and Pemphis, the latter dropping out and Neisosperma becoming abundant, forming pure stands in places, with a dense ground cover of its seedlings. Intsia is common on the seaward side, more or less replacing Neisosperma, Ipomoea macrantha and Wollastonia biflora form tangles in the mixed forest.

On the northwest end is a scrub, dominated by Scaevola, mixed variously with Guettarda and Tournefortia tangled locally with Cassytha. In openings Thuarea and Lepturus form a grass cover. The scrub gets lower toward the extremity of the islet. On the seaward side the Scaevola

fringe is tall at the top of the beach, with some Guettarda and Tournefortia. On the seaward side of the northwest end is a tremendous series of beachrock.

MAJURO ATOLL

This is the present governmental headquarters, or capital, of the Marshalls Republic. It lies at 07° 09' N, 171° 12' E, is quite wet, has 57 islets, one of them half the length of the south reef. The islets of the eastern end and southern reef are connected by a paved road and causeways. The southern and eastern islets have practically no natural vegetation. Surprisingly nothing seems to be on record about the numerous north and northwest islets. They would repay a visit, which should be easy, as the headquarters of the field party will most likely be Majuro.

Fifteen species of birds are known from this atoll. Most of the weeds recorded from the Marshalls are, as might be expected, from Majuro and Kwajalein. There is seldom even a casual visit by a botanical observer that does not turn up a new weed record or two.

MALOELAP ATOL

This very large atoll lies at 08° 45' N, 171° 03' E. It is elongate-triangular in shape, 32 by 16 miles long and wide, and has 89 islets well distributed around the entire reef. It is rather wet, said to be more luxuriantly vegetated than most of the Marshalls, and supports a large human population. Scientific information on it is very scanty, almost nothing on vegetation, a few plant species recorded. Even the birds are scarcely known. Probably some of the smaller islets may still have natural vegetation, but most are certainly planted to coconuts. It should be visited if convenient, and collections made, but would scarcely justify a special trip.

JALUIT ATOLL

Jaluit is in some ways one of the best studied atolls in the Marshalls (except geologically). It was the headquarters of both German and Japanese administrations. It lies at 06° 00' N, 169° 35' E, and is a very large atoll, 30 miles long, 15 miles wide. On a short visit in 1946 I noted that the whole atoll seemed to be planted to coconuts and breadfruit. Only a few of the larger islets were seen then. Some of the smaller islets were still in more or less natural state, but not examined. Much of the pre-1946 information on the Marshalls was from observations and collections on Jaluit. The main islets were the sites of heavy bombardment and fighting in World War II.

In 1956 the atoll was hit by 3 typhoons in quick succession, the third Typhoon Ophelia, incredibly violent and destructive. Two Pacific Science Board expeditions, 1958 and 1960, visited the atoll to study the effects of these storms. The vegetation, both cultivated and natural, was devastated, especially on the southern and larger part of the atoll. The principal interest, scientifically, of this atoll, is now to study the processes of recovery from this damage. Unfortunately, after the 1960 study, this opportunity was neglected. There is no record of the recovery or even of the present status of the Jaluit ecosystem that seemed totally destroyed in 1958.

Two islets, Lijeron (Ledjiok) and Ribon, where the former in essentially unaltered condition before the storm, and the latter only partly planted to coconuts. Lijeron was probably a traditional bird and turtle reserve (Tobin 1952) in pre-European times and in recent times, even to 1958, regarded with a semi-superstitious awe, and usually avoided. Lijeron and part of Ribon were covered by dense Pisonia forest, with some large Intsia trees, and surrounded by a narrow zone of Tournefortia and Scaevola scrub and scrub-forest. The trees were mostly blown down by the storm, but, even by 1960, the areas were occupied by a dense stand of sprouts of Pisonia, 1-2 meters tall.

Jaluit would be well worth a visit, with special attention paid to at least these two tiny islets. Any description of present vegetation on Jabwor, Imruj, and Mejatto, the most affected by the typhoons would be of permanent value. In 1958 they were an incredible tangle of fallen trees, coconut trunks and broken stubs, criss-crossed as though by a tornado. In 1960 this was still the case, but many trees were either sprouting or putting out new branches.

On the NW extension of Lijeron was a pure stand of Pemphis, badly beaten by the storms, but still alive. Its present condition should be checked. Pemphis is a tree that is able to survive both wind beating and sea-water innundation.

Jaluit also has a greater development of mangrove swamps and depressions than are known from elsewhere in the group. In 1958 the trees, at least the dominant Bruguiera, were still standing but leafless and dead. In 1960 abundant seedlings were growing up between the bare poles. Their present status should be determined and described. Such swamps are present on at least Jabwor, Mejatto, Pinlap and Jaluit islets. Small mangrove depressions, rock-or sand-bottomed, are generally distributed.

The bird fauna of Jaluit is impressive, 33 species out of a total of 70 species known from the archipelago. Even in 1958, after the storms, there were thousands of birds flying over Lijeron Islet, which had probably long been their home.

JABWOT ISLAND

This tiny islet, only less than a quarter of a square mile, lies at 07° 47' N, 168° 59' E. It has no lagoon nor even a pond. It has been inhabited for some time and is generally planted to coconuts and breadfruit. It has not been scientifically studied, except for birds, of which 9 species are listed. I flew over it in 1960 and was able to identify with confidence Scaevola, Tournefortia, Thuarea, Guettarda, and cultivated coconut, breadfruit and papaya. It is surrounded by a band of native vegetation, narrow on three sides, broader on the other (east ?). It would be scarcely worth-while to make a special visit for biodiversity studies, but any observations would be new information.

RONGERIK ATOLL

Rongerik is a medium sized atoll, semi-dry, lying on 11° 21' N, 167° 26' E, with 5 principal islets and a number of smaller ones, wall distributed around the roughly circular reef, which has a large gap on the west side. This atoll was not considered habitable by the Marshallese, but the Bikini people were put there by the U.S. Navy to make way for the nuclear tests on Bikini. They were unable to subsist there, and had to be moved again. There are very few coconuts. Principal vegetation types on the larger islets are Cordia forest and mixed Cordia and Pisonia, with a continuous stand of Pisonia forest on the west end of Eniwetak Islet.

The only area studied, and very briefly, in 1956 was Eniwetak Islet, which was being much disturbed by construction of a radio station, involving bulldozing a strip across the center and a road the length of the seaward coast.

The Cordia and Cordia-Pisonia forests were in very poor shape, locally the Cordia was dead or nearly so. The soil in these forests is very peculiar, resembling only that found on Sifo Islet, Ailinginae. The upper horizon is a brown fluffy loam, underlain by a gray fine sand. Time was not available to prepare a proper sample or to describe the profile.

Twelve species of birds were seen during this short visit.

RONGELAP ATOLL

Rongelap Atoll, at 11° 20' N, 166° 50' E, is a large rather dry (60-70" rainfall) atoll, 30 x 23 miles, with a rather small population which was seriously affected by fallout from the Bravo hydrogen bomb explosion in 1954. It has a large number, said to be 58, of islets scattered on the north, southeast and south reefs, one tiny islet in the middle of the west reef.

Rongelap has a generally poor scrubby aspect, with forest, in places pure Pisonia, in poorer places Guettarda and Tournefortia changing to Scaevola-Tournefortia and Scaevola scrub, sloping and getting lower toward windward beaches. The better, darker soils are planted to coconuts, which are nowhere in very good conditions. The biggest plantation is on Rongelap Islet back of the village. But a large part of this islet is in poor mixed forest and scrub. The "elbow" of this islet is covered by a boulder-cobble ridge, with Scaevola scrub on the windward part, scattered bushes of Scaevola, Tournefortia and Guettarda to leeward.

Small islets seen from air have Scaevola scrub with scattered Pisonia and Pandanus. Some have a few poor coconuts. We actually landed on three, chosen to represent part of a logarithmic series of increasing intensities of fallout dosages from the "Bravo" blast in 1954 on Bikini Atoll to the west.

Eniwetak Islet has a double beach-ridge of sand, to 3-4 m high, back of the lagoon beach. Sandy areas have sparse coconuts, much grass, patches of Cordia and Morinda. Along the seaward side is Scaevola scrub with scattered Pandanus, edged with Suriana, most of it dead.

Kabelle Islet has a wide sand flat lagoonward of an old sand-ridge, with Scaevola, Tournefortia and Guettarda bushes, back of this flat coconut trees have a poor yellow appearance. In the central part is a rather loose Pisonia forest, surrounded by a scrub forest of Guettarda, Scaevola and small Pisonia. In the Pisonia forest is a rather poorly developed Jemo Soil, with 5-10 cm of humus. Lining the seaward beach is a rather open, wind-sheared and wind-grooved Scaevola scrub. Pumice pebbles are quite plentiful on the sand on this islet.

On Gegen Islet the seaward third is Pisonia forest, the rest of it is a scrub-forest of Guettarda and Cordia, with

Suriana that is completely dead, with a few isolated coconut trees. Back of the lagoon beach are two broad beach-ridges of sand and small gravel, with scattered shrubby vegetation. Between this and the scrub forest is a rather open mixed scrub of Scaevola, Guettarda and Cordia.

At the time this atoll was visited, in 1956, most of the vegetation was in conspicuously poor condition, with only two of the species, Scaevola sericea and Tournefortia argentea appearing in normal healthy condition. Pisonia was essentially leafless, possibly from previous dry weather, and flowering. It had clumps of dark.green leaves here and there that almost looked like mistletoe. The Guettarda was partly dead and otherwise dying back from the tips. All other species were in clearly unhealthy shape, or dead.

This poor condition was suspected to be the result of cumulative effect of the radioactive fallout from the "Bravo" hydrogen bomb explosion 2 years earlier on Bikini. This islet had much the heaviest dose of radiation of any of the islets examined. If Rongelap can be visited by the biodiversity team, special attention should be paid to the condition of the vegetation on the four islets described above, to see if there has been reeovery or further deterioration in the 21 years that have elapsed. An observer in 1956 who had seen Gegen Islet in 1955 said that the vegetation appeared in much worse condition than in 1955. Another observer who examined it in 1957 and photographed places found that trees that were still living but in poor condition in 1956 were dead in 1957. It would be worthwhile to protect at least Gegen Islet from disturbance for long-term studies. Light might be thrown on the possibility of long delayed appearance of genetic changes due to ionizing radiation.

ERIKUB ATOLL

This medium-sized atoll lies at 09° 08' N, 170° 02' E, just south of Wotje Atoll, is 17 miles long and 5 wide, with a land area of only a third of a square mile. It has 14 islets, most of them near the southeast end of an oblong, NW-SE oriented reef. Erikub Islet, the largest, is mostly planted to coconuts. The atoll is uninhabited but is visited by Wotje Islanders who come to harvest copra. Nothing is on record as to the natural vegetation except unpublished notes of visits by Pacific Ocean Biological Survey personnel, not readily available. I flew over the atoll many years ago at a high elevation and remember that most of the islets, except Erikub, seemed to be relatively undisturbed. The birds are rather well-known, but any other information gathered would be new. This atoll would be well worth a visit by the Biodiversity Project team if practical.

UJELANG ATOLL

Ujelang is the westernmost of the Marshalls, lying at 09° 49' N, 160° 55' E, actually farther west than Kusaie, easternmost of the Carolines. Ujelang was considered one of the Carolines by early writers and administered from Ponape by the Germans. It is a medium sized atoll, roughly narrowly oblong, oriented NE-SW, 14 x 2-3.5 miles long and wide. Thirty-five islets are well-distributed on the reefs, the largest, Ujelang Islet, is at the south end of the northwest reef. Although this atoll traditionally belonged to the Eniwetak people, the Germans regarded Ujelang as government property and planted all the suitable parts to coconuts and managed it commercially. This practice may have been followed by the Japanese. The U.S. Administration, when Eniwetak was required for nuclear testing, moved the Eniwetak people to Ujelang. Recently, many, if not all, have been returned to Eniwetak when it was declared safe enough.

It is a somewhat moist atoll, with the larger islets well-vegetated, with some rather dry and grassy or scrub areas on small islets. Most of the available information on the natural history dates from a visit by the U.S. Geological Survey party in 1952.

Most of the land suitable for coconut culture was planted to coconuts by the Germans. Some of their plantings were on such rocky or saline ground that they did not do well. On many of the smaller islands only a few coconut trees were planted, perhaps experimentally. Most of these islets are very rocky, probably considered unsuitable for coconuts, and so are still covered by forest or scrub, or in some cases, grass and such creepers as Triumfetta procumbens. Some of the islets show boulder and cobble ridges and scoured areas with little soil or vegetation, regarded as the results of past typhoons.

Kalo Islet, at the northeast end of the southwest reef, is largely planted to coconuts, but with a strip of forest on seaward and northeast passage sides, mostly scrub forest of Guettarda, Tournefortia and Scaevola. The plantation is neglected and has a tall thicket of Pipturus, Pisonia and Guettarda between the trees.

The next three islets, Kirinyon, Enimoni and Enilap are very rocky, largely covered by mixed forest of Pisonia, Cordia, Guettarda, Allophylus, and on outer parts, Tournefortia. Some coconut planting on lagoonward side, but neglected, overgrown, and in poor condition. Substantial areas on these islets are of coral conglomerate, swept clear

of soil, and covered by Pemphis forest, often pure stands.

The islets on the northeast side of the atoll, from Bikan to Rais (Daisu) are very wind-beaten, partly wooded but with mixed scrub-forest or rather low Pisonia. Pemphis on rock-surface. Kileken and Rais have been largely planted to coconuts.

On most of these smaller islets on both reefs are large bird populations. Some 15 species of birds were seen on this atoll, several in large numbers. Noddies, however, were being killed and eaten in some numbers in 1952.

Ujelang Islet, where most of the people live, is almost entirely planted to coconuts, except for the two ends and an enormous storm ridge along the seaward side, ends and ridge covered by scrub of Scaevola and Tournefortia. The undergrowth in the plantation is mostly Pipturus.

In a shallow area in the lagoon off Ujelang Islet is a bed of turtle grass, Thalassia hemprichii, one of the few such in the Marshalls.

The vegetation of Ujelang is in general rather impoverished, though there is considerable area of at least spontaneous scrub and scrub forest. Curiously, Neisosperma is either absent or rare. The atoll is scarcely worth a visit, except for the birds, and to determine present condition of the small islets, one or more of the less altered ones of which might be set aside as a protected natural area.

UJAE ATOLL

Ujae is an elongate diamond-shaped atoll, oriented NW-SE, lying at 09° 05' N, 165° 40' E, is 27 miles long, 8 miles wide at widest part, with 15 islets, the 3 largest at the ends and middle angle of the NE reef. The largest islets are mostly planted to coconuts, the smaller ones in something like original condition, with forest and scrub. Geomorphology and soils are diverse for an atoll, and have been studied in 1952, but detailed descriptions remain unpublished. The flora, of 61 known species, is large for an atoll. The climate is medium wet, 70-100 inches of rain annually.

Ujae Islet, largest islet and site of the village, is mostly planted to coconuts, locally with breadfruit, Pandanus, papaya and bananas. The outer and both passage shores are lined with a zone of scrub and scrub-forest, of the usual Scaevola, Tournefortia, Morinda, Pandanus, Terminalia, Allophylus; somewhat inland away from the beach,

Pisonia. A patch of Pisonia-Guettarda forest is somewhat inland from the southeast coast.

Coconuts are planted locally on most of the other islets in suitable soils, but, in 1952, these smaller plantations were rather invaded and overgrown by native wild species. The vegetation of the principal other islets is a mixed forest, rich in species, for an atoll forest, closed-canopy forests of 25-30 m stature, large trees. The largest, tallest trees are Pisonia, Intsia and Neisosperma, with, as lesser components, Guettarda, Allophylus, Tournefortia, Pandanus, Terminalia, Ximenia, Cordia and Pemphis. These trees occur in many proportions, combinations, densities and statures. Several of the species occur in significant pure stands, or dominant stands, describable and mappable as distinct vegetation types. Among these are Pisonia forest, Intsia forest, and Pemphis forest. These and the various facies of mixed broad-leaf forest occur in differing habitats, but the patterns are complex, possibly involving a component of chance.

Ujae has, for a coral atoll, a very complex geomorphology and a corresponding vegetation. The geomorphology shows much variation within the constraints of rather uniform chemical nature and geological history, the vegetation within the constraints of a rather uniformly wet environment with occasional temporary dry spells, and of a flora that is very limited as tropical floras go. There is no very definable pattern, though the geomorphic features and the vegetation types repeat themselves.

In 1952 the islets on Ujae were studied and described in more detail than were any other comparably wet atoll. These descriptions, a few sketch maps, and floristic features are recorded in my field notes, but to spell them out in this report would be repetitive and boring, as well as expensive.

I would strongly recommend that the team plan to spend some time on Ujae, with the view of preparing descriptions of some of the islets and determining any that should be placed in the planned protected area system. My descriptions are available for comparison, to indicate something of the dynamic status, both of the geomorphic features and of the vegetational features. I am not aware of any typhoon that has passed over Ujae in the 35 years that have elapsed, though the geology indicates typhoon effects previous to our 1952 visits.

One aspect meriting special mention as to 1952 condition and that would make desirable a 1988 resurvey is

the abundance of birds present, very unusual for an inhabited atoll. I observed the use of young black noddies for food, and was told that the people ate all of the kinds of birds except the reef heron, which "eats rats!" The following birds were seen in 1952 by me, not an expert ornithologist:

Great Frigate bird	Fregeta minor
Brown booby	Sula leucogaster
Red-footed booby	Sula sula
Common noddy	Anous stolida
Black or white-capped noddy	Anous tenuirostris
White or Fairy tern	Gygis alba
Black-naped tern	Sterna sumatrana
Crested tern	Thalasseus bergii
Pacific golden plover	Pluvialus dominica
Wandering Tattler	Heleroscelus incanum
Ruddy turnstone	Arenaria interpres
Bristle-thighed curlew	Numenius tahitensis
Whimbrel	Numenius phaeopus
Reef heron	Egretta sacra

A list of 14 species is not large, but the numbers, not counted, of course, were impressive.

An interesting behavioral feature, observed by my colleague, F.S. Macneil, was a noddy picking up an operculate snail, Nerita sp., flying with it to a considerable height, dropping it on a rock surface, following it down, and eating the animal from the broken shell. That this was not an exceptional behavior was shown by a large number of freshly broken Nerita shells scattered on the bare limestone surface of an erosion ramp.

Selected References on Marshall Islands Botany, Ecology and Geography

Following is a list of papers and books with information pertaining to the Marshall Islands and related topics that may be of interest in connection with the biodiversity investigation. Annotations for practically all items may be found in Island Bibliographies, by M. H. Sachet and F. R. Fosberg, 1955, and its supplement, 1971, National Academy of Sciences-National Research Council Publication 335.

Detailed field notes on various Marshall atolls may be found in the field note-books of F. R. Fosberg, by arrangement with him, Smithsonian Institution, Washington, D.C. The note-books will not be loaned.

This list does not, of course, exhaust the literature

that is available on coral atolls, or on the Marshall Islands. For example, there are well over 300 articles in the Atoll Research Bulletin (here abbreviated A.R.B.) many of which, more than listed here, may be of interest. The ones listed will document many of the statements in the present review, though much of what is said comes from personal experience and knowledge of the compiler.

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