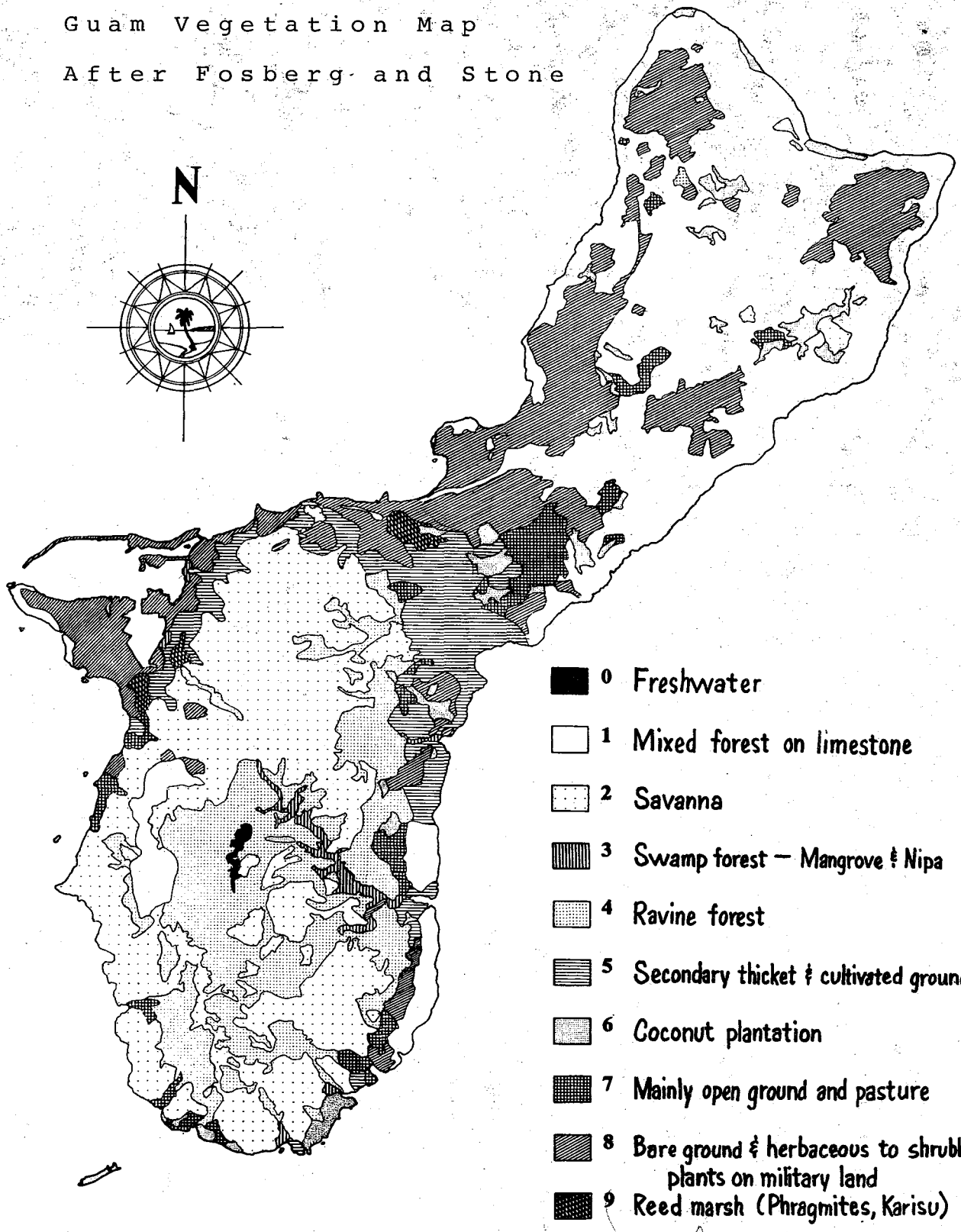
Life On Guam Limestone Forest

by Larry Behrens

art L Hotaling

Guam Vegetation Map

After Fosberg and Stone



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Life On Guam

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"....to ultimately graduate citizens who are knowledgeable and conscientious about environmental concerns of Guam and the rest of the World."

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Introduction

Modern technology has produced many benefits and conveniences for the home, for school, for work and play. Industry has provided new vehicles, houses, apartments, office buildings, and their machines, shopping centers, roadways, airplanes, and other achievements of civilization. Like other places, Guam has acquired its share of these signs of progress.

How many more do we want?

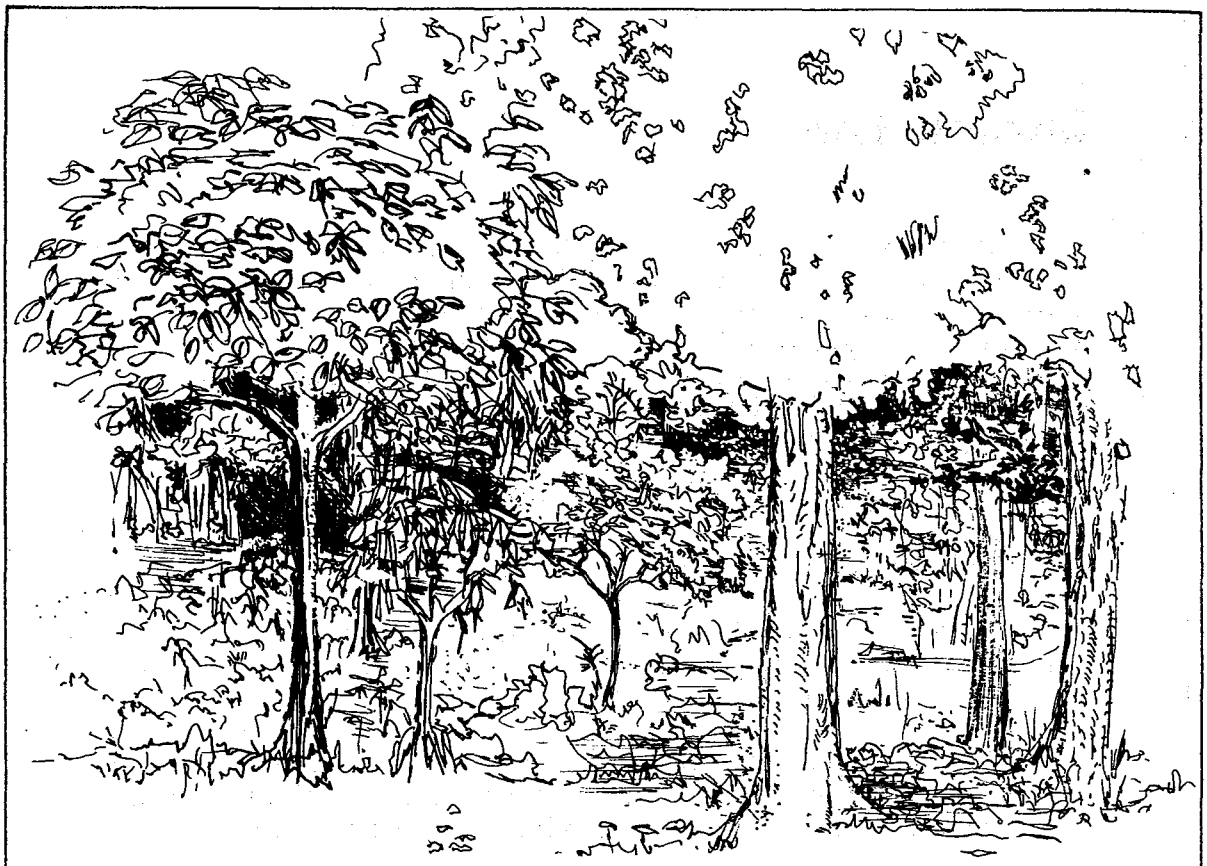
How many more can we take?

Have you considered the possibilities if we continue to accept more and more products of modern life on this small Island?

Our natural habitats are gradually disappearing before the sweep of the bulldozer blade which cuts into trees, land, and even the offshore reef.

The reefs sometimes become accidental victims of progress. Soils exposed and loosened by bulldozing are washed downhill by rainstorms and out onto the reef where they smother the living organisms.

How much of our natural environment should we give up in the name of progress? How much of our natural environment must we keep in order to maintain an acceptable standard of living? Think about answers from now on.



The Limestone Forest

Many of you have enjoyed hiking to the scenic waterfalls, through the boonies, over the fascinating coral reefs, and along the miles of beaches. These outdoor activities are fun, relaxing, healthful, and a pleasant change from everyday routine. They can be even better when you know something about the plants and animals. Their unique character and relationships to each other and to the physical environment are part of the ecology of Guam.

In this book we'll look at some ecology of the limestone forest. The survival of this forest, like many other natural areas on Guam, is being threatened by man in his attempt to provide more housing and industry for an ever-expanding population.

As its name suggests, the limestone forest contains many trees growing in or on limestone rock. This forest is one of Guam's many kinds of

ecosystems. An ecosystem is a community of plant and animal populations living together with their physical environment. This environment includes rocks and soil, bodies of water, wind, rain, moisture in the air, sunlight available to plants, and temperature. The special characteristics of the limestone floor of this forest give us a unique combination of plant and animal populations.

The true limestone forest hasn't changed much at all for hundreds and thousands of years. It has remained the same for so long because of few or no disturbances like fire, bombing during war, and bulldozing. It suffers only temporary damage from inevitable typhoons. In fact, Dr. Ben Stone calls Guam forest 'the typhoon forest'. Since gross changes no longer occur in this forest, it has also been called a climax community. Its plants and animals are no longer being replaced by different kinds of plants and animals. You can return to this forest year after year and find things the same.

This is not a forest which has been cleared and then abandoned. On Guam, such a clearing will grow plants like Bidens (the 'Guam daisy', beggar's tick), grasses, creeping vines, papayas showing their heads through the many short ground plants, and if it's limestone, tangantangan. The plants which first grow into a clearing are pioneer plants.

In a few years, the tangantangan excludes other pioneers. As various kinds of plants take their turn living in an area, so is there a succession of various kinds of animals. In cases like this, the climax community does not return. The new community is seldom as desirable as the old one. A bulldozed limestone forest would never return to its former integrity.

Even though some limestone forest on Guam has been destroyed, some of it still stands around the Island. You may wish to protect what remains of the only climax community on Guam.

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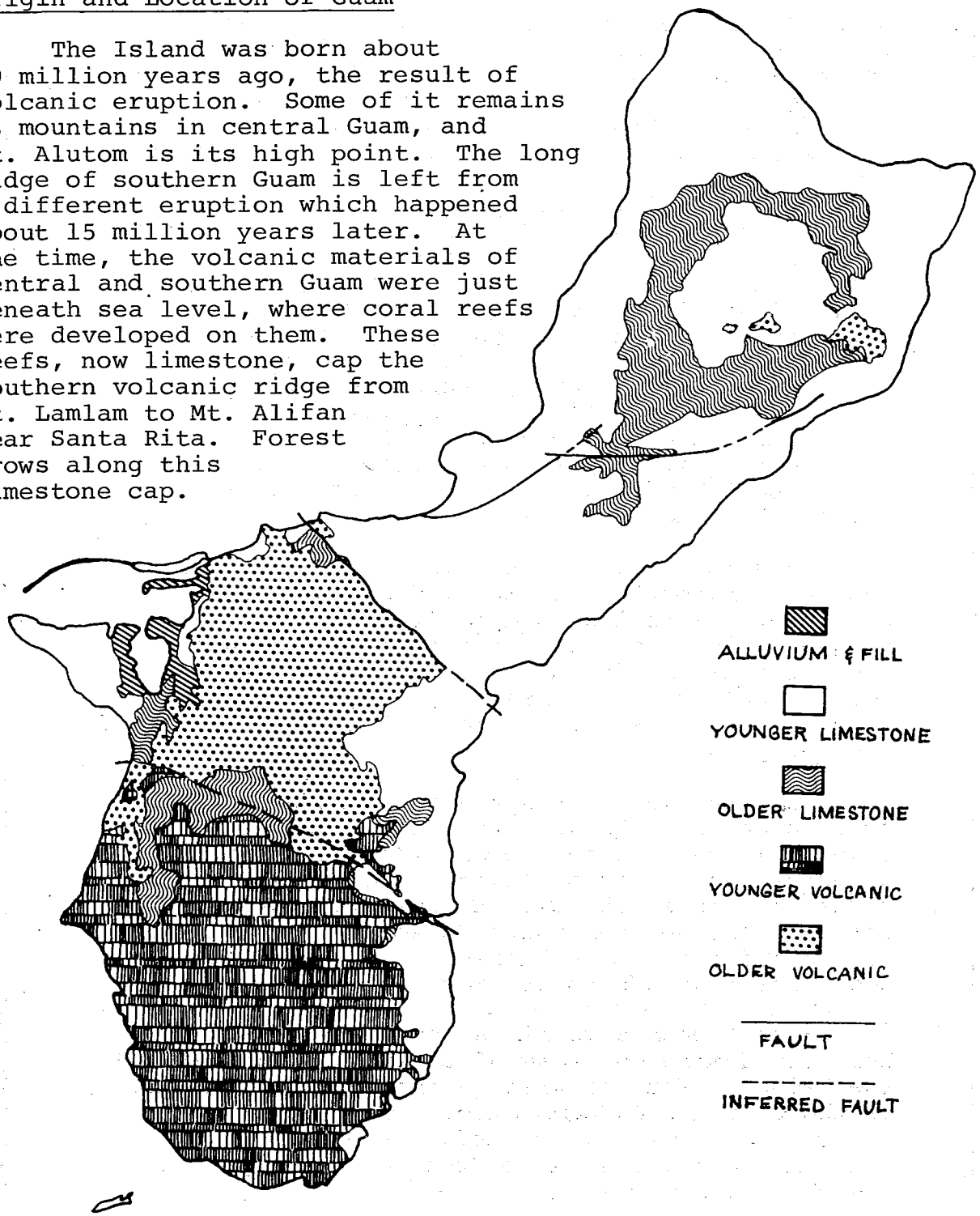
Physical Characteristics of a Limestone Forest

Origin and Location of Guam

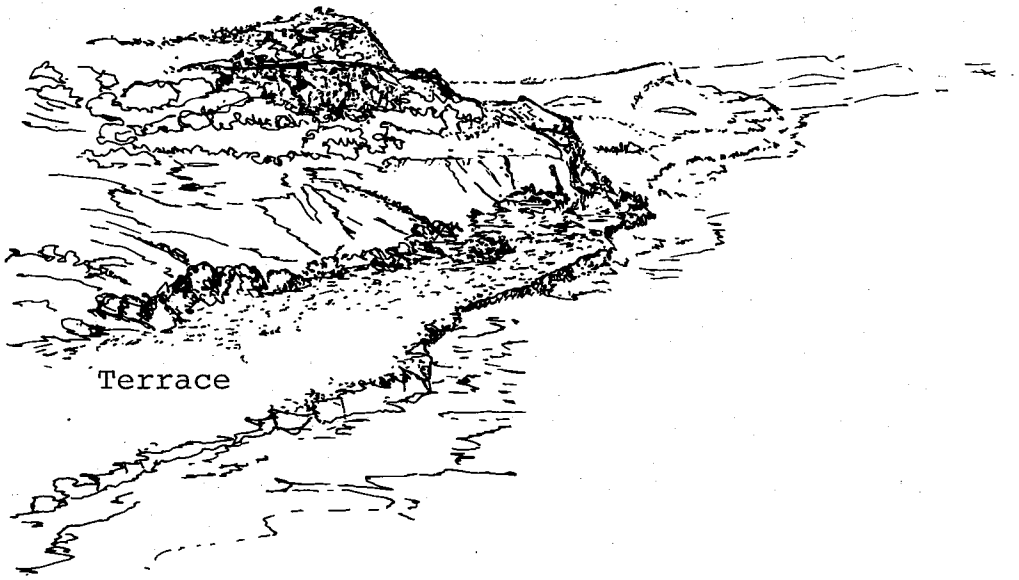
The Island was born about 50 million years ago, the result of volcanic eruption. Some of it remains as mountains in central Guam, and Mt. Alutom is its high point. The long ridge of southern Guam is left from a different eruption which happened about 15 million years later. At one time, the volcanic materials of central and southern Guam were just beneath sea level, where coral reefs were developed on them. These reefs, now limestone, cap the southern volcanic ridge from Mt. Lamlam to Mt. Alifan near Santa Rita. Forest grows along this limestone cap.



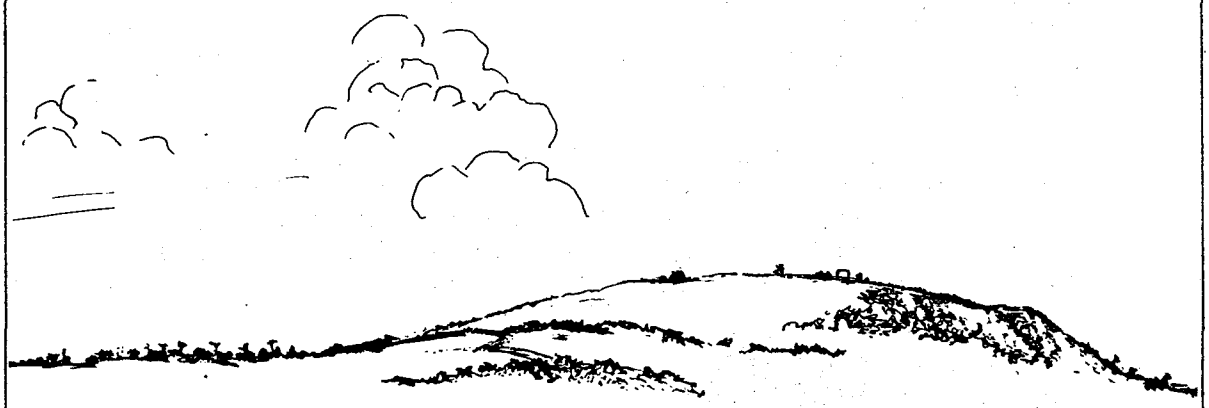
Geologic Map of Guam
(After C. J. Huxel, U. S. Geological Survey Office, Guam)

The north of present-day Guam is a limestone plateau. The plateau is ancient coral reef which grew on the undersea volcano materials north from the central volcanic rock. The plateau remains higher in the northeast than elsewhere. Steep cliffs rise there to 180 m above the sea. From here, the plateau slopes downward to sea level at Agana on the Island's western side.

Tremendous forces beneath the Earth's crust were at work to lift the ancient reef to its present level. The step-like cliffs and terraces along the eastern side of the Island show that this lifting has been interrupted once in a while.



Further evidence exists that the Island has been lifted not steadily, but intermittently. Nips (cuts) are seen at different levels in cliffs such as Puntan Dos Amantes (Two Lovers' Point). Each nip is the result of crashing waves and boring organisms cutting into the cliff when that section was at sea level. Then that part of the Island was lifted, followed by a new nip being cut at the new water level. In the future Guam may again be uplifted. If this happens, reefs like those at Tumon and Agana Bay will add more limestone terraces to the Island, followed by more new reef growing out from the terraces. When you stand at the brink of a limestone cliff, say Two Lovers' Point, you are standing at the edge of what was once living reef. Here waves once crashed and the reef edge dropped suddenly into the darkness of the ocean deep.



Barrigada Hill is the highest uplifted limestone formation in the north. From this hill more recent limestone extends in all directions. Most of the northern half and the eastern side of the Island south to Talofofo Bay is made of this limestone. Mt. Santa Rosa, of the same volcanic material as central Guam, at some time in the past pushed its way through the limestone of the northern plateau. (See the Geology unit in this series.)

Locations of Limestone Forests

More than half of Guam is limestone. Because of fire, bombing, and bulldozing, much less than that is covered by forest. The remaining limestone forests are found in areas not easily reached. These include the Lamlam-Alifan ridge, the cliff area near the University and behind George Washington High School, and the cliffs north from there around Ritidian Point and to Gun Beach. Small fairly well-preserved limestone forests are scattered here and there at Yigo and Barrigada Hill. Much clearing has been done for farms, subdivisions, military establishments, and businesses. Cliff areas have been cleared throughout these forests for quarries and military installations.

Physical and Chemical Properties

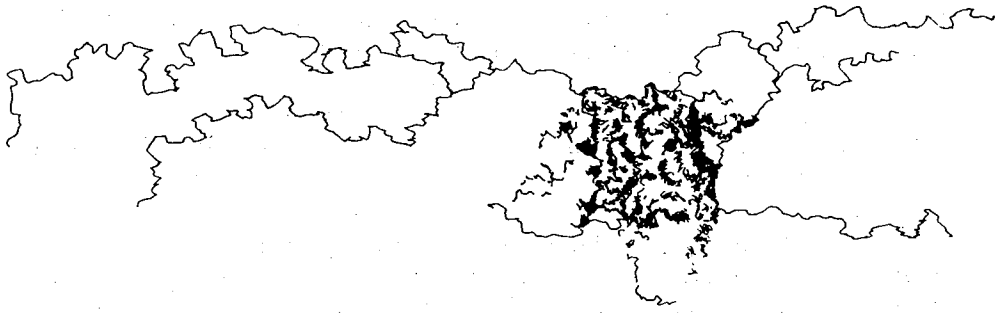
The limestone plateau consists of the hard skeletons of the many types of plants and animals, mainly stony algae and corals, which once made up a reef. When these organisms died, their hard remains, mostly calcium carbonate, were left behind. Over millions of years these skeletal remains built up, hundreds of feet thick. Uplifted, this mass of fossil reef material is called limestone. ? Would not be limestone if not uplifted?

Exposed limestone eventually turns dark gray. A freshly broken piece is white and in it you can still see some of the patterns of reef plants and animals.

Limestone is very porous; it is full of many small holes, and these soak up rain rapidly. This explains why no rivers flow on the northern limestone plateau. In the south, the volcanic soil is not so porous and rainwater does not soak in rapidly. Thus, there are many rivers on that end of the Island.

Immediately inland of the cliff edge there is usually a lower portion of the limestone plateau called a moat. The cliff edge itself may be higher than the plateau and is called a rampart.

The limestone of the moat and rampart has been dissolved away at different rates by water and possibly by weak acids that formed when plants died. The result is a forest floor of sharp, jagged gray limestone.



After limestone has been dissolved and carried into the ground, you may find pits and caves. Caves existing then would have been submarine when the reef was beneath the sea.

Not much soil occurs in the rampart-moat area of the limestone forest. The lack of soil and the hardness of the limestone favor plants whose roots can penetrate the cracks and holes in the rock.

Limestone Forest Flora–Plants

In this section we will discuss the flora of a limestone forest. These are the plants common to forests of northern Guam. We'll concentrate on the one behind George Washington High School. This property is a conservation area owned by the Government of Guam.

Origin of Guam's Plants

Here are some basic terms referring to how long plants have lived in a certain area, in our case, Guam. Endemic plants live only on Guam or the Mariana Islands. Indigenous plants occurred on Guam before man arrived, and are also found elsewhere in the World. The word 'native' is sometimes used in place of indigenous. Introduced plants were brought to Guam accidentally or on purpose by man. Many of them have become naturalized—they have spread throughout the Island on their own.

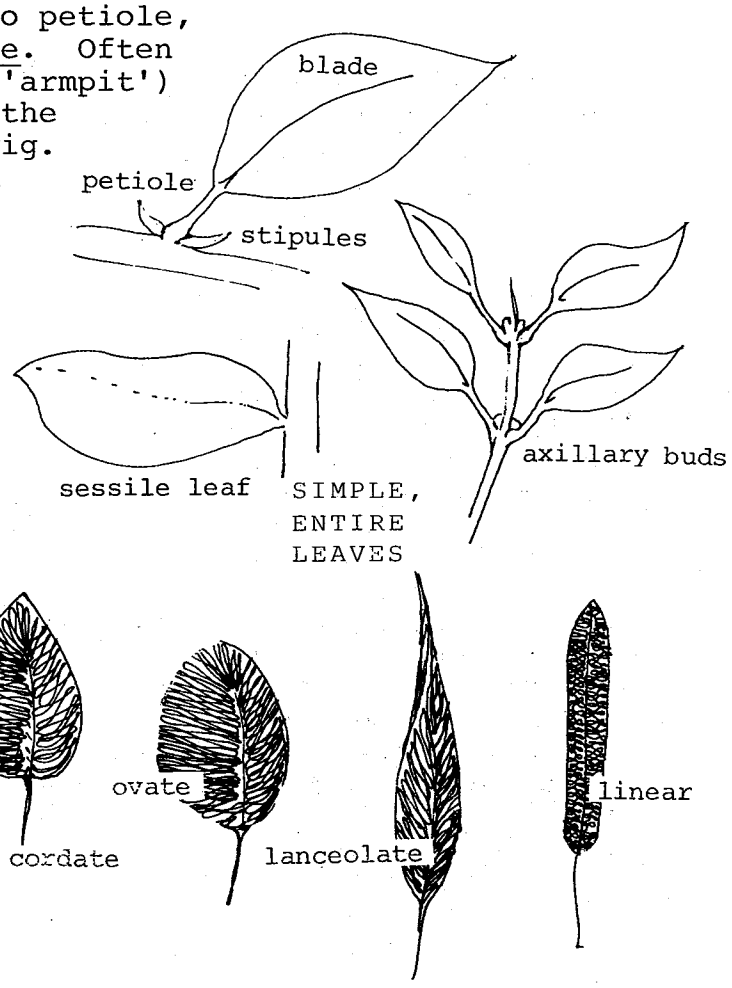
If the forest has remained undisturbed over many years we should find no pioneer plants present. You'll remember that pioneer plants come into a clearing or disturbed area. If pioneers such as papaya and tangantangan are found in the forest, we can be sure that the forest floor has been disturbed or some of the climax community has been removed.

Identification of Limestone Forest Plants

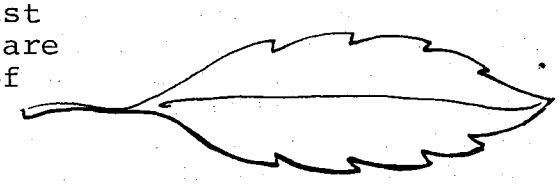
Twenty-two kinds of trees, shrubs, and herbs (small soft plants) in the forest behind the school will be discussed, starting with the most common. We'll identify them by leaf shape, leaf arrangement on branches and twigs, and by other easily seen characteristics.

A typical leaf consists of a blade (broad part), petiole ('little stem'), always somewhat swollen at the base, and often two stipules (small leaf-like parts at the base of the petiole).

If there is no petiole, the leaf is sessile. Often a small axillary ('armpit') bud grows between the petiole and the twig. If the leaf should drop off, the axillary bud will grow into a new leaf replacing the lost one. A simple leaf has a single blade. The edge of the blade is the margin. The leaves of most limestone forest plants have entire, smooth margins. Some of the more common shapes of simple leaves are shown here.

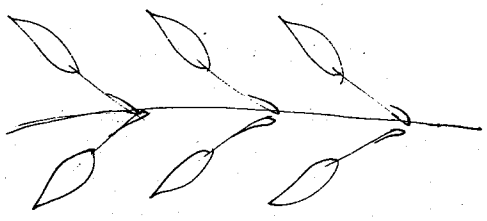


A few plants in the forest have leaf margins which are <u>toothed</u> (like the edge of a saw).

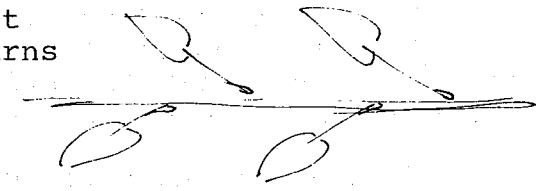


Leaves attach to stems in different ways:

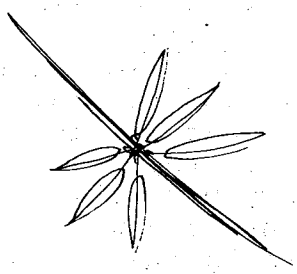
They may be directly <u>opposite</u> each other along the branch.



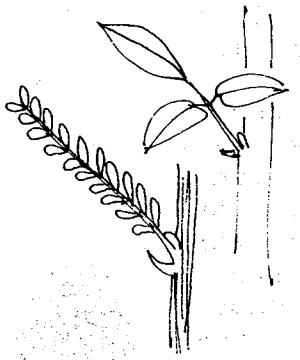
If the right and left sides of a branch take turns putting out leaves, the leaves are <u>alternate</u>.



If leaves grow in a circle around the twig they are <u>whorled</u>.



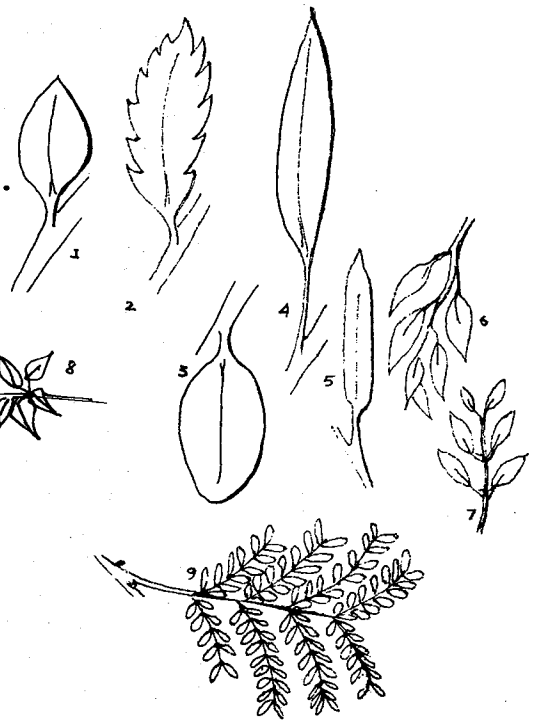
<u>Compound</u> leaves have more than one blade; each blade is a <u>leaflet</u>. Leaflets share the same petiole. A leaflet may look like a simple leaf but has no axillary bud or stipules. (These will be found at the base of the petiole of the compound leaf.) If a leaflet falls off, it is not replaced. If a whole compound leaf falls, however, the axillary bud usually grows into a new one. Try it and see.



Leaf Collecting Exercise

This exercise is intended to help you become familiar with the structure, shape, and arrangement of leaves.

Using information from these pages, and working in teams of 3 or 4, collect from home or near home a sample of each type listed below. (If you can, cut the twigs rather than break them.)



1. Simple leaf with entire margin. (Include part of twig to which leaf is attached.)
2. Simple leaf with toothed margin. (Include part of twig to which leaf is attached.)
3. Simple ovate leaf.
4. Simple lanceolate leaf.
5. Simple linear leaf.
6. Branch with alternate leaves.
7. Branch with opposite leaves.
8. Branch with whorled leaves.
9. Pinnately compound leaf. (Include part of twig to which leaf is attached.)

To identify each specimen, tag it with its number (1 through 9).

Questions:

A. Do specimens 1 and 2 have stipules at the base of the petiole?

B. Which specimens of leaves 1, 2, 7, and 8 have axillary buds?

C. Which leaves have petioles with swollen bases?

D. Which specimen has the longest petiole compared to blade length?

E. What shape is each leaflet of the pinnately compound leaf?

F. Are stipules or axillary buds at the bases of the leaflets of specimen 9?

G. List two ways you can tell if a leaf is simple or compound.

System for Naming the Limestone Forest Flora

Most of Guam's plants have local names. One example is the woody vine which grows in the south and produces that big brown bean, 'bayogo'. It also grows in the Philippines and is there called 'gogo'. On the U.S. Mainland it's 'sea-bean'. If you moved from one of these places to another and tried to look for the plant in a library book under the name you knew 'back home' you'd probably not find it. As you can see, local names for the same plant differ and so cause confusion.

Karl von Linné, 1707-78 (better known as 'Linnaeus'), Swedish botanist, devised a two-name system to avoid such confusion. In his system every known kind of plant or animal on Earth is given a scientific name not shared with any other kind of plant or animal. The first part of the name is the genus, the second part the species. The scientific name for man is Homo sapiens. The genus is like your last name and is shared with other members of your family. The species is like your first name and belongs to you only.

The genus Homo is shared with prehistoric man who differed in some ways from ourselves. Therefore, we read about earlier man with scientific names such as Homo erectus and Homo habilis. One plant example is our native tangantangan, Leucaena insularum var. guamense, and the Central American tangantangan now widespread in Guam, Leucaena leucocephala. (Read more about them in the Savanna, Old Fields, Roadsides unit in this series, pp 36-38.) Notice that the first letter of the genus is capitalized. Also note that both genus and species are underlined.

Another way to show a scientific name is to use italics and no underlining: *Homo sapiens*. Both ways are acceptable. No matter how many common names may be used for the same plant or animal, it has just one scientific name throughout the World. This makes it easier to look up information about any plant or animal. The genus name of bayogo, by the way, is *Entada*.

Our plants will be introduced by names, family, and status on Guam.

So, let's go into the limestone forest!

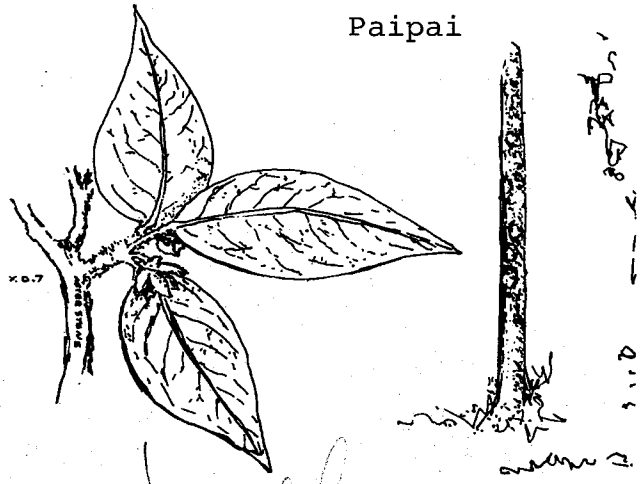
Entering the trail behind George Washington High School you walk up a disturbed slope now grown over with tangantangan. Moving on, you become aware of a much different environment. It gets darker and you walk on jagged gray limestone. Trees seem to grow right out of the rock. You are now in the forest. One of the first trees you meet is named for Guam.

Guamia mariannae

Family: Annonaceae—— Custard apples
Endemic

Paipai is a small tree with many branches growing out from the upper two-thirds of its slender trunk. Many patches of close-fitting lichens cover the bark.

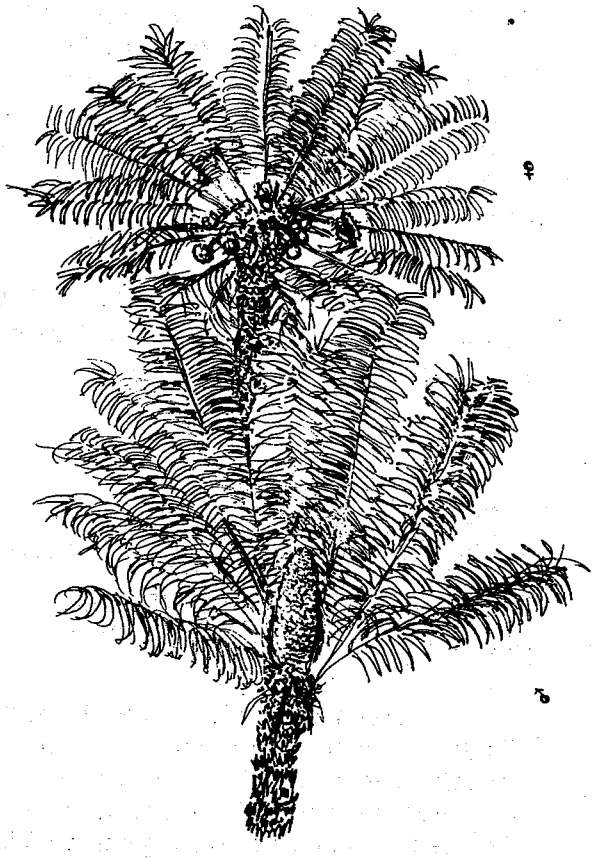
Paipai



Cycas circinalis

Fadang, federiku palm

Family: Cycadaceae
—— Cycads
Indigenous



Guam's only indigenous gymnosperm is this palm-like tree. Gymnosperms don't make flowers or fruits. In most gymnosperms the seeds are produced by cones. When the seeds ripen, scales on the cones open outward and let the seeds blow away on the wind. 'Gymnosperm' means 'naked seed', one not enclosed within a fruit.

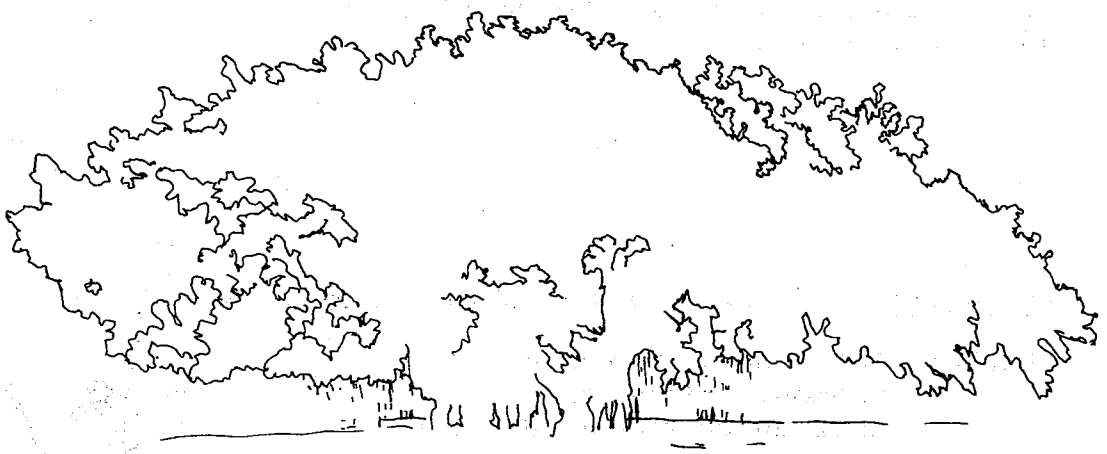
Cycads are different. They are either male (below) or female (above). Try to tell them apart before they mature and produce sex organs! The male grows one large yellow-brown cone straight up from the crown. It's about the size and shape of an elongated football. It releases a huge amount of pollen with a strong, sweet odor which drifts through the forest.

Some of the pollen may find its way to female fadangs. A small amount of this pollen may fertilize some of the pea-sized ovules (little eggs). Ovules are produced on the many strap-like leaves growing out of the female crown. One ovule is fertilized by one pollen grain. At fertilization the ovule becomes a seed and grows a bit larger than a golfball, still attached to the mother tree. At this stage seeds can be collected, opened, and washed several times to remove the poison. The insides are then dried and ground into a flour, used for making titiyas (tortillas).

If fertilization doesn't happen, the ovule shrivels into a sort of large dark raisin.

Because it was a common plant two hundred million years ago when dinosaurs were stomping around, fadang is a living fossil. An individual tree grows very slowly, 2.5 cm a year. How tall will one get in 100 years?

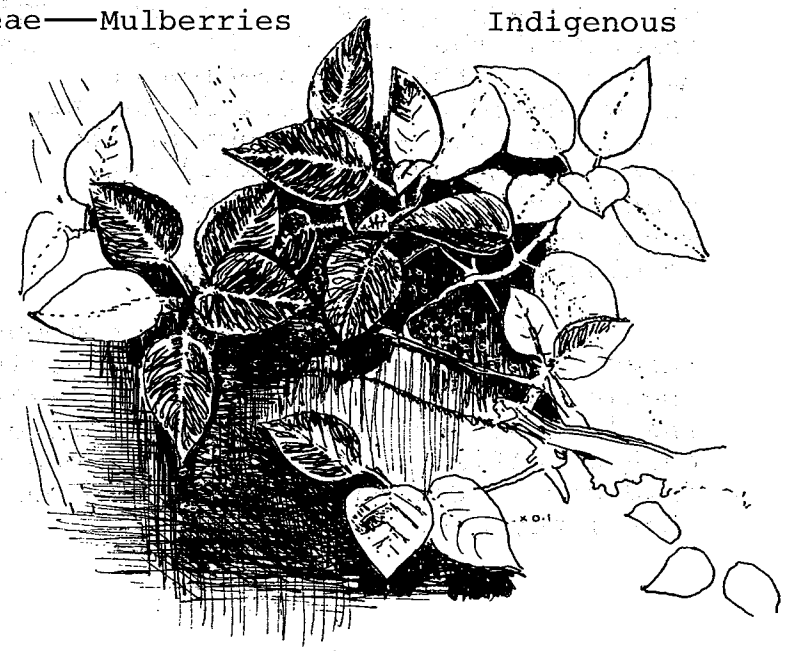
If the crown of a cycad is cut off, the remaining trunk may grow side crowns. If a cut tree is placed in damp soil and kept moist it may grow new roots. In January 1975 the Guam Legislature passed a law protecting this ancient tree from being cut or damaged by humans.



Ficus prolixa — Nunu, banyan, strangler fig

Family: Moraceae——Mulberries — Indigenous

Nunu is in the same family as dokdok and lemmai (breadfruit). It is also in the same genus (Ficus) as the tree which gives us the figs in fig newtons.

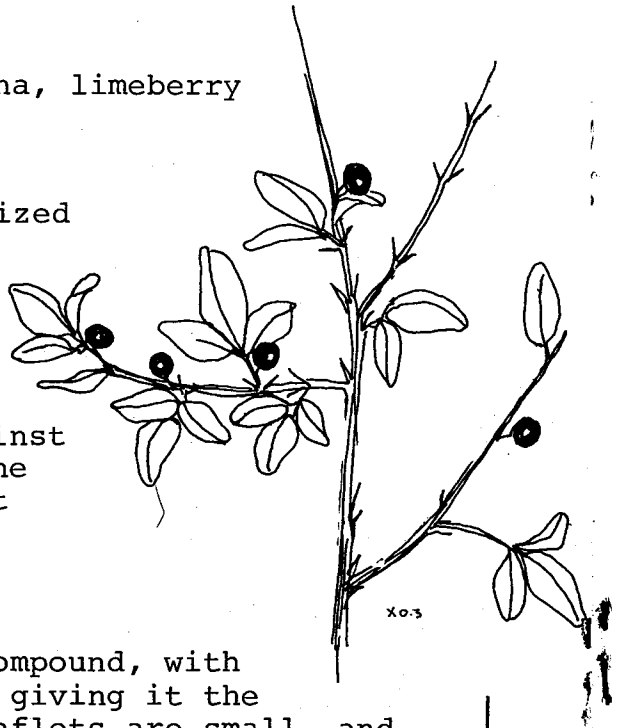


The strangler fig tree lives a 'captivating' life. A bird eats a fig. The fruit is digested, the seeds are not. They pass, with some fertilizer, from the bird. They can sprout in lots of places. If one is deposited on the branch of a tree it can sprout and send aerial roots downward to the ground. The seedling's roots can closely surround the host tree. As the young nunu gets older and spreads out, more aerial roots grow down.

After a while the host dies, maybe of strangulation, maybe of old age, and the nunu is supported by its own roots. Spreading out over a large area, the nunu, with a mass of prop roots, may house a taotaomona. One nunu at the Country Club of the Pacific is 60 meters across.

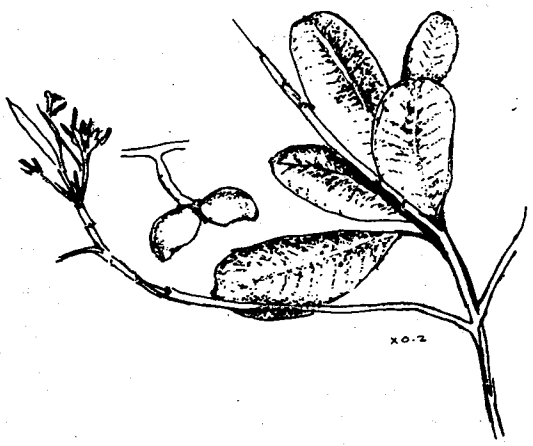
Triphasia trifolia Lemon China, limeberry

Family: Rutaceae—Citruses
Common, native or
introduced and naturalized



An attractive shrub, it is often a pain to hikers because of the sharp spines. It grows throughout the forest. It is also one of the main species on the windward eastern cliffs against which the trades blow much of the time. Maybe you've noticed that plants growing in these strong winds don't get so tall as they do elsewhere. Any ideas why?

Lemon China's leaves are compound, with three (tri-) leaflets (-folia), giving it the species name. The first two leaflets are small, and the largest one is at the tip of the petiole. If you mash a leaflet in your hand you can smell the limey fragrance. The edible small red berries also have that limey odor.



Ochrosia oppositifolia Fago'

Family: Apocynaceae——Dogbanes
Indigenous

Fago' is common inland and in more open areas of the forest behind George Washington. The nearly elliptic leaves are usually in whorls of 3 or 4, sometimes opposite. The branches are whorled around the trunk, with long spaces between whorls. Considering the size of the tree, it doesn't have many leaves. A close look at the tips of the leaves shows them to be slightly pointed.

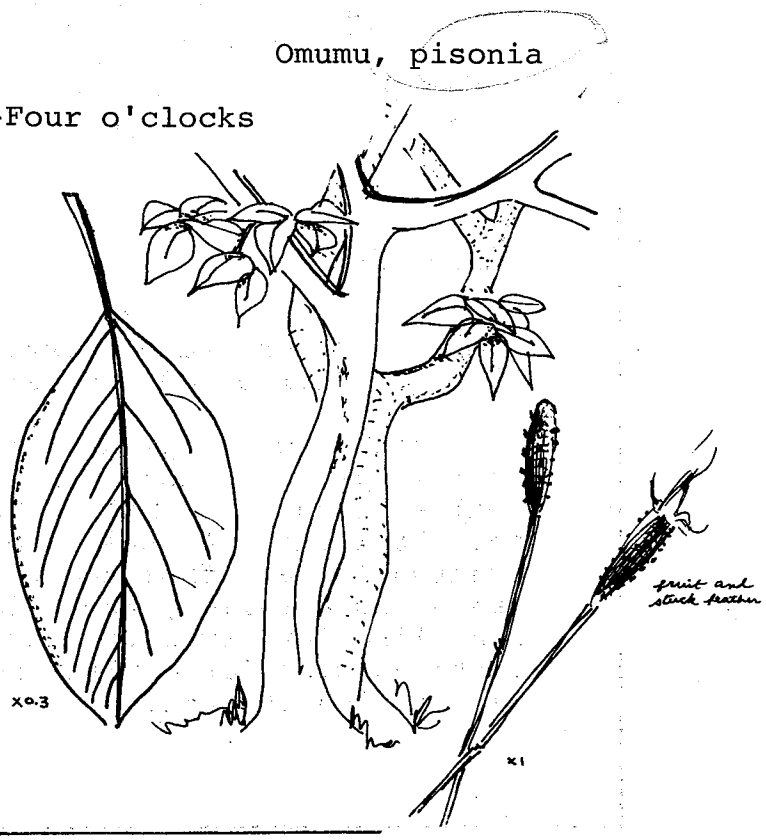
The young fruits are green and usually in pairs. When ripe the thin outer covering becomes yellow and is supposedly edible. The flattened seeds taste like coconut. When the fruit drops to the ground, its covering soon falls away exposing a fibrous layer resembling the husk of betelnuts. Fago' survives typhoons better than most trees. This may explain why it's so common in open areas of the forest.

Pisonia grandis

Omumu, pisonia

Family: Nyctaginaceae——Four o'clocks
Indigenous

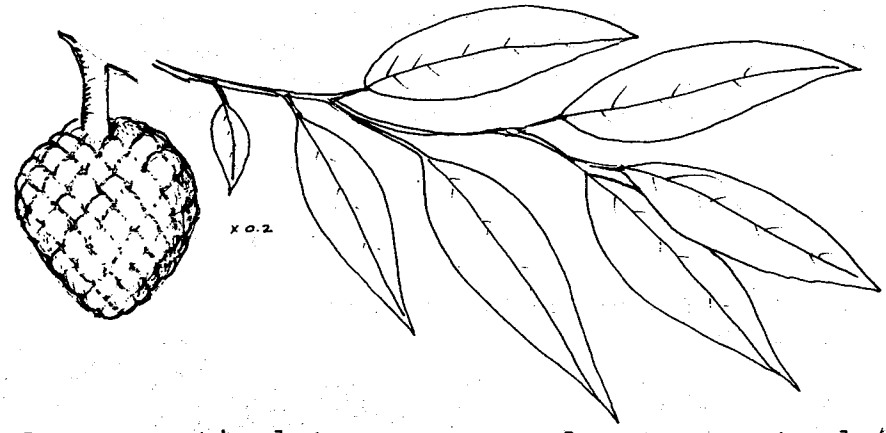
When you see a large tree with a thick light-colored trunk, chances are you have come to the soft-wooded omumu. Large ovate, pale, thin leaves are bunched at the ends of the twigs. In certain parts of the Pacific, the wood is used for canoes, and the leaves are eaten like cabbage. Do the leaves look as if anyone else eats them? Who might? The branches are often broken by strong winds.



Flagellaria indica Bayogon halom tano', false rattan

Family: Flagellariaceae——Flagellarias Indigenous

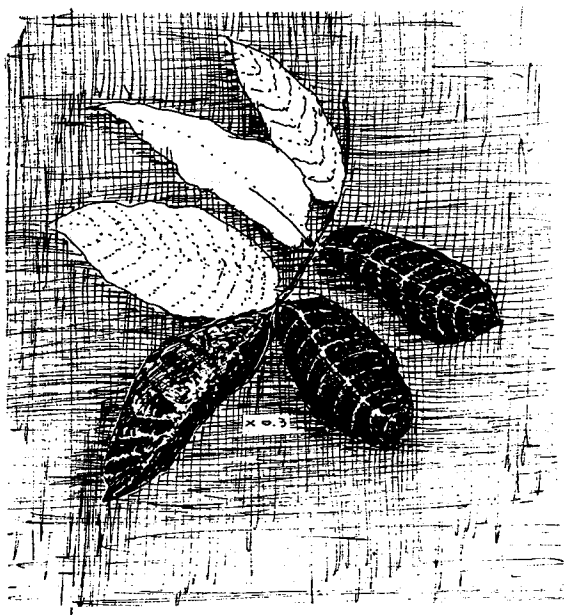
There are very few lianes (vines) in the forest. When young, this slender cane-like plant holds itself upright, but as it becomes a few feet high begins to bend over. The tips of the long narrow leaves are tendrils and coil around other plants. This gains support for the increasing weight. A single one of these vines may clamber through much of the upper storey of a forest. Near the end of the hard stem grows a large bunch of small round fruits.



Annona reticulata Anonas, custard apple, bullock's heart

Family: Annonaceae——Custard apples
Introduced and naturalized

Ates (sweetsop) and laguana (soursop) also are in this genus. Anonas in the wild are often a bit smaller than a baseball. The leaves are lanceolate and alternate. As they grow older they darken and eventually fall from the tree. After most of the leaves have fallen, the reddish fruits mature and hang like Christmas tree ornaments. The fruit contains many large black seeds and tastes good. Fanihi like it, too.



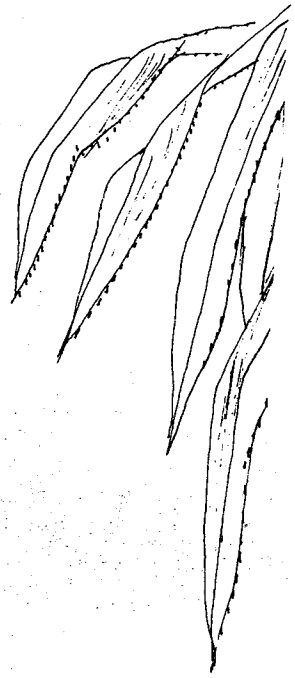
Aglaia mariannensis

Mapuñao

Family: Meliaceae——
Mahogany
Endemic

This small tree is common in the denser parts of the forest. The leaves are covered with short, dark brown hairs. The pretty flowers are a light salmon color. A hand lens look at the outside of the flower stems and sepals shows many tiny hairy rosettes.

Pandanus dubius Pahong, pandanus

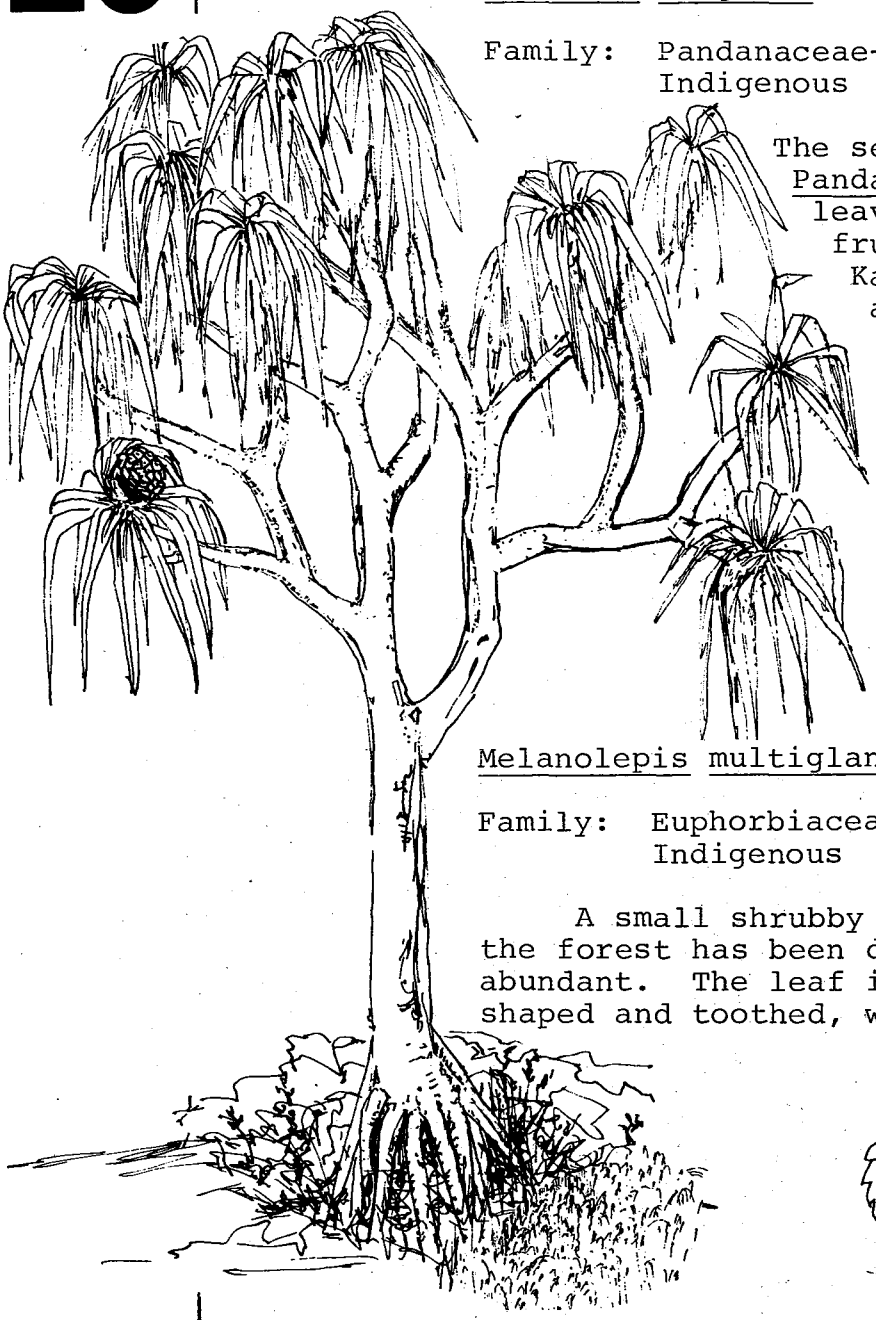


Family: Pandanaceae——Screwpines
Indigenous

Although this plant is not ? common in the limestone forest, it is noticeable because of its massive size. Of the two species of Pandanus here, this one has larger everything except height—— larger roots, larger stems, leaves and fruits. The leaves are up to 3 m long, 20 cm wide, and grow screwily around the ends of the branch. The heavy, stiff leaves eventually bend sharply downward somewhere along their length. Pointed teeth grow along the margin and the midrib on the leaf's underside. These teeth point toward the end of the leaf, so rubbing your hand along a leaf toward the trunk ain't what to do!

The flowers are not easily seen from the ground. The fruit may be the size of a volleyball and looks a bit like a pineapple. A single fruit may weigh 20 kilograms. The large fruit consists of many smaller sections which separate from each other on ripening. The inner part of each section contains a whitish meat that tastes something like coconut.

20



Pandanus fragrans Kaffo', screwpine

Family: Pandanaceae——Screwpines
Indigenous

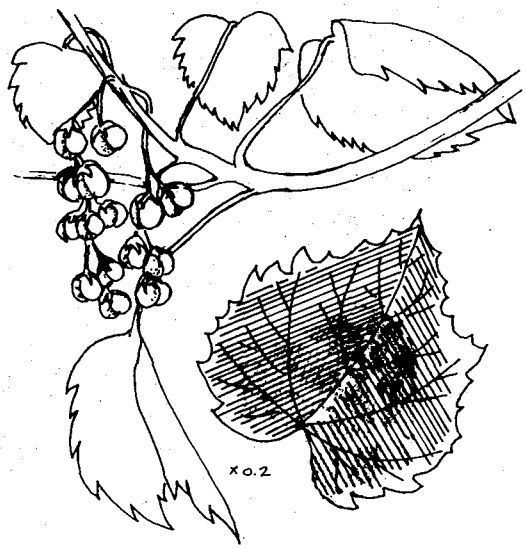
The second species of Guam Pandanus has narrower leaves and smaller fruits than pahong. Kaffo' grows taller and is more common in the open.

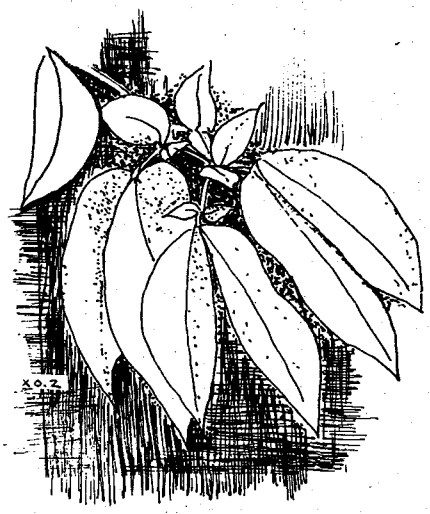
The fruits have been mistaken for pineapples, but pineapples grow on the ground in a rosette of stiff leaves. (For more on kaffo' see Savanna, Old Fields, Roadsides, in this series.)

Melanolepis multiglandulosa Alom

Family: Euphorbiaceae—— Spurges
Indigenous

A small shrubby tree, alom grows where the forest has been disturbed and light is abundant. The leaf is .10-35 cm long, heart-shaped and toothed, with veins spreading out from the base of the blade like fingers on a hand. It is a pretty sight when sun lights the leaves from behind. Stems supporting the flowers and fruits are covered with short, dark brown, starry hairs. The plant may have some medicinal value.





Cynometra ramiflora Gulos

Family: Leguminosae—Beans
Indigenous

The leaf of this relatively small tree, of the same family as ifil and tangantangan, is compound with two pairs of leaflets, the larger pair at the tip. Leaflets are often pinkish and drooping, with off-center midribs, making the tree easy to identify. Fruitbats eat the fruit. These trees are concentrated here and there in the forest.

Intsia bijuga Ifil, ifet, ipil

Family: Leguminosae—Beans
Indigenous

Ifil is the official tree of Guam. In earlier years of the century, lumbering, especially the good hard wood of this tree, was the Island's major industry.

A few large ifils are scattered around northern Guam. The cut wood darkens with time. A fine young specimen is in the yard of the Legislature building on the Post Office side. It flowers September-October.

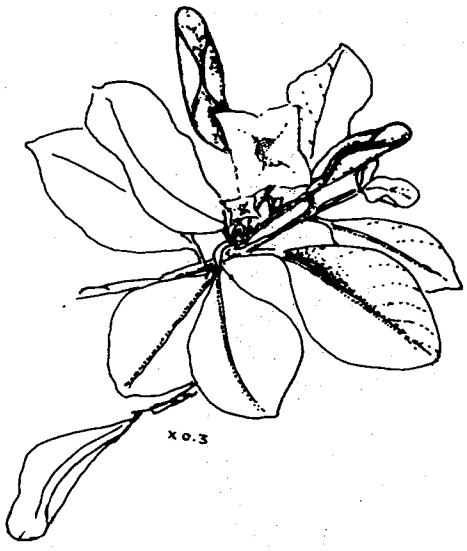
The laissez-faire attitude of the landowner and the laissez-moi of the entrepreneur combined to all but wipe out this Island treasure. Most likely it will never regain prominence.

22

Mammea odorata — Chopak

Family: Guttiferae——Mangosteens
Indigenous

A medium-size tree, chopak has similar leaves and is closely related to Palo Maria (da'ok, Calophyllum inophyllum) which has been planted along Marine Drive in Agana. Leaves are opposite, dark green on the upper surface, shiny, and thick, usually elliptical. Chopak is not now common in this limestone forest. In the past it was used for its very hard, durable, deep red wood. The sap is yellow. The white flowers, which appear around November, have a very pleasant odor.



Bikkia tetrandra — Gaosali

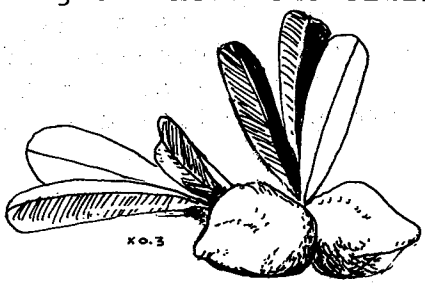
Family: Rubiaceae——Madders
Indigenous

This good-looking shrub is found only on ramparts facing the sea, mixed with wind-dwarfed lemon China. Its leaves are opposite, slightly pointed, stiff and shiny. The white flowers are shaped like trumpets with square bells.

Bleekeria mariannensis — Langiti

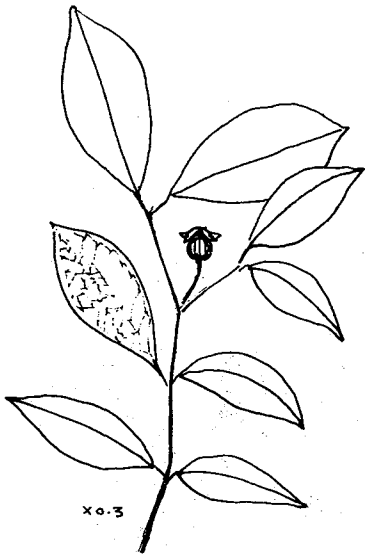
Family: Apocynaceae——Dogbanes
Endemic

Langiti looks like a miniature fago'. The two are in the same family. Langiti grows near the cliff edge. The leaves are in whorls of three. The paired fruits become orange, then red as they ripen. When a branch is broken, it oozes a milky sap.



Eugenia reinwardtiana A'abang

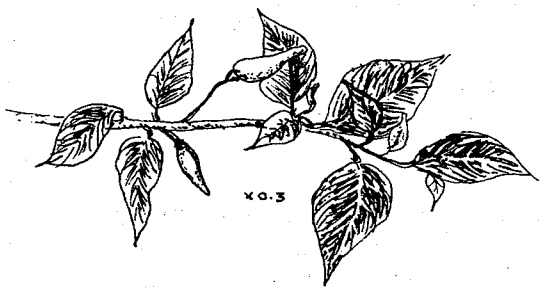
Family: Myrtaceae——Myrtles
Indigenous



A'abang, a shrub, occurs mainly near the forest edge. Its leaves are small, opposite, and fairly stiff. The flowers are attractive but the white petals fall soon after blooming. The fruit is edible. A'abang isn't bothered much by insects and might make a good plant for your yard.

Capsicum frutescens Donne' sali, chili pepper

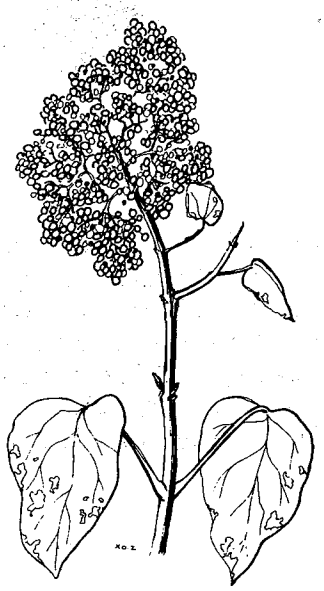
Family: Solanaceae——Nightshades
Introduced and naturalized



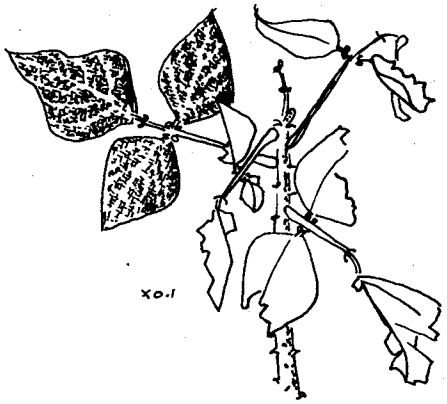
This small shrub is generally found in disturbed parts of the forest. The little red hot pepper fruits are used in cooking. Fina' denne' is a sauce made with these peppers, soy sauce, vinegar, lemon juice, and chopped onions. Fina' denne' can be used to pickle papayas, mangoes, and other favorites. Donne' sali is in the same family as bell peppers, tomatoes, and potatoes.

Premna obtusifolia Ahgao

Family: Verbenaceae——Verbenas
Indigenous



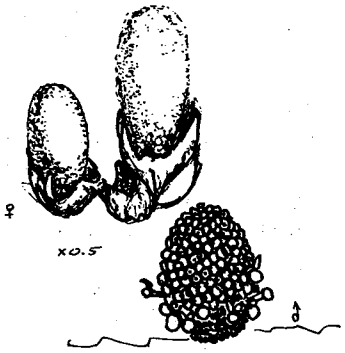
An aggressive little tree, it is plentiful on limestone, along roadsides and the coast, and in lots and fields. Leaves are opposite, and as you can see, edible.



Erythrina variegata Gaogao, gabgab, coral tree

Family: Leguminosae——Beans
Indigenous

A few specimens live here but this large tree is not common in the forest. Three leaflets make up each compound leaf. It is one of the few deciduous trees on Guam—— it drops all its leaves at the same time. It produces bunches of attractive red flowers. The tree is also known for short tough spines on the branches and trunk, making it tough on climbers.



Balanophora pentamera Chilen duhendes

Family: Balanophoraceae ——Balanophoras
Endemic

In November and December, at the end of our rainy season, this small plant shows up on the forest floor. It is a flowering parasite. It grows on the roots of such trees as gulos (Cynometra ramiflora) and paipai (Guamia mariannae) and apparently does no harm to the host.

Chilen duhendes produces separate male and female plants. Each grows about 12 cm tall and has underground stems. Above ground the stems are covered with small overlapping red leaves. The 'heads' of both the male and female produce many small white flowers. After female flowers are fertilized by male pollen, the above-ground parts quickly decay. This funny little plant deserves further study.

Fieldtrip

This fieldtrip can be the best thing you do in this unit. You'll get to know some of the sights, sounds, smells, feels and tastes of the forest. The limestone forest is your friend and asks nothing of you. Treat it with care. 'Take nothing but pictures, leave nothing but footprints!'

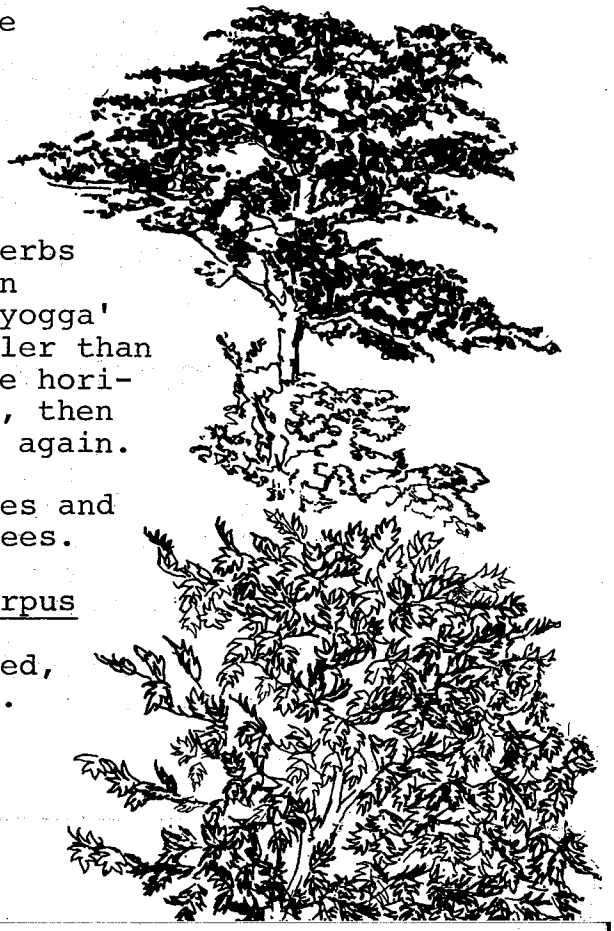
1. Before you start get your team a string 40 m long. Mark each 10 meters somehow. These marks will be corners of your quadrat (square study site).

2. Walk through the forest and identify all the plants you can. Make a checklist as you go.

3. Compare light, wind, humidity, and temperature with outside the forest.

4. Density is the number of plants of one kind in, say 100 m^2 of forest. Determine the density of the more common plants. Do this by stopping at random, and string off a square 10 m on a side. (Where is random?) Count the individual plants of the more abundant species within your quadrat. (If you don't know the names of the plants, give them numbers. Make simple, accurate drawings of their parts and later try to identify them.)

Back in the classroom discuss results with other teams. From all results determine the most common trees and other plants in the forest.



Other Limestone Forest Plants

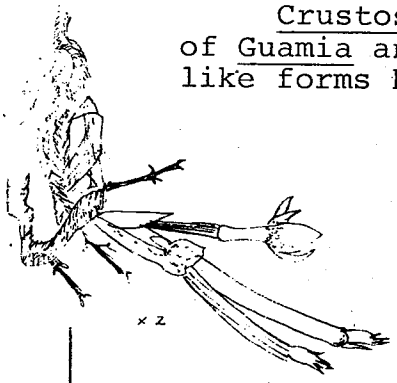
Some different trees, shrubs and herbs grow in some interior forests. A common species in the north is the indigenous yogga' (Elaeocarpus sphaericus). It grows taller than most trees around it and has distinctive horizontal limbs. The leaves are first red, then green, and just before falling, reddish again.

Breadfruits, with their large leaves and fruits, are among our biggest inland trees. Two kinds are here, in inland forests and in villages: native dokdok (Artocarpus mariannensis) and introduced lemmai (A. incisus). The fruit can be baked, boiled, fried, or made into dumplings or donuts. The folded leaf makes a nice sunhat.

Many mosses, ferns and lichens grow in the limestone forest. Some mosses cover rock formations adding green to the gray limestone. Mosses grow also on fallen trees.

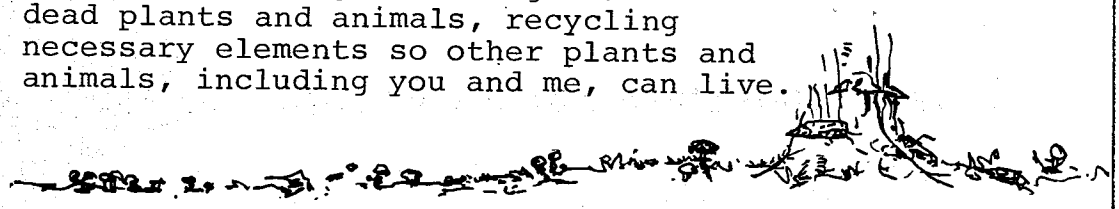
Ferns are abundant, some growing in crotches and on branches of larger and older trees. One fine species, galak, birds' nest fern (Asplenium nidus), has long smooth leaves. It is easily recognized by its very dark midrib. It grows upward from the crown of the fadang or from the crotches of various other trees, or even in the soil.

Crustose, flattened lichens grow on the bark of Guamia and other trees, and fruticose, beard-like forms hang on lemon China near the rampart.



As small as some mosses is the tiny orchid, kamuten nanoffe, Taeniophyllum mariannense. It is stemless and has green creeping flattened roots which cling tightly to the trunks and branches of forest trees. The pale flowers of this orchid are very small.

The last of the plants we look at put valuable organic materials back into circulation. Bacteria, bracket fungi, puffballs, coral fungi and other mushrooms (some glow at night!) live on dead plants and animals, recycling necessary elements so other plants and animals, including you and me, can live.

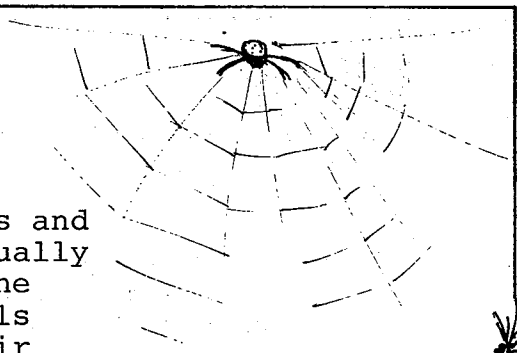


Limestone Forest Fauna—Animals

Many of the fauna of the limestone forest also live in other ecosystems. These animals may prefer the limestone forest because of its many hiding places——crevices, holes, and small caves. The animals are free to come and go but usually hang around where food is and where people aren't.

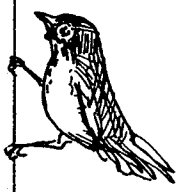
Since herbivores' food comes from plants, the bare or almost bare forest floor is not the best

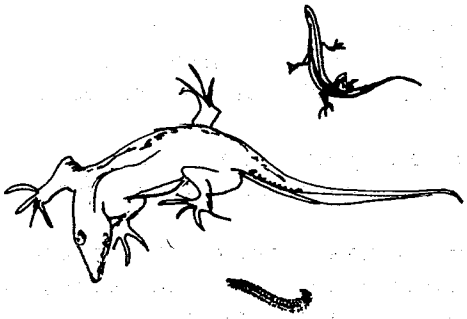
place to find plant eaters. Most leaves, flowers and fruits grow in the upper parts of trees and shrubs. Herbivores will usually be found toward the canopy, the top of the forest. Some animals in this group are insects, their larvae, birds, and fanihi (fruitbats).



These animals may be hard to see because they're often active at night and feed high in the trees. We can tell, however, by the holes and missing edges in the lower leaves that some of them certainly feed near the ground.

Probably your observations of animals in the limestone forest will be of those on or near the forest floor. Here the consumers are for the most part predators, animals which capture other animals for food. They include guali'ek (skinks), spiders, and an occasional hilitai, the monitor lizard. Skinks and spiders feed mostly on insects, but the monitor will eat just about anything. Scraps from the various dinners are cleaned up by forest scavengers including ants (otdot), millipedes, hermit crabs (dukduk) and coconut crabs (ayuyu).





You may find a couple of species of snails (akaleha') here and there. Some snails feed on tender leaves or other new growth of young plants. No doubt you will notice the pesky little mosquito (namu) which feeds on juices of soft-stemmed plants when your juice is not available.

You will have a chance to learn more about forest animals when you visit the library.

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Library

Look up answers in encyclopedias and other reference books. Consult with zoologists, botanists.

1. Lichens are a good example of the ecological relationship mutualism. What is mutualism and how does it apply to lichens? (Further, what relationship is there between the lichens and the trees they grow on?)

2. Mosses and ferns reproduce similarly. How? What part does water play in this kind of reproduction?

3. Many fungi (mushrooms, molds and bracket fungi) live in the forest. Fungi have no chlorophyll, so they cannot make their own food. How do they get their food?

4. Balanophora is red. Does this mean it doesn't make chlorophyll? Does it make chlorophyll? How does it get its food?

5. Where besides Guam are fadang found? Why are they called living fossils? What ancient animals were common when cycads were most abundant on Earth?

6. Does the designation 'climax community' really apply to our limestone forest? If not, why not? (You don't have to agree with the author.)

7. Three trees on Guam are Australian pine, Norfolk Island pine, and screwpine (Casuarina, Araucaria, Pandanus). Are they really pines?

8. Donne' sali (chili pepper) is used in different kinds of hot sauces on Guam. Where are chili peppers grown for profit in the World? What is the name of the sauce produced?

9. A small wasp plays a very important part in the 'love life' of a fig tree. Describe this interesting relationship.

10. False rattan (bayogon halom tano') has a very stiff stem similar to true rattan. Where is rattan found in the World, how is it prepared for use, and what is made from it?

11. One of the animals living everywhere in the limestone forest is guali'ek, the skink. The immature male has a bright blue tail. What does a skink eat and what happens if it gets caught by the tail?

12. Dukduk, the hermit crab, is fairly common in the limestone forest. What does it do most of the time? (What does it do when it doesn't do that?) What special problem does it have as it grows up?

13. Find out more shapes, arrangements and other characteristics of leaves. What does 'palmate' mean? 'Trifoliate', 'obovate', 'glabrous', 'pinnatifid'?

14. Ayuyu, the coconut crab, is quite busy during the night and not often seen during the day. Can it really open coconuts? If so, how? What is ayuyu's life history?

15. Hilitai, the monitor lizard, lives in several Guam ecosystems. It is often called an 'iguana'. What are some differences between a monitor lizard and a true iguana? What does the monitor lizard eat? Is it able to swim and if so, how?

16. How do fanihi differ from birds? What do these bats eat? What do people do that may cause the fruitbat to become extinct here?

17. Other than as food, how do we use the papaya? Where else in the World are papayas grown for profit?

18. In the Temperate Zone it's easy to find the age of a tree. How is it done? How do we do it in the Tropics? How old is the oldest tree in our limestone forest? On Guam?

Review

1. Introduction

   a. Modern developments on Guam are what some people call 'progress'. What do they mean and what do you mean by 'progress'?

   b. Can we use the word 'progress' to describe what is happening to the natural environment? If not, what word would you choose?

   c. How can bulldozing the land surface affect a coral reef?

   d. What have you done in various wildlife areas on Guam?

   e. List reasons you would like to see wildlife areas preserved.

   f. What is ecology?

   g. What is an ecosystem?

h. Why does the 'limestone forest' have this name?

i. Why is a limestone forest ecosystem different from other ecosystems such as the ravine forest and savanna?

j. What is a 'climax community'?

k. What are 'pioneer plants'?

2. Physical Aspects of a Limestone Forest

a. Where did the mountains of central and southern Guam come from?

b. What evidence is there that some of these mountains were under water long ago?

c. What is a plateau?

d. What evidence do we have that the northern Guam plateau was lifted unevenly?

e. What evidence is there that parts of Guam were raised more than once?

f. At the edge of a limestone cliff, you stand on a 'rampart'. What part of the former reef was the rampart?

g. Today the types of plants in some forest areas are the same as they were hundreds and thousands of years ago. Why?

h. What color is the substrate of a coral reef? How come limestone forest rock, the remains of coral reef, is gray?

i. Why are there no lakes or ponds, rivers or streams in northern Guam?

j. What happened to make the limestone forest floor so sharp, jagged and holey?

3. The Limestone Forest Flora

a. Find out two plants not discussed in this booklet that are indigenous to Guam.

b. Name two plants described here that are introduced on Guam.

c. If a small area in the limestone forest were cleared, what pioneer plants might appear?

d. How does a simple leaf differ from a compound one?

e. What does a leaf do for a plant?

f. Name a limestone forest leaf with sharp teeth along its margin.

g. What tree can sprout on a host tree and eventually take the host's place?

h. Why is the cycad, fadang, a 'gymnosperm'?

i. Name some characteristics of lemon China.

j. Which tree would you choose for Guam's official forest tree? Why?

k. What does 'deciduous' mean? Name a deciduous tree of this forest.

l. Which tree here has branches and leaves in whorls?

m. What special adaptation is on leaves of bayogon halom tano'?

n. Which plant in this forest has the longest leaves?

o. Mosquitoes, namu, breed only in water. Many mosquitoes are in the forest. Do namu breed there or fly in from outside? Where could they breed inside the forest?

Acknowledgement

In addition to L Hotaling for art, layout, and literary contribution, the author wishes to thank Lita Payne and the Learning Resources Center for the ahgao drawing and the task of refurbishing the Fosberg-Stone vegetation map. Thanks also to Philip H. Moore for a critical reading of the final draft.

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Plant Index

one last thing...

Sometime, return alone to the interior of the forest. Sit still for 10 or 15 minutes. What do you notice different from the class trip?