

Introduced grass found mainly on the west side of the island. Probably introduced during the guano mining period.

Native grass confined to the highly saline guano soils of raised islets in the lagoon and low normally dry lagoon bottoms. Often associated with Sesuvium and Portulaca. Large areas covered with small, young clumps suggesting periodic inundation of low former lagoon areas. Common over the island and in sandy soils along the west shore. Very vigorous clumps are scattered at the edge of the lagoon where runoff flows over hardpan and into the lagoon. Such clumps always show a heavy salty coating of stems and leaves.

Planted on the island during the guano mining period. Aerial photographs of WW II vintage show some living trees but in very dry condition. Only dry remains were evident in 1964.

Fourteen plants of this species were found growing on the west side of a small guano pile of the mid north section in June 1964. Several sheets were collected. In October of 1964 the exact site was revisited. A few dried stems were found. This species is usually found on islands which have a higher rainfall and more verdant vegetation. The location and condition ie, not spreading suggests that this species was introduced.

Common over the island, an evident pioneer on wave washed sand beaches. This is a white flowered form of the taxon probably referable to B. repens L.

Succulent herb found in low former lagoon flats and on top of raised islets in the lagoon. Found also on the NE rim in sand over hardpan. Usually associated with Eragrostis whitneyi and Portulaca. No seedlings were found in a thorough search of the mat surrounding the lagoon and in open sites with favorable conditions. Sprigs of this species are used in rudimentary nest sites of the bluefaced booby often found nesting at the flat edge of the lagoon. After initial introduction to an island the mat probably forms very quickly due in part to the habit of this bird in snipping off sprigs to place near the eggs. Vegetative propagation is apparently the most important mode of reproduction. The variety griseum confined to the Phoenix and Line islands is somewhat variable as to color of flower and size of stems and leaves.

Common over the island in sandy soil. The guano mining may have stripped large areas of a Portulaca dominated association from the guano soil areas of the N. portion of the island.

Confined to the guano mining area on the NW side growing on Sida, Lepturus and Boerhavia. The range suggests that this species may have been introduced although it is native on the other dry islands of the Phoenix and Line Groups.

An introduced weed found in 1924 " - about the dup-up guano field, -". Not found in 1964.

Found on the NW side of the island in sandy soils on the sides of depressions. These are probably formed as the result of storm action depositing coral rubble in high waverows later covered with

The Vegetation

On the west slopes of the island is a solid stand of Boerhavia-Lepturus with high density of nesting Blue-gray Noddies, Hawaiian Noddies and Common Noddies. Also common in this vegetation type were nesting Fairy Terns, Christmas Island Shearwaters and Wedgetailed Shearwaters. The Lepturus on the west side averages between 60-70 cm. high. The Boerhavia is very thick with stems to 1.2 m. long and very green. The Lepturus on the east side of the island above the lagoon in pockets of sandy soil averages .8-1.1 m. in height with a thick tangle of stolons which have formed new tufts. The width of the Sesuvium mat is highly variable depending on the angle of the slope measured from the lagoon edge. On the west side the slope is gentle so that in some areas the Sesuvium mat is 9 m. wide. On the slope above a mixture of Sesuvium and Lepturus occurs with a width of 4m. On the slope above an almost solid stand of Lepturus covers the sandy soil. Bluefaced boobies nest in the mat area on the SW side. Common in such areas are "pockets" which have been laid bare by the nesting activities of this species. A ring of freshly deposited guano surrounds the nest. The bare coral rubble ridges at the south end support Portulaca lutea. As one walks up this slope from the lagoon depending again on the angle of the slope one passes through a Sesuvium mat with Lepturus and Boerhavia above and then coral rubble with Portulaca. At some spots along the south edge one can walk from the dry lagoon up to the Lepturus - Boerhavia - no mat being present. No Boerhavia plants were seen with lavender flowers, dark green, coriaceous leaves or heavily anthocyanized stems. Lepturus appears very robust in areas just above the lagoon where seepage occurs. On the south end the Lepturus and Sida are flattened. In the more exposed sites the Lepturus forms shorter, more compact clumps which are often brown and dry in appearance. A transect from the south beach to the lagoon revealed the following sequence of plant species and associations: beachrock, Lepturus-Portulaca, Lepturus - Portulaca - Sida - Boerhavia, Lepturus-Portulaca, bare, Lepturus - Portulaca, Lepturus - Sesuvium, Sesuvium, bare lagoon floor. On the NW side occurs a thick stand of Sida to 1 m. high. The plants were deciduous during the dry period. Redfooted boobies and lesser Frigatebirds nest on the Sida or on the Lepturus toward the lagoon edge. The Lepturus was heavily matted in the nesting sites. The lesser frigatebirds use Boerhavia stems placed in a circular pattern for the nests built on the ground. An area of the Sesuvium mat several square meters in size was surveyed for flowers which varies from white to a light lavender. White seems most common. The Portulaca lutea flowers showed the following variation: flowers with petals 5 to 7 in number, stamens from 22 to 54 in number. Only two seedlings of the species represented were observed: Sesuvium and Sida. The largest accumulation of humus was found around the edges and beneath coral slabs. Hermit crab burrows led under the slab. These areas were more moist than the surrounding matrix of coral sand and gravel. On the N end Boerhavia and Lepturus form the dominant association. Portulaca is found in a narrow band in sand pockets amid coral talus. Beachrock is exposed on the N tip. The reef on the W, N and Ne sides is very abrupt. The surge channels are worn smooth by constant wave action. Algae were collected from the SW reef where beachrock has potholes with a mat of algae. Two seeps at the edge of the lagoon on the SE side poured water into the lagoon floor during a high tide beginning about 12:10 PM, November 4, 1964. On the SE edge of the lagoon a small depression which appeared scooped out was found. Around this were numerous rabbit droppings. Rabbits were observed eating Sida and Sesuvium leaves. One seep also occurs at the north end of the lagoon. Sesuvium flowers with four petals

are common. A narrow rim of beachrock is found on the (SE) side with no well-developed surge channels near the high tide line. The beach is composed of polished beachrock stones and the remains of clam shells formerly cemented in a matrix of coral sand and gravels. These fossil shells appear to wear less swiftly and have a "soapy" texture. The burrows of the Wedge-tailed Shearwaters and Christmas Island Shearwaters are found in the sandy soils along the rim of the island. Often these burrows are beneath clumps of Lepturus or under slabs of half exposed beachrock. In July 1964 a series of six areas on the (E, SE) and (S) sides of the lagoon were chosen along which (and twenty-one) between fifteen stakes 3 dm. high were inserted into the powdery soil approximately 4dm. apart. The stakes were orientated in such a way that a growing stem of the prostrate Sesuvium did not bisect a straight line drawn between any two stakes. It was hoped some idea of the growth rate of Sesuvium could be obtained. This species is usually found on thin layers of soil underlain by a well watered hardpan layer. It appeared that some stems which had grown onto the lagoon surface during a dry period had been killed by inundation. In November the sites were revisited and the length of stems which had grown beyond the line drawn between each stake were measured.

Description of Site	Average Growth of Stems
I S edge of lagoon, 6 m. long	9cm. (81)
II SE " , 8 m. long	Only one stake left standing due to booby activity
III & IV E edge, S side of mat peninsula, 12 m. long	III - 5 cm. (17)* IV - 0 (2)**
V E side, evidence of stems killed by inundation, 6.4 m long	11 cm. (37)
VI E side, S of V, much guano, some stems extended .75m. from solid mat on bare crust, 6.4 m. long	11 cm. (66)

This information gives some idea of the rapidity of growth of the Sesuvium mat in a four month period during which no heavy inundation of water from high tides or rain filled the lagoon to a level where the peripheral mat was covered. In site IV several stems had died back indicating that water during a high tide had seeped to a depth which covered a few stems or, possibly local disturbance at the edge of the mat had killed these stems.

^{booby}
The soil underneath the Sesuvium mat is reddish with a large amount of humus derived from dead stems and leaves. This soil is augmented by the addition of material when the nesting activity of the bluefaced booby clears an area for nesting. The outer periphery of the nest site is covered with guano by the adults and nestlings. This fertilization doubtless speeds the regrowth of the mat after the birds have left. The depth of the soil layer varied being .5 to 4 dm. thick with a hardpan formed beneath perhaps through an exchange reaction between the layers of humus rich soil and the powdery saline soil beneath. The Sesuvium mat is probably trimmed periodically by waters seeping in during the highest yearly tides. This plant species is important in the building of soils at the periphery of the lagoon basin, and as the seeps become clogged with less water pouring into the inner basin, the Sesuvium advances over the surface crusts. Even in those cases where the periodic trimming takes place the amounts of humus added to the detritus of the lagoon must over a period of time help raise the level of the lagoon. As this process continues the dry land area of the island is increased.

* The number in parentheses indicates the number of stems measured.
** See text.

Little is known about the original aspect of Phoenix Island. (Hutchinson, 1950). Guano was mined from the peripheral portions of the lagoon as indicated by Arundel (1890), "which now resemble empty plates". The floor of the present lagoon may also have been used for mining if we are to take this description literally. The island was worked for eleven years but it is not clear whether this was a continuous operation (Bryan, 1942).

refer to McKean and Phoenix islands

Since Bryan's visit several noticeable changes have taken place on the island. The ridge of broken coral on the east side has become populated albeit sparsely in many areas with a stand of Boerhavia and occasional plants of Portulaca. Triumfetta was not found in 1964. In the latest account (Bryan, 1942) the presence of Sesuvium is mentioned from the west side of the island only. If this is so the present peripheral mat has surrounded the entire lagoon in the last forty years. There is also a suggestion that if the guano was mined from the lagoon periphery that the guano deposit may have been deposited under the conditions which exist at present as described elsewhere in this paper. In that case the Bluefaced Booby (Sula dactylatra) might be indicated as a major source

Bryan also mentions that frigatebirds nested on the Sesuvium mat at the time of his visit. This was not true in 1964.)

of the guano soils on Phoenix Island and the other dry islands which exhibited guano deposits in sites approximating those found on Phoenix. The high density of individuals of a large number of species of nesting birds probably provide the vegetation with plenty of fertilizer. This guano "rain" is of vital importance in the periodic bloom of vegetation on these dry islands and is fundamental to soil building. There is evidence for a fresh water lens on Phoenix Island. A water sample was taken from a seep at the SE end in November 1964. At this time water was flowing onto the lagoon floor. The corrected salinity reading for this sample was 20.4 parts of salt per thousand, considerable below that of normal seawater. This seems to indicate that the freshwater lens was elevated by the rise in saline waters under the island during the period of high tide rise and portions of the lens spilled into the lagoon.

no evidence of the Cocos reportedly planted by S.T. Arundel in the 1880's (Maude, 1952) was found in 1964.

Arundel, J. T. 1890.
The Phoenix Group and other islands. Typed copy, 10 pp., B. P. Bishop Museum, Honolulu.

Bryan, E. H., Jr. 1942.
American Polynesia and the Hawaiian Chain. 1-253. Honolulu.

Hutchinson, G.E. 1950.
The biochemistry of vertebrate excretion. Am. Mus. Nat. Hist. Bull. 96: 1-554.

Maude, H.E. 1952
The colonization of the Phoenix Islands. Journal of the Polynesian Society 61: 62-69.
62

Typical
Sesuvium
mat
on Phoenix
islands
CR 200
to 1960

July 11, 1964 (evening showers - short)

Phoenix

July 12, 1964

5 = 15cm

20 = 60-70cm

Posts I-IV (see map).

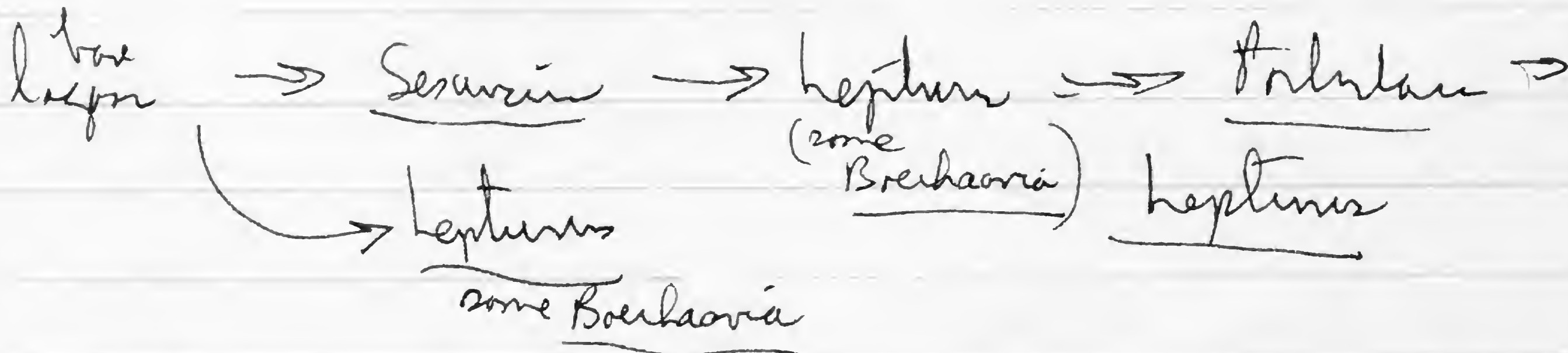
I one-half distance between lagoon (bare area) and rock beach west side of island approx. $\frac{1}{2}$ distance from north point to south point of island. approx 54 in. above soil level. Solid Boerhaavia - hepturus stand. nesting blue-gray noddies, Hawaiian noddies, common noddies. also Xmas Is. shearwaters, Fairy terns, Wedge-tailed shearwaters

hepturus on west side of island avg. 20-30 in high. Boerhaavia very thick, green. hepturus on east side of island in pockets 36 in. high with unnumerable runners produced.

II on edge of lagoon - to east bare flats, to west solid Sesuvium (about 30 ft. back hepturus in clumps; about 50 ft back solid hepturus - (Sesuvium beneath).

marshed boobies in open rocky area S.W. side of lagoon - Sesuvium; on edge of lagoon in "pocket" where Sesuvium has been killed by droppings and in central area of lagoon. open areas prepared for take off which are difficult without bare open stretches.

Bare stony ridges at south end of lagoon - Portulaca



no Boerhaavia var. with lavender fls, dark green coriaceous lvs. or heavily orthocymized stems seen. Even in rockiest area wild full spruce stems are green, fls. white

July 12, 1964

Soil Samples:

one taken from hepturus at edge of lagoon (narrow strip of Sesuvium at very edge). Soil very black.

2 - surface soil - wind blown and collected around stone obstacle 1/2 in deep at surface.

on slopes of lagoon bank are in wet pockets hepturus green - in all others dull green to brown and dead. In exposed gravel area (south end) hepturus flattened to within inches of surface.

TI - south end of island

beach rock → hepturus
Portulaca → hepturus
Portulaca
Sida
(procumbens)
Boerhaavia

hepturus
Portulaca → bare → hepturus
Portulaca → Sesuvium
hepturus → Sesuvium
(Portulaca) alone on bare spots

→ bare Two "hills" - one behind high rock beach one at edge of lagoon. First bordered by bare area.

I A: South edge of lagoon - bamboo stakes 10 in. wide at tip of vegetation approx 1 ft apart along vegetation periphery. Straight line between each stake does not intersect with any vegetation.

July 9, 1964 Hull Island - Tsunami warning
quake near Spirit Sancti

July 10, 1964 ^{Plant list} landed Phoenix Island. 4pm. ^{Associations} ^{herbicide}
Boerhaavia Lepturus
Portulaca Lepturus - Portulaca
Lepturus Sida
Sida Sesuvium - Portulaca
Sesuvium Sesuvium
Boerhaavia

Mashed Boobies - open area in lagoon or dry coral and gravel

Red footed Boobies - in Sida patches

Phoenix I. Petrel - in hollowed burrow

(all nesting)

Wedgetailed Shearwater - in burrows in Lepturus - Boerhaavia

Common & Hawaiian Noddy in open / Bluegrey in open

Christmas Island - open area or vegetated

Audubon Shearwater - in open or vegetation or stone.

Lesser Frigate - in open area / cleared Sida patches.

Greater Frigate - Lepturus

Son: Ruddy Turnstone

Golden Plover

B-T. Cuckoo

July 11, 1964

Portulaca sp. in open mid north area stamens ± 26

along lagoon edges

Boerhaavia - Portulaca border I

" " Sesuvium border II

Sesuvium border III

Boerhaavia - wd. fls. (~~at least~~) all seen to date
None with high anthocyanin content or dark
glossy lvs. as at Cook (with white and lavender
fls.)

Sesuvium - flowers few at this
writing (had on wooden).

North east - east - small leaf
rocky area - Sesuvium - on lagoon
side; Boerhaavia and Portulaca

on north east and north side - sandy area
Lepturus - Portulaca also on west side and
get Boerhaavia with L-P.

Five soil samples taken - color, texture and
water content varies
spatially -

at north west side of lagoon noticed
succulent Sesuvium in beds by Lepturus
and Sida. Lepturus form patches further
down the slope into the lagoon.

(65-70% below vegetated) open area
mainly in central lagoon, along beach, rocky
exposed areas in from beach. Sida forms
clumps in central lagoon - eggs on soil
crust.

note - the more exposed bare beach rock
the more Portulaca less Lepturus - as
sand fills in around rocks Lepturus
tend to predominate.

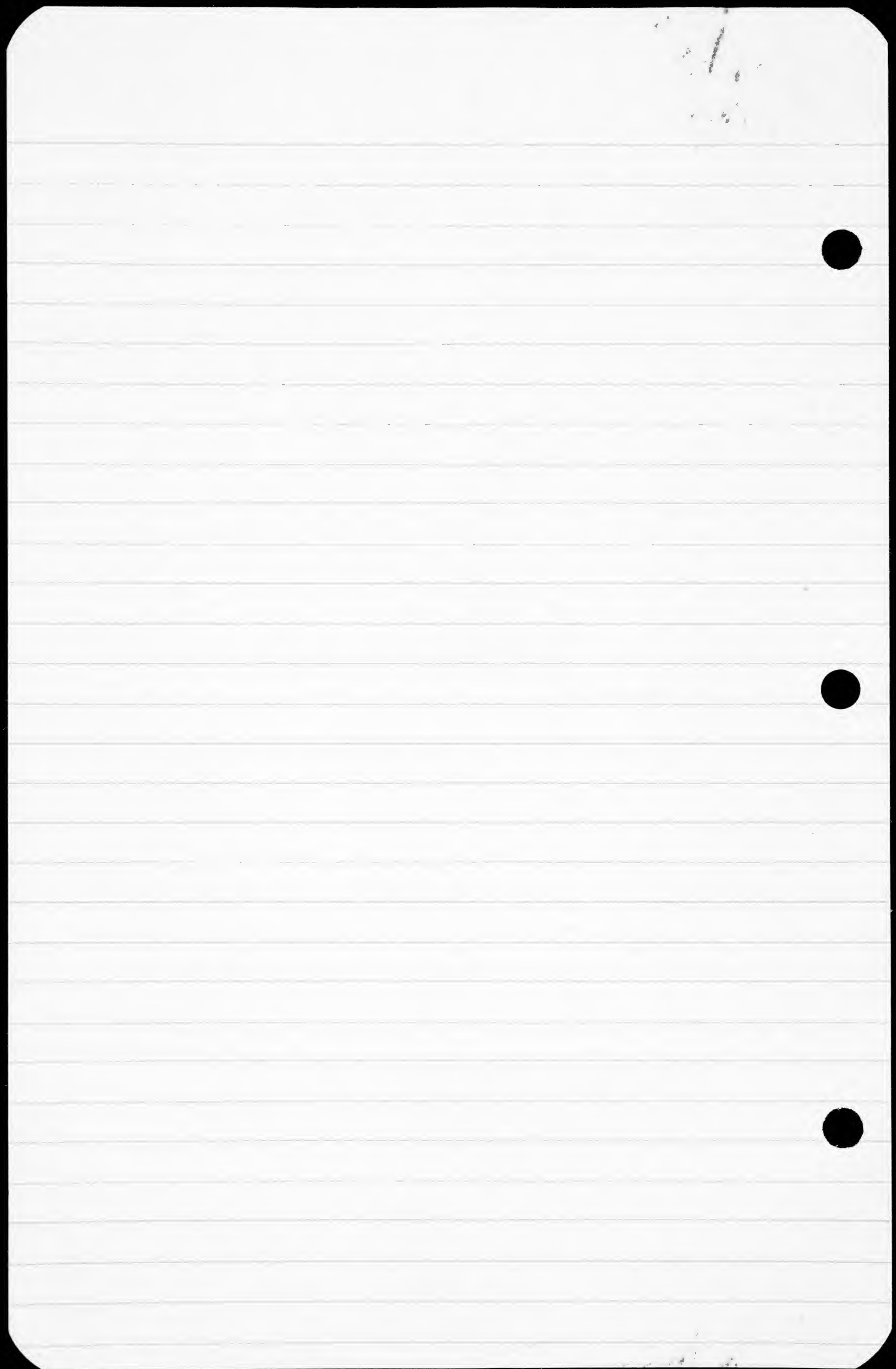
on east side of island patches of Lepturus
on inner side of bowl - sandy area with Borhavia
and Portulaca. On surrounding rocky areas Borhavia
via & in sandy patches Portulaca.

The Lepturus n.e. side of lagoon bowl - 3ft
high - many runways - soil dark, fine texture
extremely lush areas, soil moist.
Blue-grey nodules nesting on top.

Lesser Frigate - nest platform of sticks on top
of tent base - Borhavia lining.

Collecting No's 2076 - 2083

Banded Mask Boobie 7-12 am.



Phoenix

July 13, 1964 (Tues)

11:15 am. - Huber printed out crested-tern.

✓
no. 5 - stake row - ^(16 stakes) along Sesuvium mat east side of island, toward the south end directly opposite the "break" in the high rocky beach (south east end).

Evidence of Sesuvium having been killed off at edges probably by lagoon waters. no. 5 - edge uniform.

Bar area within Sesuvium (many bird droppings) 21 stakes. no. 6. further south ^{behind no. 5} along lagoon edge. (21 stakes); edges appear to advance - some stems 24-30 in from mat extending onto bare crust, at extreme south end of

6 ✓ former booby nest area - many dead Sesuvium stems. (Dry season favorable to advance(?), wet

retards - kills?). Only a few uncommon areas along edge of mat killed by apparent inundation. Bird nest at edge much more common.

no. 7
Above no. 6. on rocky shelf (hepturus - Portulaca - Boerhaavia) - periphery of Boerhaavia marked (7 stakes) runner radiate (to 30 in. from center), plant green, in fl. (wt.).

	petals ♂	
<u>Portulaca</u>	7:36	6:22
	5:34	5:44
	5:43	5:31
	5:24	6:42
	5:44	6:26

no. 8. on flat rocky area behind site no. 7. Sida foliosa procumbent marked on periphery with 16 stakes. Stems radiating out into bare gravel area.

Just to southeast a nesting area (in low Sida and hepturus) for lesser frigates $\frac{1}{2}$, 28 nests. Chicks

large - eggs still incubating in some.

Few seedlings noted: exception: Sida - seedling and small plants in Sesuvium patch - ground very wet. Lepturus runners go out into wet Sesuvium patches (1 seedling observed but may have been vegetative).

#1 Soil sample: Sesuvium - dry open area $\frac{1}{2}$ - 2 in. many roots present - dark brown.

White-tailed tropic bird flew up - landed in shade of my shed and Koversak. Quite tame in appearance. Obviously needs shade.

Soil

#2 - soil accumulation under coral rock slab, windblown mineral matter; dead organic (Lepturus; Portulaca - crab burrows under rocks).

#3 - bare soil surrounded by Portulaca, Lepturus gravelly at surface ($\frac{1}{2}$ - 2 in) sample.

Transect from stake II (edge of lagoon to high-tide mark).



a. Sesuvium → Lepturus → Portulaca → Boerhaavia → b
(Lepturus) (Lepturus)

Note: Phoenix Island illustrates very clearly the importance of island forming processes and topography in the distribution of vegetation. In islands only feet above

sea level with slab rock beaches, some beached; wind-blown areas; inner flat gravel terraces and slopes and lagoon edge / a few inches may determine the distribution of Sesuvium (or, distribution and depth of water accumulation; depth of salt water beneath crust); or hept-
ternis at lagoon edge where drainage occurs; slope toward or away from prevailing wind; substrate (large slab rock; coarse reef rock; gravel; sand; windblown or residual soils; sand on beach. of wide barrier beach of Starbuck; lagoon area of Maeder).

2089 - Side fallay - S.E. end of island in gravel, proaumbent, in flr., large ls.

Site ~~11~~ - East side of lagoon
only 1 stake of 13 left standing
rest knocked over by borkie
takeoff from mat edge.

13 placed further south at west
edge

~~IV~~

B. Twenty stakes due east - placed along Sesuvium edge so that straight line does not direct vegetation.

Where rocky shelf behind high beach wall extends to lagoon edge Lepturus found along the edge - area of brackish water seepage after rains (see picture).

Boerhaavia - Lepturus associated on dry platform above lagoon.

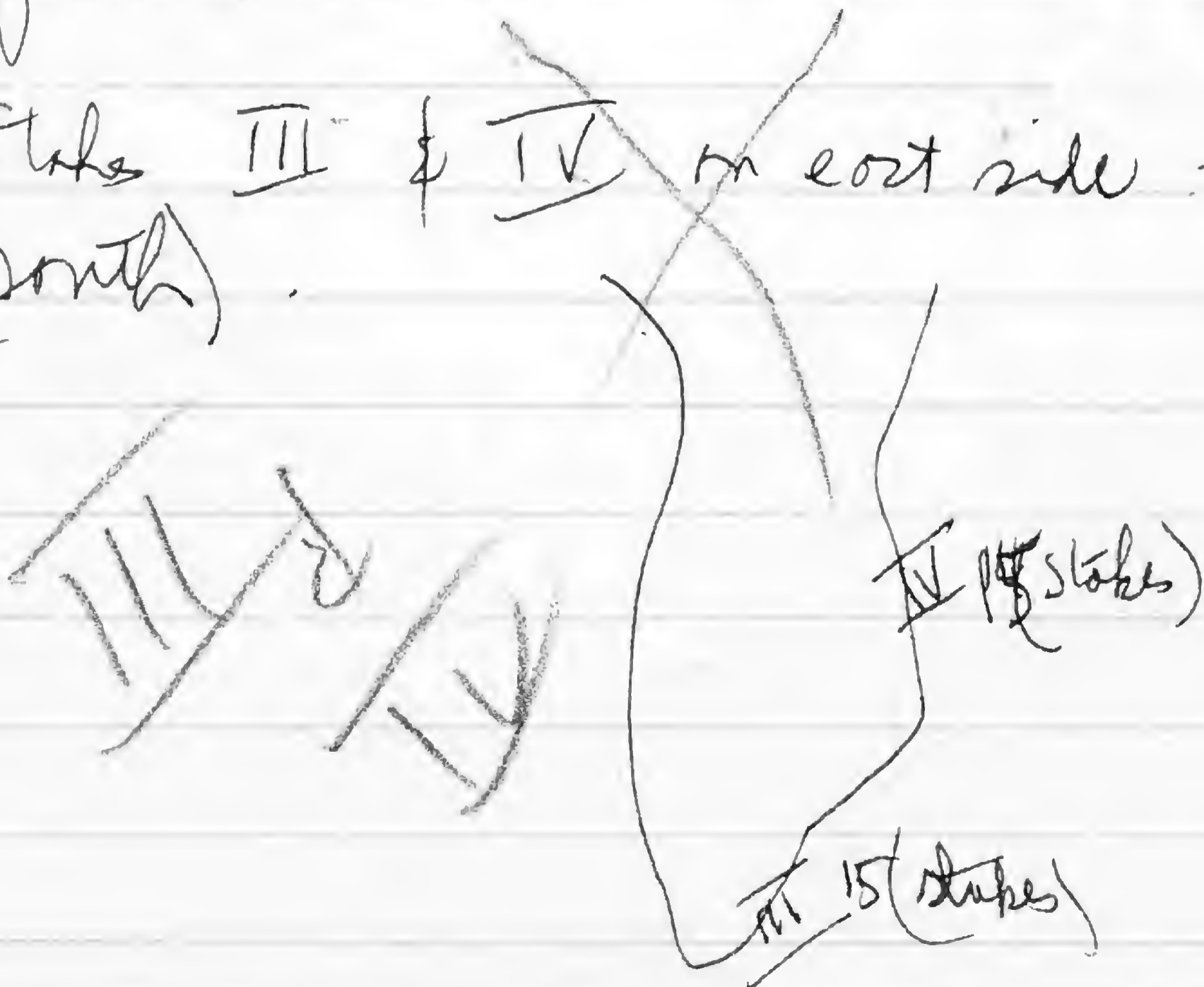
at edge of lagoon under crusty litter $\frac{1}{2}$ deep - green algae layer - below brown wet muck. Sample of algae taken.

Sida at soil end on raised platform - prominent - upper sprouts bleached by dry prevailing winds of high beach.

Post III on edge of Sida (42 ft. high) patch ^(Lepturus - Boerhaavia) ^{to the west} ^{nesting} ^{area} frigate n.w. side of island behind camp site. Majority of frigate nest on bare open area - Boerhaavia - Lepturus - Leucaena flight take - Lepturus heavily matted in these nesting sites.

heron frigate use rounded stems of Boerhaavia for nest on flat area.

Stakes III & IV on east side - edge of peninsula (south).



Part 4 - east side - pure hepturus stand
on gentle slope - toward lagoon sp hepturus
in Sesuvium.

Toward beach (rocky area) - Portulaca and
scattered hepturus. Boerhaavia

around part hepturus heavily matted - if up-
right 36 in. tall.

Sesuvium coll. on east side of lagoon - pinkish - lavender
fls. (partially) coll. at 4:15 pm.

Portulaca oleracea here:

5, 6, or 7 petals (7th may be petaloid (stamen?)).
Much variation in size and petal matching - often a
small raised area in apex or joint of petal.

♂ counts Portulaca sp.

45

26

style bands

28

5, 6

28

41

43

37

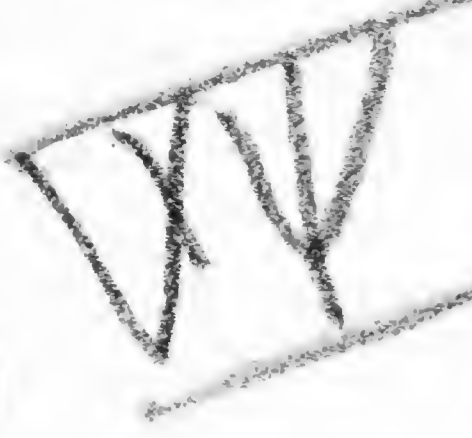
30

54

Sesuvium along lagoon shore pink fls. common -
inside stand white more common. Heat, age of fls.?

Banded marked boots 7:30 - 1:30. Red forts with
marsh.

Site III - 21 stakes (next site of
body)



- | | | | | |
|----|-----------|-----|----|--------------|
| 1 | 5 in (3) | | 13 | 6 in (2) |
| | 3 in (2) | | 14 | 10 in (1) |
| 2 | 12 in (1) | 75 | | 8 in (2) |
| | 5 in (1) | 104 | 15 | 10 in (2) |
| 3 | 3 in (1) | 72 | | 4 in (2) |
| | | 40 | 16 | 14 in (1) |
| 4 | 10 in (1) | | 17 | 5 in (3) |
| | 4 in (2) | 29 | | 7 in (1) |
| 5 | 8 in (1) | 26 | 18 | 8 in (1), 72 |
| | 3 in (3) | 270 | | |
| 6 | 10 in (2) | | 19 | 14 in (1) |
| | 12 in (1) | 75 | | 4 in (2) |
| 7 | 8 in (3) | | 20 | 2 in (2) |
| | 13 in (1) | | | 2 in (1) |
| 8 | 17 in (1) | | 21 | 4 in (1) |
| | 9 in (2) | | | |
| 9 | 4 in (1) | | 22 | 12 in (1) |
| | (2) 9 in | | | 2 in (2) |
| | (3) 6 in | | | |
| 10 | 6 in (2) | | | |
| 11 | 10 in (1) | | | |
| | 9 in (1) | | | |
| 12 | 4 in (2) | | | |
| | 3 in (1) | | | |
| | 4 in (1) | | | |
| 13 | 4 in (1) | 104 | | |
| | 3 in (1) | | | |

Approx. $\frac{1}{16}$ area
of 28 sq ft original
plot covered by 10 ~
20 branching stems.
hat - not counting
bars are behind bars
draw between stakes

5 Nov. 1964

Phoenix Is. 11^{am}

Samoan roll

- 25. - Phoenix Is. entrance to wedgetailed shearwater burrow under hepturus
- 26. D. Hackmii uncovers shearwater burrow.
- 27. " collecting bird -
- 28. hepturus on sand, wedgetailed burrow.
- 29. Typical expert, wedgetail burrow.
- 30. Lesser frigates - P. Woodward
D. Menne
- 31 } Shot 125/ upward - ♂ + ♀
- ↓ } Lesser frigates.
- 36 }

new roll 5 Nov. 1964

- 1. nestling Lesser frigate "sunning pose"
 - 2. ♂ Lesser frigate
 - 3. 250/ Lesser Frigate ♀ + chick
 - 4. 125/ nestling sunbathing
 - 5. ee
 - 6. a
 - 7. NW
 - 8. NW
 - 9. W
 - 10. NW
 - 11. W
- } 360° - from low boulder north end.

4 November 1964 Phoenix Island

2:30 pm.

Southwest side: dry Lepturus, Borhavia still green, Portulaca in flower. Quono dust noticeable as one stumps through the Sesuvium and dry Lepturus. Hundreds of immature sooty terns perched on coral rock wall above SW beach. The SW end of the island seems best for algae collecting - here there is exposed beach rock reef with pot holes containing several feet of water at low tide. Reef on W, NW, and ^{one} N sides are all abrupt with smooth steep channels. on the SE side pot holes are present and the slope of the reef not so abrupt - here one finds matted algal cover on the rocks.

6 November 1964

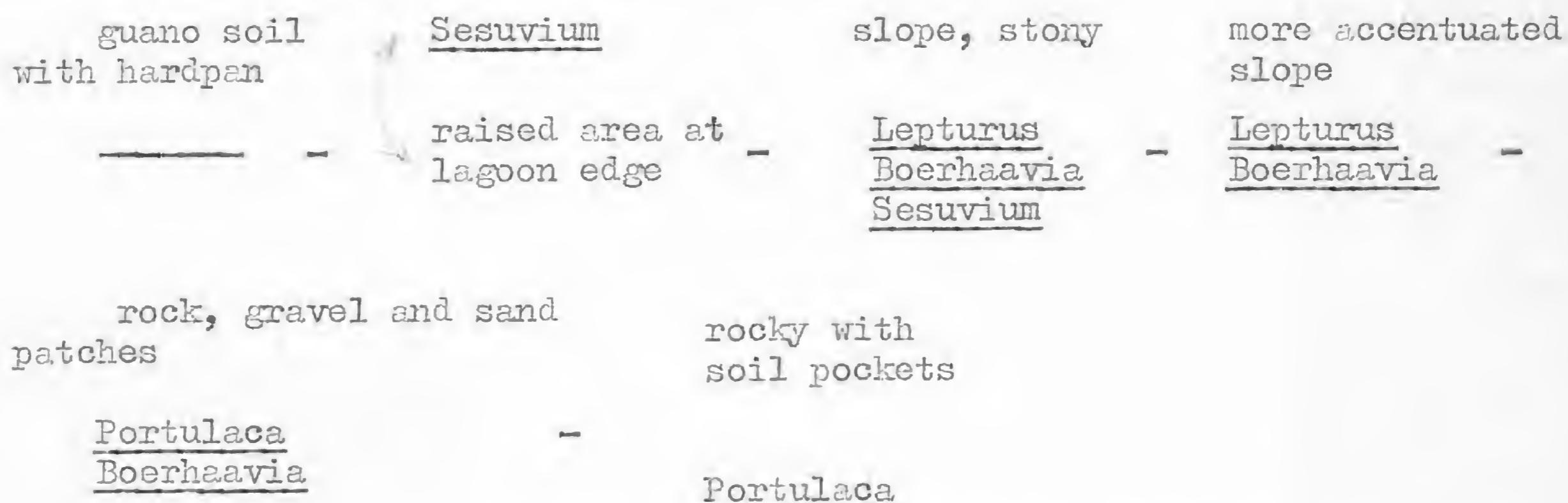
all permanent markers were observed to be intact.

Phoenix Island

July 12, 1964 - Permanent markers - I. Placed one-half the distance between the lagoon (bare area) and the rock beach on the west side of the island, and, approx. one-half the distance from the north point to the south point. The above ground portion approx. fifty-four inches above the level of the soil. A very solid, vigorous Lepturus-Boerhaavia association. Nesting blue-gray noddys, Hawaiian noddys and common noddys. Also in the general area were fairy terns, Christmas Island shearwaters and wedgetailed shearwaters. The Lepturus on the west side of the island averages 20-30 inches high. The Boerhaavia is very thick and green with new growth. On the east side of the island the Lepturus is found growing in pockets and often 36-40 inches high with innumerable runners being produced.

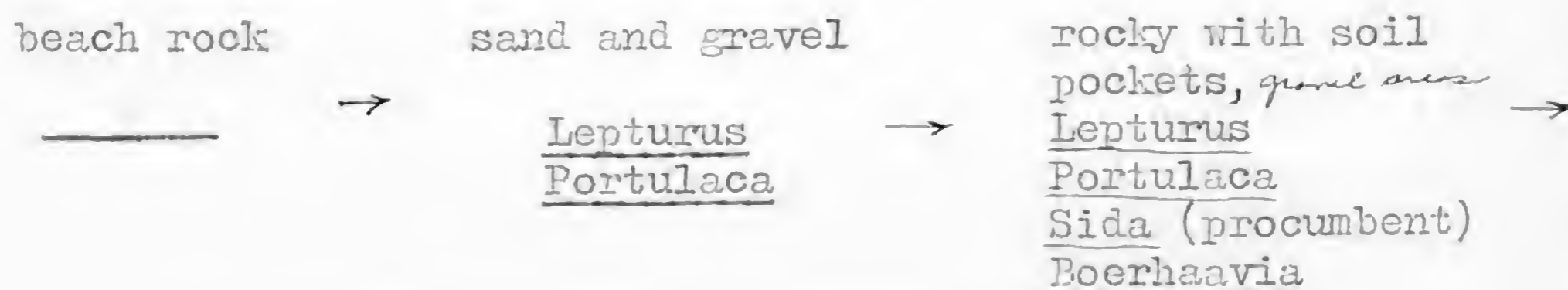
Permanent marker II - On the edge of the lagoon (west side), to the east bare salt flats and to the west the Sesuvium mat (about twenty-five feet west of the mat edge are large vigorous clumps of Lepturus, and about forty-five feet back are small, solid stands of Lepturus with Sesuvium found underneath the sprawling plants. On the edge of the lagoon - in the Sesuvium mat are indentations or pockets where the Sesuvium has been killed off or cleared off by the nesting masked boobies. These areas have been denuded by the activities of the nesting birds (physical injury and the guano cover). Similar areas are found in the Sesuvium patches in the central lagoon area. The boobies make use of the prevailing wind blowing over the bare area of the central lagoon and the absence of plant cover to facilitate easy take-offs. In the bare stony ridges at the south end of the lagoon one finds stands of Portulaca and often with Boerhaavia.

Transect I (from bare lagoon flat to beach se end).



None of the Boerhaavia observed on the island had lavender to pink flowers or dark green leaves and heavily anthocyanized stems as that seen on Hull island. In the most exposed rocky areas on this island the species shows light green stems and leaves and white flowers. The slopes of the lagoon seem to provide wet pockets for the vigorous growth of Lepturus which is green and lush. The same species in other areas on the island is drier and less vigorous in appearance. In the exposed gravel areas on the south end the Lepturus is flattened to within inches of the surface.

Transect II - (south end of the island).



rocky with soil pockets

rocky

slope with
soil pockets

slope -
guano soils

Lepturus
Portulaca

→

—

→

Lepturus
Portulaca

→

Sesuvium
Lepturus

→

guano soil, slight slope

flat, guano

Sesuvium

→

—

On this end of the island there are two "shelves" - one behind the high rock beach and one at the edge of the lagoon. The first is bordered by a bare area on both sides and the second by a bare area on the inner side. At the south edge of the lagoon I placed ~~some~~ ^{twenty} bamboo stakes, ten inches high, at the tip of the growing Sesuvium stems edging the side of the lagoon flat. These are approximately one foot apart along the irregular periphery. A straight line drawn between each succeeding stake will not (at placement) intersect any of the vegetative cover. Some idea of rate of growth of the Sesuvium mat may be ascertained from these. Twenty stakes were placed along the lagoon edge due east of the first area.

Where the rocky shelf behind the high beach extends to the lagoon edge one finds brackish water seepage and good stands of Lepturus. On the drier platform above one finds the Boerhaavia-Lepturus association. At the edge of the lagoon under crusty layer one-half inch deep one finds a dark green but very thin algal layer. Below this is a dark brown muck soil with a high concentration of salts. Algal sample was taken. The Sida on the south end is found on the raised platform. The plant is procumbent - bent by the wind as a seedling and with the sprouts on the upper outer side killed by the dry prevailing wind off of the high beach.

Permanent marker III - At the edge of the Sida patch on the nw side of the island. The Sida here stands up to forty inches high and is somewhat protected by the ruined walls of the old guano operation. Just adjacent are the Lepturus-Boerhaavia association - to the west. Nesting lesser frigates are common - some on slightly raised nests built in the Sida but most on the ground. The Lepturus has been heavily matted by the nesting frigates. The Boerhaavia is used as a nest material by the frigatebirds in the flat nesting areas - the long stems are rounded up to approximate the immediate nest area. Along the southeast side of the lagoon two areas were selected for the placement of bamboo stakes at the edge of the extending Sesuvium stems. This was on the south side of the most prominent extension of the Sesuvium mat into the central area.

Permanent marker IV - Placed on the east side in a stand of pure Lepturus on the gravelly slope of the lagoon - on the inner side the Lepturus mixes with the Sesuvium to form a distinctive local association. On the outer side toward the beach is a rocky area with soil pockets - Portulaca and Boerhaavia are found here with scattered patches of Lepturus. Around the marker the Lepturus is heavily matted - up to 38 inches high. The Sesuvium collected on the east side of the lagoon has pinkish or pale lavender flowers (sepals). Collected at 4:15 pm. The Portulaca sp. has five, six or seven petals (usually one smaller than others and obviously derived from a stamen, bright yellow, highly variable in petal size and notch at the apex - ranges from no notch to a good indentation with a raised point in the center; style branches five and six and stamen number variation (flowers from separate plants) as follows: 26, 28, 28, 30, 37, 41, 43, 45, 54. The Sesuvium with the pink to lavender flowers seems to be more common along the shore

of the lagoon. The additional heat here and/or the age of the flower may be responsible for this color. Some of the plants on the inside of the mat have white flowers (sepals).

July 13, 1964 Observed a crested tern. Sixteen bamboo stakes were placed along the Sesuvium mat on the east side toward the south end and directly opposite the "break" in the high rocky beach (southeast end). The Sesuvium may be limited in inner expansion by the periodic inundation of the dry lagoon with rain water. The edge of the lagoon at this site is uniform without an irregular pattern of growth suggesting an even edge of water. Twenty-one stakes were placed along the edge of a bare area within the mat near the above site. This was probably a result of nesting boobies. An accumulation of dropping was observed but no birds were nesting in this site currently. Further south along the lagoon edge twenty-one stakes were placed along the edge of the Sesuvium mat - in this area the plants seem to be advancing - some stems being 24 to 30 inches from the mat and rooting at the nodes in the bare soil. At the extreme south end of this site a former booby nest area was observed with many dead Sesuvium stems. It may be that a dry season is favorable for the advance of the mat onto the crust of the lagoon - the wet season and rainwater accumulation limiting. Perhaps of greater significance is the subtle raising of the lagoon edge several inches above the bare floor of the lagoon by the slow accumulation of guano deposits mixed with some organic material largely from Sesuvium. Only a few areas observed about the periphery of the lagoon where the mat or extensions of the mat might have been killed by inundation at a recent time. Evaporation may be so fast that only a few depressed areas at the edge of the lagoon retain pools which might kill the Sesuvium. Nesting boobies are very commonly found at the edge of the mat. On the rocky shelf above the last site is found the Lepturus - Boerhaavia - Portulaca association. The peripheral, radiating stems of one large plant of Boerhaavia were marked with bamboo stakes to get some idea of rate of the current seasons growth. The stems extended as much as 30 inches from the crown, stem and leaves light green and flowers white. Flowers from different plants of the Portulaca sp. in this area were observed: petals were bright yellow varying in number from five to seven and stamens varying in number - 22, 26, 31, 34, 36, 42, 43, 44, 44. In a flat rocky area about 20 ft. behind the last site (toward the beach) the peripheral area of a Sida plant was marked with sixteen stakes. The plant is procumbent and the stems are radiating out into bare gravel soil. Just to the southeast is a small area of nesting lesser frigates - in low Sida and Lepturus - about 28 nests with large chicks and incubating eggs. Few seedling plants of any species noticeable with the exception of Sida seedlings and small plants in the Sesuvium mat. Here the soil is wet. The Lepturus clumps have runners extending onto the mat. No Lepturus seedlings observed.

Transect III - (from permanent marker II at the edge of the lagoon to the high tide mark).

<u>Sesuvium</u>	-	<u>Lepturus</u>	-	<u>Portulaca</u> <u>Lepturus</u> -	<u>Boerhaavia</u> <u>Lepturus</u>
guano with hardpan		rocky with guano soil		rocky with gravel and soil pockets	rocky with sand pockets and gravel

Phoenix island illustrates very well the importance of localized topographical features in the distribution of the plant and animal life. In islands only a few feet above sea level the disposition and placement of the parent materials whether it be slab beach rock, sand, windblown sand pockets, inner flat gravel or rock terraces, slopes of various degree with varieties of surface and subsurface components, height of lagoon floor above sea level, presence or absence of raised heads in the lagoon with fossil marine material - all play a role in the present distribution of vegetation and animals on these islands. Certainly the exposure of these components to the sometimes violent action of wave and wind (not to mention the more even, predictable action of these forces) and the equally unsettling action of man whether it be ^{construction dictated by} military expediency or ^{digging} fertilizer for the farms will determine to a large extent the distribution and sum total of living things to be found. Not to be disregarded are the slight earth tremors or high waves which might effect the height of the entire island or its parts and the deposition of new material on the peripheral part of the island or on the interior.

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Phoenix Island

July 12, 1964 - Permanent markers - I. Placed one-half the distance between the lagoon (bare area) and the rock beach on the west side of the island, and approx. one-half the distance from the north point to the south point. The above ground portion approx. fifty-four inches above the level of the soil. A very solid, vigorous Lepturus-Boerhaavia association. Nesting blue-gray noddys, Hawaiian noddys and common noddys. Also in the general area were fairy terns, Christmas Island shearwaters and wedgetailed shearwaters. The Lepturus on the west side of the island averages 20-30 inches high. The Boerhaavia is very thick and green with new growth. On the east side of the island the Lepturus is found growing in pockets and often 36-40 inches high with innumerable runners being produced.

Permanent marker II - On the edge of the lagoon (west side), to the east bare salt flats and to the west the Sesuvium mat (about twenty-five feet west of the mat edge are large vigorous clumps of Lepturus, and about forty-five feet back are small, solid stands of Lepturus and Sesuvium found underneath the sprawling plants. On the edge of the lagoon - in the Sesuvium mat are indentations or pockets where the Sesuvium has been killed off or cleared off by the nesting masked boobies. These areas have been denuded by the activities of the nesting birds (physical injury and the guano cover). Similar areas are found in the Sesuvium patches in the central lagoon area. The boobies make use of the prevailing wind blowing over the bare area of the central lagoon and the absence of plant cover to facilitate easy take-offs. In the bare stony ridges at the south end of the lagoon one finds stands of Portulaca and often with Boerhaavia.

Transect I (from bare lagoon flat to beach se end).

guano soil with hardpan	→ <u>Sesuvium</u>	slope, stony	more accentuated slope
	↙ raised area at lagoon edge	<u>Lepturus</u> <u>Boerhaavia</u> <u>Sesuvium</u>	<u>Lepturus</u> <u>Boerhaavia</u>
rock, gravel and sand patches		rocky with soil pockets	
<u>Portulaca</u> <u>Boerhaavia</u>	-	<u>Portulaca</u>	

None of the Boerhaavia observed on the island had lavender to pink flowers or dark green leaves and heavily anthocyanized stems as that seen on Hull Island. In the most exposed rocky areas on this island the species shows light green stems and leaves and white flowers. The slopes of the lagoon seem to provide wet pockets for the vigorous growth of Lepturus which is green and lush. The same species in other areas on the island is drier and less vigorous in appearance. In the exposed gravel areas on the south end the Lepturus is flattened to within inches of the surface.

Transect II - (south end of the island).

beach rock	sand and gravel	rocky with soil pockets, gravel areas
→	<u>Lepturus</u> <u>Portulaca</u>	→ <u>Lepturus</u> <u>Portulaca</u> <u>Sida</u> (procumbent) <u>Boerhaavia</u>

C.R. Long
1964

rocky with soil pockets

rocky

slope with
soil pockets

slope-
guano soils

Lepturus
Portulaca

->

-> Lepturus
Portulaca

->

Sesuvium
Lepturus

->

guano soil, slight slope

flat, guano

Sesuvium

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C.R. Long
1964

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C.R. Long
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C.R. Long
1964

Phoenix
Summary of June-July Botanical Field Work

Hull Island

July 8, 1964

Collections were made on the west island and along the islets stretching to the northeast. Collection No. 1998 - 2038, C.R.Long. Soil samples and photographs were made.

July 9, 1964

Collections were made on the islets due south and across the lagoon from the ATF camp and proceeded southwest to the west island. The northeast islets were not visited. Collection No. 2039 - 2076, C.R.Long. Soil samples and photographs were made.

Phoenix Island

July 10, 1964

The island was circuited and traversed several times. Collection No. 2077 - 2083. Photographs and soil samples secured.

July 11, 1964

Collection No. 2084 - 2088. Photographs and soil samples taken.

July 12, 1964

Permanent markers were placed. Transects of vegetation carried out. Collection No. 2089, C.R.Long. Assisted with the banding of masked boobies and red-footed boobies.

July 13, 1964

Vegetation information was gathered and permanent markers were placed.

Enderbury Island

July 15, 1964

Collected the west side of the island. Collection No. 1990 - 2010

C.R. Long.

C.R. Long
1964

Phoenix

Phoenix Islands - A preliminary List of Plants Collected by C.R. Long
June - July ATF, 1964

Hull Island July 8 and 9

- 1 Portulaca lutea Sol.
- 2 Portulaca oleracea L.
- 3 Mimosa sensitiva
- 4 Mirabilis jalapa L.
- 5 Boerhaavia diffusa L.
- 6 Euphorbia prostrata Ait.
- 7 Pedilanthus sp.
- 8 Euphorbia hirta L.
- 9 Carica papaya L.
- 10 Pandanus sp.
- 11 Morinda citrifolia L.
- 12 Cocos nucifera L.
- 13 Cynodon dactylon (L.) Pers.
- 14 Fimbristylis sp.
- 15 Centhrus echinatus L.
- 16 Eragrostis amabilis (L.) W. and A.
- 17 Fleurya ruderalis (Frst.) Gaed. (Observed by C.D. Hackman)
- 18 Messerschmidia argentea (L.f.) Johnston
- 19 Cucurbitaceae
- 20 Truimfetta procumbens Forst.

Phoenix Island July 10, 11, 12, and 13

- 1 Sesuvium portulacastrum L.
- 2 Boerhaavia diffusa L.
- 3 Sida fallax Walp.
- 4 Portulaca lutea Sol.
- 5 Lepturus repens (Forst.) R. Br.

Vascular plants recorded from Phoenix Island

by C. R. Long

checked
against McBees -
all accounted
for.

Gramineae

Lepturus repens (Forst.) R. Br.
E. H. Bryan, Jr. 16 (BISH), C. R. Long 2078, 2079, 2079a,b,
2086, 2099, 2615, 2623 (UH).

Nyctaginaceae

Boerhavia sp.
E. H. Bryan, Jr. 17 (BISH), C. R. Long 2077, 2081, 2083,
2087, 2612, 2622 (UH).

Aizoaceae

Sesuvium portulacastrum var. *griseum* Deg. and Fosb.
E. H. Bryan, Jr. 19 (BISH), C. R. Long 2083, 2088, 2625
(UH).

Portulacaceae

Portulaca lutea Sol.
E. H. Bryan, Jr. 18, C. R. Long 2624 (UH).

Malvaceae

Sida fallax Walp.
C. R. Long 2077, 2079, 2080, 2089, 2614, 2634 (UH).

Vascular plants recorded from Phoenix Island

by C. R. Long

Five species of vascular plants have been collected from Phoenix Island. All of these species are considered native. Vascular plant collections have been made by the following: E. H. Bryan, Jr., March 1924; C. R. Long, July, 1964, and November

Gramineae

Lepturus repens (Forst.) R. Br.

Bryan 16 (BISH), Long 2078, 2079, 2079a,b, 2086, 2099, 2615, 2623 (UH). The common bunchgrass found in sand of beach rim or sandy soils of the inner slopes. Lush stands are found at base of slopes just above the lagoon on the east and south sides. Plants with stolons common in these sites. Stems often covered with salt crystals.

Nyctaginaceae

Boerhavia repens L.

Bryan 17 (BISH), Long 2077, 2081, 2083, 2087, 2612, 2622 (UH).
(as B. tetrandra)

Pink and white flowered forms present. This species is common in sandy soils particularly in sand pockets of coral rubble. Often found with Lepturus and Portulaca.

Aizoaceae

Sesuvium portulacastrum var. griseum Deg. and Fosb.

Bryan 19 (BISH), Long 2083, 2088, 2625 (UH). This succulent herb forms a nearly continuous mat around the edge of the lagoon. Flowers white or off white. The mats are often the site of bluefaced booby nests.

Portulacaceae

Portulaca lutea Sol.

Bryan 18 (BISH), Long 2624 (UH). Common on the south end in coral gravel and with Lepturus and Boerhavia over the island.

Tiliaceae Triumfetta procumbens Forst. f. / Mentioned by Bryan (1942) as present on the east side of the island. Not found in 1964.

Malvaceae

Sida fallax Walp.

Long 2077, 2079, 2080, 2089, 2614, 2634 (UH). This species forms upright stands on the N side. Used as a nesting site by lesser frigatebirds on west side in 1964. On the S and SE end this normally upright herb is prostrate where it is rooted in coral rubble and exposed to the constant wind from that direction.

C.R. Long
1964

Soil Samples - June-July 1964

Phoenix

- July 11, 1964 Phoenix Island
(5) L199-L203
L199 - 1 1/2-2 in. Lepturus, Portulaca
L200 - 2 Sesuvium 1/2-2 in.
L201 - 3 Lepturus, Portulaca Nesting Sooty Terns
L202 - 4 1/2-2 in.
L203 - 5 1/2 - 2 in. Sida patch - mid north part of island
- July 12, 1964 Phoenix Island
(3) L204-L206
L204 - 1 Algal layer 1/2 in. deep lagoon. Lepturus stand at edge of lagoon (with a narrow strip of Sesuvium at edge between the grass and the bare surface of the lagoon.
L205 - 2 1/2-2 in. windblown soil around slab rocks.
L206 - 3 1/2-2 in. Lepturus South end.
- July 13, 1964 Phoenix Island
(3) L207-L209
L207 - I Sesuvium mat - dry, open area (0.5-2 in. layer), many roots present; soil dark brown.
L208 - II Soil accumulation under coral rock slab. Windblown mineral matter; dried organic (Lepturus, Portulaca) - crab burrows along edge of rock.
L209 - III Bare soil surrounded by Portulaca and Lepturus. Gravel at surface 0.5 in. (0.5-2 in. layer)
- July 15, 1964 Enderbury Island
(1) L210
L210 Eragrostis, Sesuvium 1/2-2 in.
- July 16, 1964 Enderbury Island
(4) L211-L214
L211 - 1 1/2-2 in. Portulaca, Boerhaavia, Lepturus west side of lagoon.
L212 - 2 Portulaca, Boerhaavia gravel top, fine beneath, northwest end.
L213 - 3 top 1/2 in. Cordia grove west end.
L214 - 4 1/2-2 in. Cordia grove west side
- July 17, 1964 Enderbury Island
(2) L215-L216
L215 - 1 South end Eragrostis sp., Sesuvium sp. soil 6 in. deep 1/2-2 in.
L216 - 2 Cement floored storage house - hermit crab accumulation.
- July 18, 1964 McKean Island
(7) L217-L223
L217 - 1 Under Sida, Sesuvium 1/2-2 inches
L218 - 2 1/2-2 in. under dead Sesuvium nest of masked booby
L219 - 3 1/2-2 in. bare lagoon dry on top
L220 - 4 Boerhaavia, Digitaria near beach, 1/2-2 in.
L221 - 5 1/2-1 in. rock area gravel on top south end
Boerhaavia, Sesuvium
L222 - 6 1/2-2 inches: Digitaria, Portulaca, Boerhaavia
L223 - 7 Sida, near old guano ruins 1/2-2 in. nesting sooty terns