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Plans of Protection Forests and Farm Forests in developing the Agriculture of Iriomote Island

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Contents

I. Introduction

As a part of the reseach activities for the Japan-U.S- sponsored consolidated development program for the Iriomote Island, anagricultural investigation was conducted from 1960 to 1961. This is the report of the survey concerning the protection forests and farm forests plan.

(1) Outline of the Island.

This Island is located 432 km. south-west of the main Ryukyu Island, 182 km. north-east of Formosa, 24°15′—25′ north latitude and 123°40′—55′ east longitude. It is reportedly about 75 km. round, and covers an area of 29, 250 ha. According to the conventional statistics, the Island consists of the government-owned land 90 %, town-owned land 5 %, and private-owned land 5 %. The 85 % area of the Island is occupied by the national forest.

The Island is a diamond-shaped island with her east-west side 30 km, and north-south 20 km. Along its long axis, there is a range of mountains including Mt. Komi (470 m high), Mt. Yae (428 m), Mt. Tedō (442 m), Mt. Hateruma (447 m), Mt. Goza (420 m), Mt. Haigishi (425 m). Among these mountains, the largest Urauchi River flowing to the north, the Nakara, Kuira and other Rivers flowing in to the East China Sea, the Nakama River on the southern slope, and the Maera, Shiira, Aira Rivers flowing in to the Pacific. So the topographical condition of the Island is mainly characterized by many mountains and little plains. The river sourse rigions are rather flat, and the lower courses of the V-shaped valleys sink, being affected by the seawater.

The geological condition is characterized by the fact that the most part of the Island layers are made of the sond-stones of Yaeyama coal measures. And the paleozoic strata scattered over some north-east part of the Island. Out of some edges of these paleozoic strata, the agglomerate or tuff of andesite crop

up. The lower stepped slopes on the coast are generally edged with the rising coral-reefs, which crop out of the surface of the stepped sloped and form an undulation.

The soil of the Island is mostly the weathered sandstone of the tertiary period, and secondary the weathered soil of the clayslate, andesite and their agglomerate. The weathered soil of the rising coral-reefs is found on a small range in various places. As the surface layers of the soil of the Island are sandy and high in acidity. But the lower layers are humus soil and extremely viscous. Because of their poor water permeability, they are immediately solidified, if they are dried.

The annual average temperature is 23.3°C. As for the monthly average, the minimum is 17.4°C in January, while the maximum is 28.7°C in August. In the mountain area, it rains more than in the plain area, where there is, however, a slight difference between the east and west regions in the rainfall. The yearly rainfall in the west region is about 2,630 mm. The min. number of the rainy days per month is 16, while the max. is more than 20. The min. monthly rainfall is 167 mm, while the max. is 304 mm. Thus there are few clear days and many cloudy days. No less than typhoons hit or approach the Island in July to September, but in as eary as May and in as late as November. On the other hand, the north-east monsoon is so strong in October to March. Its max. speed is sometimes not less than 18 m.

(2) Forests in Reclaimed Land

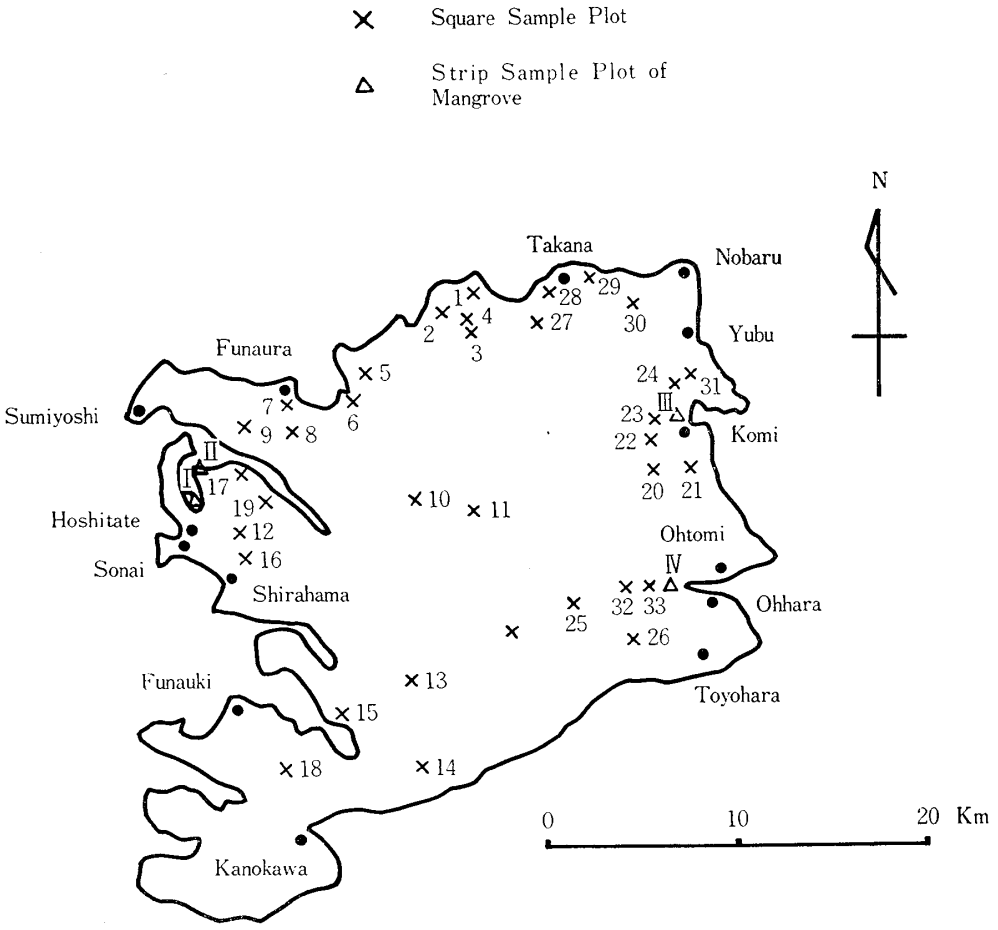
i) Stand Composition

As already mentioned,[33] the forests of Iriomote Island can be generally divided into two classes, tropical forests and sub-tropical forests, the former being further divided into three classes, mangrove, coast xerophytes forests and tropical hardwood forests. As the areas of tropical forests and grassland generally lie along the coast or in low land along rivers, they have a comparatively favorable site condition for this Island. For this reason, many available trees of the forests in these areas were cut down tn the past, and the remaining trees are small in diameter, while very few of them can be utilized as good form timber. As good form timbers suitable for furniture or construction materials in the subtropical forests of the areas which are comparatively high in altitude have been cut down for long years, there are comparatively few big trees that are good in quality, but they are bigger in diameter than those in tropical forests. There is a fairly great deal of growing stock which can be utilized as useful timber, when transportation facilities are completed.

Generally speaking, in this Island there are many evergreen broad-leaved trees which easily regenerate naturally. Therefore most of the forests are dense forests of many storied forest type, and their growth is extremely rapid, and the average increment amounts to 10 m^3 per ha. Accordingly, the appearance of forests can rapidly improved by intensive tending work. But on account of frequent strong winds caused by typhoons and the monsoon, there is a fault that trees in this Island, except in valleys or sunken places, are generally low in height and their branches are spreading. The positions of sample-plot estimates of our present investigation which were carried out in the areas to be developed and the stem number and volume by d. b. h. class

are shown in Fig. 1 and Table 1 respectively.

Fig. 1. Positions of Investigated Sample Plot (Iriomote Island)



According to this investigation as forests of the reclaimed areas for agriculture in the circumferential area of the Island have a great number of trees, but few gross diameter ones, the volume of timber per ha amounts to only 80~200 m^3, and in the case of mangrove, it is even less, say, about 30~70 m^3. On the contrary, forests on the elevated ground near the center of the Island have a small number of trees, but comparatively many large diameter ones, the volume of timber amounting to 190~379 m^3 per ha.

ii) Nature of Tree Species

Tree species in the forests of reclaimed areas can be classified as follows, trees to be cut down at the time of reclamation and those to be reserved for farming and protection. The former depends upon the value of utility and difficulty of development, while it is important to investigate the condition of standing trees and the nature of tree species with regard to the latter. Dualities of main tree species which are regarded as important in making farm forests, forests for salt spray control, shelterbelts or buffer strips are comprehensively shown in Table 2,[3)4)5)6)] their details being described later.

Table 1. Data of Sample-plot.

No. of Sample plot	aera actually measured	Compartment (Forest)	Number of trees of Sample plots by diameter and their volume of timber per ha									
			4—10 cm		12—20 cm		22—30 cm		Over 32 cm		Total	
			No. of trees	Volume	No. of trees	Volume	No. of trees	Volume	No. of trees	Volume	No. of trees	Volume m^3
1	m^2 20×20	103c	5375	57.16	800	47.93	100	17.65			6275	122.74
2	10×10	town F.	3900	50.39	1300	67.70					5200	118.09
3	20×20	103a	3500	49.76	900	91.63	50	14.35	50	43.48	4500	199.22
4	20×20	103a	3825	50.82	425	39.33	100	21.93	100	70.83	4450	182.91
5	10×10	104b	5400	72.10	200	10.00					5600	82.10
6	20×20	106b	2625	32.22	450	35.33			50	116.25	3125	183.80
7	10×10	108c	7300	77.60	900	56.00					8200	133.60
8	10×10	108c	5400	59.87	500	41.70					5900	101.57
9	10×10	2a	4400	44.37	900	55.00	200	49.00			5500	148.37
10	20×20	8a	1750	18.90	650	63.15	75	20.43	175	226.08	2650	328.56
11	20×20	9a	1650	17.25	500	51.98	75	16.38	100	101.98	2325	187.59
12	20×20	38a	2475	16.91	675	55.18	400	99.35	75	31.90	3625	203.34
13	20×20	50a	3275	27.33	500	50.85	125	39.38	125	140.28	4025	275.84
14	20×20	58b	2500	21.30	425	32.73	175	71.70	100	104.05	3200	229.78
15	5×10	56c	5600	72.80	1000	68.20					6600	141.00
16	10×10	39a	3800	38.79	1100	102.40	100	32.40			5000	173.59
17	20×20	36c	3450	33.71	875	62.93	175	46.55	75	54.55	4575	197.74
18	20×20	61a	3825	42.45	700	55.33	75	22.18	75	54.40	4675	174.36
19	14×15	38a	3476	46.02	477	30.10	95	26.14	48	27.52	4096	129.78
20	20×20	91a	3350	36.55	700	44.80	25	5.03	25	10.85	4100	97.23
21	20×20	88b	4200	51.19	1125	60.48	25	6.95	25	13.20	5375	131.82
22	10×10	94a	7700	75.10	1800	104.00	100	18.90			9600	198.00
23	10×10	96a	4200	46.43	1200	64.00					5400	110.43
24	20×20	97b	4375	46.78	1350	76.93	125	27.03			5850	150.74
25	20×20	84a	5700	46.54	950	72.20	25	4.55			6675	123.29
26	10×10	73b	5700	53.98	900	43.90					6600	97.88
27	10×10	101b	2300	25.35	700	51.30					3000	76.65

28	10×10	town F.	8100	75.48	700	40.10					8800	115.58
29	10×10	〃	6500	49.10	1000	49.80					7500	98.90
30	20×20	99b	2550	25.85	825	46.75	150	28.20			3525	100.80
31	20×20	98d	3675	38.00	800	45.80	50	8.35			4525	92.15
32	10×10	85a	6600	68.92	400	20.30					7000	89.22
33	10×10	86a	6700	68.06	300	19.00					7000	87.06
34	20×20	83a	2075	27.04	325	28.08	50	17.20	175	297.60	2625	369.92

(Mangrove)

No. of strip	area actually measured	Position	Number of trees by diameter per ha and their volume									
			4—10 cm		12—20 cm		22—30 cm		Over 32 cm		Total	
			Number of trees	Volume	Number of trees	Volume	Number of trees	Volume	Number of trees	Volume	Number of trees	Volume m^3
I	m^2 2×252	Hoshi-tate	4464	25.79	60	4.50					4524	30.29
II	1×100	Urau-chi	12400	40.25							12400	40.25
III	1×86	Shiira	12790	75.72							12790	75.72
IV	1×233	Naka-ma	10429	74.12							10429	74.12

(3) Plans of Protection Forests and Farm Forests.

An afforestation plan of farm forests and protection forests and a plan of cutting trees in the areas to be developed have been made, along with the determination of areas to be developed as well as the investigation of the composition of forests.

By making as many reconaissances as possible and judging from aerial photographs, forests, grassland, areas to be reclaimed, cultivated land and villages were lotted on a scale: 1—10,000 map, and thus where to make forests for salt spray control, shelterbelts, farm forests was determined, by taking the geographical features and the road construction plans into consideration. Their positions and sizes, and necessity of new afforestation were shown on the map.

The total area under the plan, calculated from the map area shown by blank area and wooded area in Table 3.

Note: (1) Additional areas are roads, canals and etc.
(2) National forests outside the area means forests outside the developed area.

As the total area under the agricultural plan amounts to 14,203 ha, proportion of developed areas and their additional areas, meadows, farm forests, forests for salt spray control and shelterbelts to the total area are respectively 48%,

Table 3. The Total Area under the Plan.

(ha)

Kind of Area	Developed areas and their additional areas (1)	Grazing land	Farm Forests	Forests for salt spray control	Shelterbelts	Protection Forests (for erosion control)	
						In Farm Forests	National Forests outside the area (2)
wooded area	3,609	380	4,986	360	690	240	1,560
blank area	3,167	271	—	180	460	—	—
Total	6,776	651	4,986	540	1.150	240	1,560

5%, 35%, 4%, and 8%. Though the proportion of farm forests is relatively large in view of an agricultural development plan, its detailed explanation will be given later. Many national forests outside the area to be cleared for farming are intended to be special protection forests. They are forests for erosion control as well as for salt spray control and so on, which require severe prohibition of cutting trees in order to protect the security of reclaimed areas. With regard to other areas of the forestry plan, all the national forests in the areas along upper waters of rivers that flow down through developed areas require reasonable forest managment as forests for headwater conservation or forests fore debris control.

II. Protection Forests.

Because of its locality of Iriomote Island, it is very frequently attacked by typhoons and gales caused by the monsoon. Therefore, it is very important to consider how to protect agricultural products against salt spray damages and wind damages, in developing agriculture of this Island. Moreover, in view of the nature of soil, geographical features and rainfalls there, proper measures must be taken to conserve headwater as well as soil.

Accordingly in this plan, for the purpose of preventing and alleviating damages caused by these natural factors to farms and settlements, emphasis was put on completion of forests for salt spray control (preventive forests against salt damage) and shelterbelts, because they are protection forests which bear directly upon reclamation and farming. Furthermore, how forests for headwater conservation, forests for debris control and forests for erosion control should be was taken into consideration, too.

(1) Forests for Salt Spray Control.

i) Position, Width and Area

As this Island is surrounded by coral-reefs, damages by tidal waves are concoivably impossible, but it is necessary to make forests for salt spray control

Table 2. Nature of Main Tree Species

Tree Species	Scientific Term	Order		Afforestation	Remarks
		Saltspray rancetole	Wind tolerance		
Ryukyumatsu	*Pinus luchuensis* Mayr.	Special 1	Special 1	Sowing	Planting in the sands is difficult; timber for general usc, for pulp.
Inumaki	*Podocarpus macrophyllus*, D. Don.	3	3	Planting, sowing	Suitable for shading intolerant species; timber (termites tolerant)
Moku maō	*Casuarina equisetifolia*, J. et. G. Forst	1	3	Planting	Suitable for sands, rapid growth; material for pulp; fire-wood, liable to break, but strong regeneration.
Fukugi	*Garcinia spicata*, Hook. f.	Special 1	Special 1	Sowing	slow growth; most suitable tree species; timber (termites tolerant)
Teriha boku	*Calophyllum Inophyllum*, L.	1	1	〃	Suitable for sands; suitable for half way down a hillside; comparatively rapid growth.
Adan	*Pandanus odoratissimis*, L. clerke. *var. liukinensis* Kanehira	1	Special 1	Cutting	Suitable for seaside areas
Birō	*Livistonia chinensis*, R. Br.	1	1	Planting, sowing	Slow growth; timber
Ryukyu akatetsu	*Sideroxylon liukinense*, Nakai	1	1	Sowing	Rapid growth; timber
Sakishima suō	*Heritiera littoralis*, Alt.	1	1	〃	rapid growth; suitable for damp land; timber
Akagi	*Bischofia javanica*, Blume	2	2	Planting, sowing	rapid growth; spreading branches; timber
Kobatéisi	*Terminalis Catappa*, L.	2	2	Sowing	windbreak,
Gajumaru	*Ficus retusa*, L.	1	1	Cutting	rapid growth; firewood
Sōshiju	*Acacia confusa*, Merr.	3	3	Planting	rapid growth; fire-wood.
Iju	*Schima liukinensis*, Nakai	2	2	Sowing	unsuitable for sands; timber (termites tolerant)
Taiwan Ogatamanoki	*Michelia compressa*, Sarg.	4	4	Planting, sowing	Many trees of this species are found in steep mountain regions.
Isunoki	*Distylim racemosum*, S. et. Z.	4	2	Sowing	slow growth; timber; firewood.
Okinawa shii	*Shiia Wspidate*, Makino. *var. lutchuensis*, Masamune.	3	4	〃	rapid growth; suitable for mountain regions; timber, pulp.
Okinawa Urajirogashi	*Quercus Miyagii*, Koidz	4	2	〃	Numerous in mountain regions; timber; pulp, firewood
Tabu	*Machilus Thunbergii*, S, et. Z.	4	4	〃	Numerous in mountain regions; timber; pulp.
Bakuchinoki	*Prunus macrophylla*, S. et. Z.	4	3	Planting, sowing	Shade tolerant.
Urajiroenoki	*Trema orientalis*, Blume.	4	3	Sowing	rapid growth
Sendan	*Melia Azedarach*, L. *var. japonica*, Makino.	4	4	Planting	very rapid growth; timber
Shichiku	*Bambusa stenostachys*, Hack.	1	1	Cutting	suitable for windbreak.
Gin nemu	*Acacia Farnesiana*, willd	1	2	Sowing	suitable for undergrowth of forests for salt spray control and shelterbelts.
Kuroyona	*Pongamia glabra*, Vent.	1	2	Sowing	rapid growth; timber.
Ōhamabō	*Hibiscus tiliaceus*, L.	1	2	〃	rapid growth: suitable for forests for salt spray control.
Hasunohagiri	*Hernandia peltata*, Meissn.	1	2	〃	〃 〃
Sagaribana	*Barringtonia rascmosa*, Blume.	1	2	Cutting	rapid growth; suitable for damp land; suitable for forests for salt spray control.
Kusatobera	*Scaevola sericca*, Forst. f.	1	2	Sowing	rapid growth; suitable for forests for salt spray control.
Butsusōge	*Hibiscus Rosa—sinensis*, L.	2	2	Cutting	Windbreak; scenic beauty.
Akariha	*Acalypha australis*, L.	2	2	〃	〃 〃

in order to protect against storms and briny winds.[8] Particularly because most to the agricultural areas to be reclaimed according to this plan lie in low circumferential parts of the Island, farmland to be developed must be protected against briny winds and storms, by establishing forests for salt spray control around the farms all along the coastline.

The most suitable width of a forest for salt spray control should differ according to its site condition and stand composition, and therefore it is necessary to determine it area by area, in due consideration of the following respects.[9][10]

(a) Directions of storms and main winds and conditions of blasts.

(b) Directions of coast-lines and their bending conditions; particularly the difference between the point of a promontory and the part surrounded by the promontory.

(c) Condition of coral reefs in front of the coast, and existence of islets or peninsulas.

(d) The nature of soil and other conditions of the area where a forest for salt spray control is made. Whether the land consists of gently sloping sand dunes, dikes made by reclamation, or ground full of ragged rocks.

(e) Geographical feature and area of the land to be protected and natural feature of the hilly district behind the land.

(f) Tree species, stand composition, tree height and regeneration method of forests for salt spray control.

(g) Kinds of crops in the culivated land.

After studying the results of reconnaissances and investigations by hearing, and the clearing and farming plans as mentioned above, width of forests for salt spray control in respective places was decided, in anticipation of tree species of anti-salt spray forests to be mentioned later and their regeneration method.

According to this plan, there are two kinds of areas, one being a blank area where a forest for salt spray control is to be newly made by afforestation, and the other an area where an existing forest is utilized as a forest for salt spray control. Existing forests consist of remaining natural forests and forests of *Casuarina equisetifolia* or *Pinus luchuensis* which were artificially afforested to control salt spray. The average height of these trees is 5~10 m. Therefore, if a management method to keep the height of trees of coming forests for salt spray control so high is introduced, the most suitable width of a forest for salt spray control to be planned is thought to be 10~20 times as high as the average.[10] Width of forests for salt spray control of this plan has been adjusted according to the present condition, while the standard width is 50~200 m. When the total area of the projected forests for salt spray control is calculated from this plan, 360 ha of the existing forests in utilized, and further 180 ha of new afforestation is necessary, namely, 540 ha in all.

ii) Tree Species

It is a necessary condition as a matter of course that tree species of a forest for salt spray control must have a great deal of salt spray tolerance and wind tolerance. But at the same time, it is important not only that they are of arborescent species that grow tall, but also that they grow rapidly, live long, and are free from damages of insects and diseases and that their regeneration

is easy. If they are of such species as are broadly available, so much the better. As there are no species that can satisfy all these requirements, the following species were adopted in this plan in accordance with respective site condition, after investigating tree species of actual forests firstly of this Island and secondly of the South-West Islands and Formosa, on the basis of nature of species in Table 2 mentioned above.[11)12)]

(a) *Casuarina equisetifolia*, J. et. G. Forst.

Existing forests (which was artificially afforested) for salt spray control in Iriomote Island are mostly of this tree species, and trees of this species are broadly found in the South West Islands and Formosa. They are of an arborescent species strong against winds from the sea, and their seedling cultivation and planting are easy. Therefore they are suitable for sand dune afforestation on the seashore. They are liable to break when a severe storm comes on, but even when they are broken, or the leaves are torn off, they can easily recover themselves by germination. They can be utilized as fuel as well as material for pulp.[12)13)] Though they are shortlived, they grow very fast, and they can be afforested even on poor soil, as they are of a fertilizable species.[14)] For these reasons, trees of this species can be made use of as an emergency method, when it is necessary to make a forest for salt spray control in a hurry. But in the case of using them as an emergency method, it is desirable that because of their defects mentioned above, *Garcinia Spicata* or *Calophyllum Inophyllum* is sowed between planting lines, and that they grow to be a forest for salt spray control after *Casuarina equisetifolia* is cut down. As it is said that it is difficult for trees of this species to grow on heavily acid soil stronger than PH 4.5 (H_2O), attention must be paid when they are planted on reclaimed land of the seashore. As there are various kinds of *Casuarina sp.*[15)] it is necessary to study their characteristics, by comparing them. (See Plate 2.)

(b) *Pinus luchuensis*, Mayr.

This is a climatic species of the South-West Islands and has strong salt spray tolerance and wind tolerance. At Ōhara there is a forest which was artificially made in order to protect against salt spray. Trees of this species grow fast and are in great demand as timber, but it is now difficult to plant seedlings on sand, and so there is no other way than artificial sowing. (See Plate 4.) Though there are some instances where mixed forests of *Schima liukiuensis* and *Acacia confusa* succeeded, mixed forests of such trees as *Garcinia Spicata* and *Calophyllum Inophyllum* which have strong salt spray tolerance, wind tolerance and shade tolerance are more desirable as forests for salt spray control.

(c) *Garcinia Spicata*, Hook. f.

Trees of this species grow in natural forests and are utilized as buffer strips of villages. They have strong salt spray tolerance and wind tolerance, and moreover they can grow even in the shade and are longlived. They are in great demand as timber, too.

They are considered to be the most suitable species as a forest for salt spray control, as their sowing and afforestation are easy. But as they have a fault that they grow very slowly for several years after they are sown, the effect to control salt spray cannot be expected in the case of new afforestation.

Therefore, by sowing this species in a natural forest which is utilized as a forest for salt spray control, or by sowing it in a forest of *Casuarina equisetifolia* or *Pinus luchuensis* for salt spray control, trees of this species can be expected to be a permanent forest for salt spray control in the future. (See Plate 1.)

(d) *Calophyllum Inophyllum*, L.

Trees of this species grow in natural forests, and are broadly utilized as forests for salt spray control, shelterbelts or buffer strips. They grow especially fast on sandy soil of the sershore or in areas of upheaved coral reefs, and they have strong salt spray tolerance and wind tolerance. Their afforestation by sowing is easy, and they regenerate very rapidly, too. In addition, as they grow comparatively fast, while young, and there is a demand for them, they are suitable for a forest for salt spray control.[5] Much can be expected of a mixed forest of *Casuarina equisetifolia* and *Pinus luchuensis* or a naturally regenerated pure forest as a forest for salt spray control. (See Plate 3.)

(e) *Pandanus odoratissimis*, L. Clarke, *var. liukiuensis*, Kanehira.

Trees of this species usually grow wild on the seashore, and have strong salt spray tolerance as well as wind tolerance. But as they area short in height, it is necessary to make use of them, together with the abovementioned arborescent species in order to protect against salt spray control. As afforestation of trees of this species, this is considered to be the most suitable species to protect against salt spray and tidal waves, by making a belt-like forest for salt spray control along the coast and by closing the lower layer of the forest. As natural growth of this tree species is abundantly found on the seashore of the Island, they should be preserved in a belt-like condition along the coast in the case of making a new forest for salt spray control.

(f) Other tree species

Principal tree species of natural forests that grow wild on the seashore were already mentioned in the part of "the vegetation of tropical forests."[33] As most trees of this species have strong salt spray tolerance, they are mostly suitable as a seashore forest.

Some of these natural forests are poor stands whose density was impaired by cutting or fires, but in clearing land it is very important to preserve the most proper width of a natural forest as a forest for salt spray control, because afforestation on the seashore is pretty difficult. These preserved forests for salt spray control should not be left as they are. They should be gradually turned into better forests for salt spray control, consisting of more suitable tree species, by tending work of artificial sowing in the forests. Main constituent tree species other than those mentioned above are such following species as grow wild in existing forests.

Heritiera littoralis. Alt.
Hibiscus tiliaceus, L.
Pongamia glabra, Vent.
Hernandia Peltata, Maissn.
Ficus Wightiana, Wall.
Ficus retusa, L.

Barringtonia rasemosa, Blume.
Scaevola Sericea, Forst. f.
Scaevola Microcarpa, Cav. *var. Taccaba*, Makino.
Sideroxylon lukiuense, Nakai.
Cycas revoluta, Thunb.
Acacia Farnesiana, Willd.
Eurya emarginata, Makino.
Livistonia Chinensis, R. Br.

iii) Treatmont of Forest

Judging from the fact that a forest for salt spray control has much to do with public interests, it is more desirable that it is managed by the government than by a private individual. At any case when the area of a forest for salt spray control is determined, a side ditch should be made along the border of cultivated land. A side-ditch will prevent roots of trees of the forest from extending into the cultivated land and will make the cultivated land drain better, while it will make the border more distinct. It is an earthen waterway whose vertical section is trapezoidal. The standard of treatment of a forest for salt spray control in the case of new afforestation on a blank area and in the case of utilizing an actual forest is respectively described in the following.

(a) New Afforestation

There are two plans of afforestation as shown diagrammatially in Fig. 2, namely a 10 metre wide strip of artificial forest of *Pandanus odoratissimis, var. liukiuensis* and a strip of artificial forest of arborescent species inside the former. As a rule, they are densely afforested by triangular planting, after making preparation in strip or in whole surface, but in the case of afforestation of *Pandanus odoratissimis var, liukiuensis*, it is more effective to plant by cutting, without getting rid of the existing trees in order to protect trees of arborescent species to be afforested inside. When such trees of intolerant species as *Casuarina equisetifolia* or *Pinus luchuensis* is used as arborescent species, it is to be desired in making permanent forests for salt spray control that such trees of tolerant species as *Garcinia Spicata* or *Calophyllum Inophyllum* are sown between planting lines so that they may mix up with the taller trees. Weeding and removal of climbing plants must be carefully carried out every year after afforestation in order to make the trees grow rapidly, and after the artificial forest has become dense, it is important that the trees in the forest are cared for so that they may grow strong and sturdy, by light thinning every several years. Though forests for salt spray control have been usually designated as cutting prohibited forests, it is not advisable to leave them as they are, by prohibition of cutting trees, from the view point not only of economy, but also the effectiveness of preserve forests. By establishing a proper working plan and by improvement cutting as well as regeneration-cutting after determination of a working system and the final age, these forests must be kept in a sound condition. The final age widely differs according to tree species. The age of *Casuarina equisetifolia* is the shortest of all the species mentioned above, that of *Garcinia spicata* being the longest. It is proper that the age of a forest for salt spray control should not be decided from the view point of economy, but it should be decided in consideration of

the age when the salt spray tolerance and wind tolerance of the forest are the strongest. A selection system is the most ideal working system, but as regeneration by selection is difficult in case of a forest of intolerant species there is no other way than to adopt a system of clear cutting in alternate strips by dividing forests for salt spray control along the seashore into two or three strips just as A strip and B strip show diagrammatically in Fig. 2.[17]

Fig. 2. Diagram of Afforestation for Salt Spray Control.

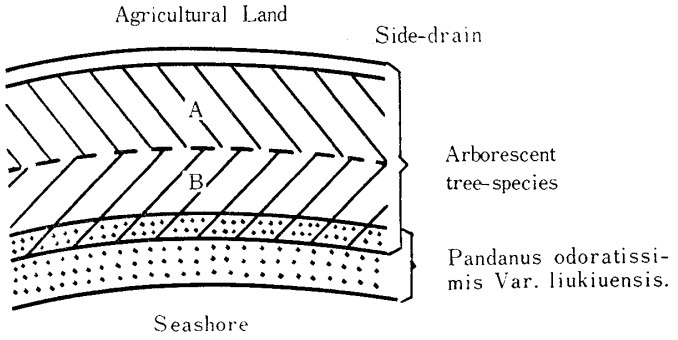
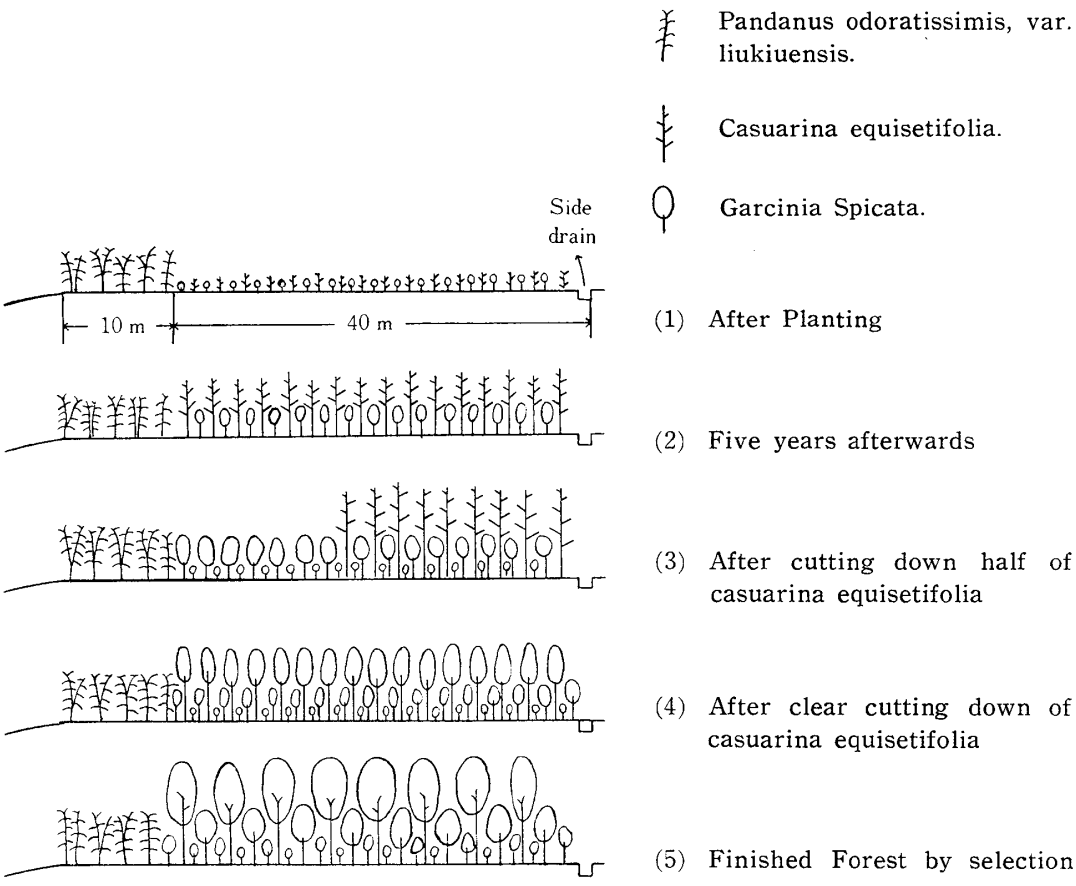


Fig. 3. Sectional Diagram of Forest for Salt Spray Control.



But when a forest for salt spray control of such tree species rich in shade tolerance as *Garcinia spicata* or *Calophyllum Inophyllum* has been completed, it will be possible to raise the effectiveness of the forest, keeping regeneration by means of single tree selection or group selection. In order to explain the purpose of treating a forest for salt spray control clearly a process to make an ideal forest for salt spray control is assumed, with making use of *Casuarina equisetifolia* of intolerant species and *Garcinia spicata* of tolerant species, as shown diagrammatically in Fig. 3.

(b) Utilization of Actual Forests

As it requires more than several years to make a new forest for salt spray control and to be able to expect effective control over salt spray, it is intended to foster gradually strong forests for salt spray control, by conserving natural forests that are growing on the seashore or artificial forests for salt spray control, as well as by after culture or tending work. It is all the same with the case of new afforestation, concerning treatment. In other words, the standard system is that strips 10 m wide along the seashore shall be left as they are, and that in cleared areas trees of *Pandanus odoratissimiss var. liukiuensis* shall be after-cultured. With regard to natural forests inside them, preparation in strips is made by weeding lower vegetation in the forests, and such salt spray tolerant species as *Garcinia Spicata* and others rich in shade tolerance are sowed there. Thus it is expected of this plan that a sound forest of salt spray control in gradually made by tending work and light selection cutting. Concerning artificial forests to control salt spray consisting of *Casuarina equisetifolia* and *Pinus luchuensis*, they should not be allowed to take their own course, but *Garcinia Spicata* or *Calophyllum Inopopllum* should be sowed. Thus it is desirable to maintain effective control over salt spray by regenerating trees with a system of clear-cutting in alternate strips several years afterwards.

(2) Shelterbelt

i) Position and Space.

It is regarded as an important requirement to complete shelterbelts for agricultural development of Iriomote Island, because this Island is visited by not only typhoons but also strong winds caused by the monsoon on account of its geographical position. When it blows always in a definite direction, a shelterbelt is established generally at a right angle to the main wind. On this Island, however, it blows in various directions according to time and place. Therefore, in the case of shelterbelts in developed areas for agriculture, basic shelterbelts surround the cultivated areas are to be established in a net-like from.[19)20)] But as most of the developed areas are rugged, complicated and hilly, it is difficult to determine uniformly the position where shelterbelts are established. For this reason, where to establish a shelterbelt was put under review with regard to each area by investigating the following points.

(a) Topographical research of developed areas, by judging from reconnaissances and aerial photographs.

(b) Topographical features which cause convergence blowing up or blowing down of wind.

(c) Directions of flow and bending conditions of rivers and mountain streams.
(d) Observation of fallen trees, slanting trees, slanting trees and tree forms.
(e) Investigation of directions of storms in the past, by means of hearing.

By putting these items together, places which are subject to storms, convergence of winds, blowing up or blowing down of wind were determined. Upon the basis of these determinations, wind breaks were planned to be establish in a net-like form, mainly on tops of mountains and other eminent places, or along planned roads, waterways and rivers. While on the other hand, shelterbelts shall be so widely apart from each other that the utmost effects on cultivated land can be obtained. Though many reports on this effective space have been made,[21)22)23)24)] most of them regard the space about twenty times as wide as the height of shelterbelt as the limit of effectiveness. It is improper of course to adopt this width as the only standard, because this numerical value should differ according to the nature of wind, topography, structure of shelterbelts and kinds of crops. With regard to Iriomote Island, however, there are no such data of experiments or investigations. The space between shelterbelts must be determined by developed area on the basis of this numerical value, taking the above mentioned items of (a)~(e) into consideration. As the mean height of the shelterbelts of this plan is generally 10~15 m, differing a little according to places, the space between basic shelterbelts was determined to be more or less than the standard width of 200~300 m, according to the present condition of respective place.

ii) Width and Area.

According to the results of the former experiments of the effects of shelterbelts on protection against wind,[22)23)] if the stand composition of forests is not injured by a storm, their width is not always an important factor, but it is rather significant to turn strong winds upward or to lessen the speed of winds by means of solidity and elasticity of stand composition. From this view point, it is said that it is far more effective to establish an intermediate shelterbelt or a buffer strip before and behind a shelterbelt than to make the width of shelterbelt too large, for the purpose of alleviating damages by stoms.[23)] But as it is conceivable that part of a shelterbelt is broken by a storm, a shelterbelt must be so wide that protection against wind can be effectively expected from the remaining trees in such a case. Moreover, shelterbelts must be so wide that a plan of cutting and regeneration can be carried out in order to maintain the effects of the shelterbelts permanently. (See Plate 5, 6.)

From this view point, what tree species to be selected, how to manage forests and where to establish buffer strips were taken into consideration, as is described later, and than a plan was made on the basis of the minimum standard width of 20 m. But shelterbelts on main mountain ridges which are unfavorable in view of their site condition and are supposed to be necessary for the purpose of protecting against winds should be 40 m wide as a rule. This standard width cannot always be said to be too large, judging from strong storms to be experienced in Iriomote Island. But as a shelterbelt is established at the sacrifice of part of suitable land for agriculture, intensive management

of shelterbelt is necessary to cxpect the maximum effects from the minimum area. When the total area of shelterbelts is calculated from this Plan shelterbelts made of actual forests amount to 690 ha, which those to be newly afforested cover 46 ha, thus making 1150 ha in total.

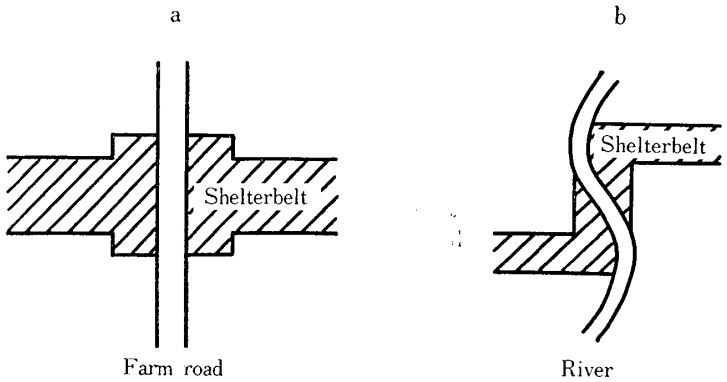
iii) Determination of Site.

As shelterbelts are established on farmland in a netlike form, their total planned length amounts to 525 km, and it is not easy to manage and maintain them. Moreover, as they are considered to be extremely important public facilities for farming in this Island, national management of these forests is more preferable than private management. At any rate, when the position of basic shelterbelts, space between them and their width have been decided, borders of sites must be concretely determined in the execution plan. Therefore important matters to be considered are described in the following.

(a) In the site of a shelterbelt, sideditches are necessary. A side-ditch which is good for drainage and prevents roots of trees from entering farms is made on each side of a shelterbelt serves as well to make the border clear.[25] It is desirable to establish shelterbelts along roads, waterways, ditches for irrigation and drainage, rivers and mountain streams, or cliffs so that effects to protect against winds may be improved, by reducing the shade caused by forests to farms, and by making control and maintenance of forests easier.[21] But in this case there is no need of making ditches along the border of shelterbelts. A side-ditch should be designed so that water may flow down in a definite direction, and it should be an earthen waterway of trapezoidal section.

(b) In the case where roads, waterways, rivers or mountain streams cross a shelterbelt, it is very probable that a storm blows through these parts, causing damages to the shelterbelt.[26] For this reason, it is necessary to prevent these damages, by afforesting strong wind tolerant tree species and by making the width of forest sufficiently large as diagrammatically shown in Fig. 4.[27]

Fig. 4. Diagram showing how to strengthen a Shelterbelt.



iv) Tree Species.

Tree species of a shelterbelt must be physically as well as biologically strong in wind tolerance, and must be of arborescent species, grow rapidly and live long. In addition, it is necessary that they regenerate easily and are not subject to damages of diseases and insects. If they have high value of use when they are cut down, so much the better. But as it is very difficult to find

such tree species as have all of these qualities, in this plan arborescent tree species rich in wind tolerance were adopted, after investigating climatic species and imigrated species growing on this Island. As it can be considered that tree species growing in actual forests are suitable for the site condition, the most suitable tree species of them in view of respective site condition should be selected when a shelterbelt is newly afforested. Main tree species for a shelterbelt are cited in the following.

Garcinia Spicata,
Calophyllum Inophyllum,
Pinus luchuensis,
Casuarina equisetifolia,
Ficus retusa,
Livistonia Chinensis,
Cycas revoluta,
Sideroxylon liukiuense,
Heritiera littoralis,
Bischofia javanica,
Terminalia Catappa,
Schima liukiuensis,
Distylium racemosum,
Quercus Miyagii,
Bambusa Stenostachys,
Cinnamomum Doederleinii,
Ternstroemia japonica,
Trochodendron aralioides,

Moreover, in the case of conserving a natural forest as a shelterbelt, other tree species than those mention above can be used for a shelterbelt. But there are not a few trees that are poor in wind tolerance or shade tolerance, many shrubs and climbing plants. After conserving them as a shelterbelt, they must be gradually supplanted with superior tree species, by tending work.

v) Treatment

It is difficult to decide how manage a forest uniformly, as a site condition of shelterbelts to be afforested differ greatly from one another. But a general standard of treatment of forest will be shown below with regard to two cases, namely, when a blank area is afforested and when an actual forest is made use of.

(a) New Afforestation.

When a shelterbelt is established newly in grassland, cultivated land or reclaimed land, it should be afforested densely by means of triangular planting, after careful preparation of soil.[1] In the case of planting such intolerant tree species as *Casuarina equisetifolia* or *Pinus luchuensis* in order to attain the effects of wind tolerance in a short time, it is preferable in afforesting a permanent shelterbelt in the future that other shade and wind tolerant trees are planted between planting lines. Where roads, waterways, rivers, or mountain streams cross a shelterbelt, the stand composition is liable to be destroyed by a storms. In such a case, such species of strong wind tolerance as *Garcinia spicata, Livistonia chinensis, Plandanus odoratissimis,* or *Washintonia* had better be planted. (See Plate 7. 8.)

After afforestation, growth will be hastened by weeding and removing climbing plants. When the forest has become dense, upper storey trees must be lightly thinned every several years in order to grow strong trees. A shelterbelt is usually designated as a cutting prohibited forest, but it not only weakens its wind tolerance but also is undesirable from the economical point of view to prohibit cutting. It is important to keep a shelterbelt strong and healthy by means of regeneration cutting, after determining the most suitable working system and final age. Selection cutting is an ideal working system. As a

shelterbelt is not so wide, the sunshine enters not only from above, but also from the side of forest. Therefore trees of wind and shade tolerant species can be considered to be regenerated by selection cutting. But when fast growing trees of intolerant species were utilized in making a shelterbelt, wind resistant trees of tolerant species must be planted in the forest, without, fail, and by cutting upper storey intolerant trees in future, they must be gradually turned into a permanent shelterbelt consisting of shade tolerant trees which can be regenerated by selection cutting, in other words, the stand composition of a shelterbelt must be of a multi-storeyed type of forest, where there are always regenerated trees of wind resistant species in the lower storey.

(b) Utilization of an actual Forest

As it requires more than several years at least until effects of a newly afforested shelterbelt can be expected, it is intended in this plan that natural forests existing in cultivated farmland where a shelterbelt is scheduled to be established are to be conserved as they are, and then gradually turned into strong shelterbelts by intensive tending work or after-culture. Therefore this shelterbelt consists of naturally growing trees, but the idea of treatment is all the same as in the case of new afforestation. The standard method of treatment is to supplant gradually trees of such species as are not suitable for a shelterbelt by superior tree species, and thus to make a forest of multistoreyed type, which can be regenerated by selection cutting. As there are usually many shrubs, climbing plants and other inferior tree species in a natural forest, seeds of superior wind resistant species, for example, *Garcina spicata*, or *Calophyllum Inophyllum* must be sowed after preparation in strips, when there are no suitable regenerating trees.

The method of utilizing an actual forest as a shelterbelt has the following advantages; it can serve as a shelterbelt at the same time of reclamation and the cost of establishing a shelterbelt can be economized. But on the other hand, it is necessary to note that trees on the edge of remaining shelterbelt are liable to death or wind damage on account of a sudden change of circumstances, and that they are liable to injury by mistake or on purpose at the time of development.

(3) Windbreaks (Fences for wind control)

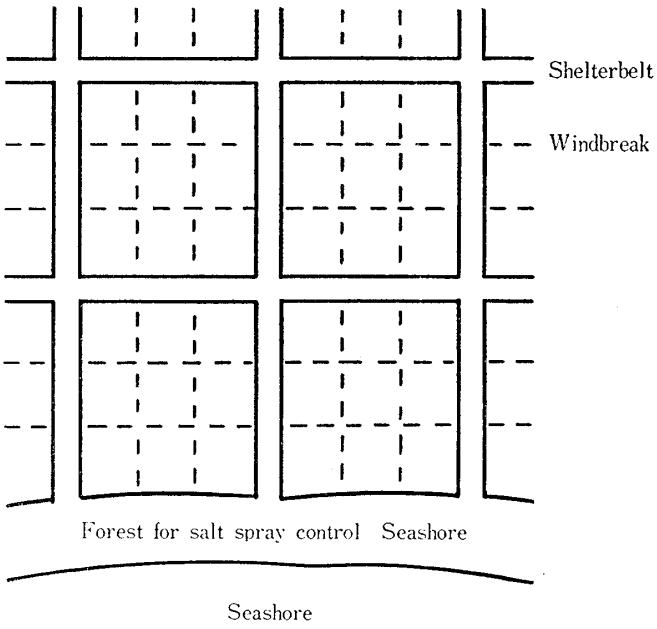
When a cultivated area is surrounded by completed basic shelterbelts which were planned throughout the developed land, there is far less danger of wind damage to crops. But as this districted is frequented by strong storms, it is necessary to further reinforce the facilities to protect against wind according to kind of crop.

The results of experiments[22)23)] about shelterbelts in cultivated land show that it is possible to turn a strong wind upward or to slow down the velocity of wind, by establishing intermediate shelterbelts or fences for wind control at proper intervals before and behind the basic shelterbelts. (See Plate 9, 10, 11, 12.) Therefore, it was decided to establish suitable fences for wind control along the border of farms or owned land in the cultivated area surrounded by basic shelterbelts. Fig. 5 diagrammatically shows fences for wind control to be set up in cultivated land surrounded by forests for salt spray control and those for wind control. A fence for wind control is set up as a rule in a line, by

planting wind tolerant trees.[22] But with regard to some kinds of crops, a stone fence or a wooden fence around the farm will do enough. The following tree species are considered to be suitable for a fence to control wind.

Garcinia Spicata,
Calophyllum Inophyllum,
Casuarina equisetifolia,
Ficus Acacia Confusa.
Ficus retusa.
Livistonia chinensis.
Pandanus odoratissimis.
Bambusa Stenostachys,
Acacia Farnesiana,
Hibiscus Rosa-sinensis.
Aclypha australis.

Fig. 5. Diagram showing relation between Shelterbelt and Windbreak.



Such tree species for gardening as *Thea sinensia* and others are sometimes used.[24]

As a fence for wind control plays a subsidiary role for a shelterbelt or a forest for salt spray control, each place where it is established should be determined in consideration of crop. Therefore it should not be designated a protection forest, but its establishment should be left to the farmer's free will.

(4) Other Protection Forests.

According to the Iriomote Meteorological Observatory at Sonai in this Island, the annual average rainfall of the past, six years was 2630 mm, the greatest amount of rainfall per day 205 mm and the greatest amount per hour 85 mm. When these numerical values are compared with those observed at Ishigaki Island or Miyako Island, rainfalls in Iriomote Island cannot always be

said to be severe. The amount of rainfall, however, greatly differ according to places. In the central mountain regions which are generally high, it is supposed that they have a larger amount of rainfall. Judging from such a large amount of rainfall, the topographical features of the Island and the characteristics of soil, it is necessary to treat all the forests in agricultural developed areas on the upper reaches of rivers as protection forests. Kinds of forests to be designated as protection forests are forests for headwater conservation, forests for erosion control and forests for debris control. And some of them need to serve as forests for salt spray control and forests for scenic beauty as well. Forests which need be designated as protection forests include forests for agriculature projected within agricultural developed areas, but most of them are state-owned forests of which a separate forestry plan should be made.

i) Protection Forests for Headwater Conservation.

Forests for headwater conservation should be designated as forests for debris control, too.[28)]

(a) Situation

Forests on the upper course of rives that run through reclaimed areas for agriculture need be designated as forests for headwater conservation in order to conserve and control water, and thus the forests should be made to keep their functions of conserving headwater and controling debris. Though it is considered possible to regulate water by projecting a dam for agriculture or a multi-purpose dam on the upper stream of the River Urauchi, the River Nakama or the River Aira, the forests along rivers flowing directly into reclaimed land, or on the basin of the upper course of a river on which a dam is built must be treated as protection forests of this kind.

(b) Essential Treatment conditions.

Essential treatment conditions are as follows;

① Prohibition of cutting all the trees over a large area and immediate regeneration of areas where trees were cut down.

② Reserving forests on mountain ridges or protection forests for wind control, because it is difficult to regenerate them if they are entirely cut down.

③ Prohibition of cutting forests on both side of rivers and mountain streams to protect the mountains by preventing sand and earth from being washed away.

④ Light selection cutting of forests on steeply sloping land and prohibition of lumber transport by throwing logs which is liable to cause destruction.

These requirements are a slight restriction on treatment of forests and are not so unfavorable to develop forests.

In other words, this way of managing forests is not only important for agriculture development of areas along the lower course of rivers, but also necessary for management of forests itself.

ii) Forests for Erosion Control and other Forests.

(a) Situation and Area.

As trees of forests in the mountain districts of Iriomote Island have not been cut down on a large scale, there is compratively little erosion there. But in a steeply sloping area, erosion on a small scale can be seen on a transport

route on which logs were thrown down in the past. Therefore careful attention must be paid to prevent erosion in developing forests in future. There are many steep slopes in this Island because of its topographical features. But destructive lumbering of forests on a steep slope cases erosion of sands and rocks as well as occasions debris abalanches, thus damaging dams in the lower streams and reclaimed areas. Therefore not only protection forests for head-water conservation in reclaimed areas for agriculture but also national forests outside reclaimed areas must be designated as forests for debris control, when they stand on a extremely steep slope. According to this plan forests in drained areas along the coast and on a mountain in front of the mouth of the River Urauchi must be designated as forests for salt spray control for the purpose of protecting reclaimed areas. Thus prevention of damages of crops to be caused by salt spray or strong winds can be expected from these forests, which are made to serve as forests for scenic beauty as well as for fish shelter, too.

It is supposed that there are many places in the mountain region which are to be designated as such special protection forests as mentioned above. But in this survey, a detailed investigation all over the Island could not be carried out. Therefore, in this plan, such areas as were regarded as specially important were entered on the map, and their areas were calculated. The total amount of areas are as follows; the area of forests for debris control is 1712 ha, and that of forests for salt spray control serving as forests for scenic beauty and for fish shelter as well 88 ha. And of the forests of this kind, 240 hectars are in the forests for agriculture, and 1560 ha in national forests outside the reclaimed land.

(b) Conditions of Treatment.

The above-mentioned forests are, as a rule, cutting prohibited forests but broken or dead trees may be cut down when it is necessary for maintaining protection forests. When lumber is transported through steeply sloping land, special attention must be paid so that breaking may not be resulted. Though these conditions of treatment are the most severe restrictions on forestry planning, it is considered that they are inevitable in order to develop this Island safely.

(c) Others.

Moreover, in Iriomote Island there are not a few forests or trees that can be regarded as natural monuments, scientific referential forests or sight-seeing resources. *Ptychosperma elegans* at Hoshidate, forests whose brent roots remarkably grow at the mouth of the River Maera, *Ficus retusa* at Shirotate, *Livistonia chinensis* at areas of Sonai, Ōhara and Komi and such other suitable forests as Mangrove that grow in moist land of various areas are their representatives. In developing this Island, it is desirable that these valuable forests or trees are preserved. (See Plate 13, 14, 15, 16.)

III. Farm Forests

i) Position and Area

The standard area for developing agricultural land was determined to be more than 30 ha of a suitable lot of land for agriculture in bloc whose inclination is under 15°. But because of natural site conditions, even in an

area which satisfies these conditions there are unsuitable places for agriculture here and there in view of topographical features and soil. Unsuitable areas for agriculture were measured with the eye by reconnaissance or judged from aerial photographs, and thus area proportions were estimated. After ratios of unsuitable areas for agriculture to suitable ones in each district were calculated from this estimate the unsuitable areas were designed to be forests for agriculture. The ratios of unsuitable areas for agriculture calculated with regard to each developed field greatly differ by district, ranging frow 0% to 35%. The total area of scattered forests for agriculture thus calculated amounts to 1494 ha. Moreover, many of the forests that were excluded from the developed fields are suitable for agriculture though they are not areas in a group. Of such forests, those that have comparatively favourable site conditions and lie next to areas scheduled to be reclaimed are included in the developed areas for agriculture and are designated as forests for agriculture. Forests for agriculture of this kind are not only forests designed for home lumbering for farmers, but also can be expected to be grass cutting meadows or cultivated land of small area after reclamation is completed. But as suitable areas for agriculture in these districts could not be investigated in this survey, they were considered to be forests for agriculture on bloc. Therefore, when the area of the above-mentioned scattered forests are added, the total area of forests for agriculture amount to 4986 ha.

ii) Possession Size.

Here the basis on which a forest for agriculture or grassland to be owned by a farmer should be determined is considered.

It is important in reasonable farming that a farmer should be able to get fuel or lumber from his forest for his own use, and in particular fuel is one of his daily necessaries in life. While on the other hand, actual forests in the area of forests for agriculture are natural ones which are left as they are. Their growing stock is generally 80—200 m^3, averaging 130 m^3, and their annual mean growth is supposed to be about 10 m^3. They consist of trees of various species as aforesaid. And generally speaking, there are a lot of small diameter trees inferior in shape and quality, but a comparatively large number of them are useful as lumber of small size or suitable for fuel. Therefore if superior trees of species are cared for by intensive management in future, they can become a good forest as one for agriculture. Judging from such a present condition and the volume of fuel consumption of a farmer, it is considered proper that the standard area necessary of a forest from which to get fuel is about 0.3 ha.[30] Meadows, grassfields afong valleys and waterways, or grass by the side of farm roads can be available as sources of fodder and fertilizer. Moreover, leaves and stems of crops can be utilized too. Even after taking these matters into consideration, more 1.0 ha of grassland is necessary for a farmer to attain the goal of live-stock breeding program as well as to secure compost for cultivated land. It is not always necessary, however, to cut all the standing trees for the purposed of making grassland. On the contrary it is said that reserving trees as a shade forest and allowing grass grow under the trees improves the quantity and quality of grass, thus increasing productivity as a grass meadow.[31)32)] For this reason, in distributing forests, respective areas of forests for fuel and forests for getting grass should not be rigidly determined but the

minimum combined areas of both of them necessary for intensive treatment should be studied. As forests which were designated as protection forests or are fertile and suitable for agriculture are included in the districts intended for forests for agriculture, it is desirable that they are most effectively made use of after later careful investigation, in the management of agriculture on this Island, by preserving them as public forests on block. And so the minimum area of forests for agriculture had better be distributed for farmers to get fuel and grass. Their areas differ according to the stand composition of forests and site conditions. But judging from examples in the main land of Japan, it is appropriate that they are distributed on the basis of 0.5 ha for a farmer on the average.

IV. Cutting Plan in Reclained Land

i) Area of Districts of Standing Trees and their Volume

Of the total area of 14,203 ha designed for agricultural developed land, the estimated area of standing trees inclusive of mangrove is 10,025 ha, which accounts for 70% of the whole. The volume of timber is estimated to be 1,399,000 m^3, and the volume per ha is about 140 m^3, on the average, as shown below.

Table. 4. Areas of Standing Trees in Developed Land for Agriculture

Kind of forest	Wooded area (ha)	Volume of standing trees (m^3)	Volume of standing trees per ha (m^3)
Forests for salt spray control	360	15,770	43.8
Shelterbelt	690	95,040	137.7
Forests for agriculture	4,986	689,930	138.4
Meadows	380	54,100	142.4
Developed land	3,609	544,410	150.8
Total	10,025	1,399,250	139.6

If the standing trees in the areas designed for the forests for salt spray control, shelterbelts, forests for agriculture and meadows are to be reserved, and all the standing trees in the areas designed for developed land (cultivated fields, roads, waterways etc.) are to be cut down, 544,410 m^3, i.e., 39% of the total volume of timber in the developed areas will be cut down according to the cutting program.

ii) Cutting Plan

Kinds of standing tree vary according to different developed areas. Judging from topographical conditions on the basis of the results of investigations about standard areas, it can be concluded as a whole that mangroves account for 4%, standing trees available for lumber 14%, and the others 82%.

Mangroves grow in places which are convenient for cutting and transportation, while their bark can be used for dyestuff for fishing nets, and at the same

time their trunks are in demand as small pieces of timber as well as fuel. Therefore mangroves in areas scheduled to be reclaimed can be cut and used. But on the other hand, as other standing trees than mangroves are very numerous, and grow in such places as are inconvenient for transport, it is not easy to make use of them.

If all the standing trees mentioned above are cut down and trees available as lumber or fuel are collected along farm roads in each reclaimed area, 37,425 m^3 of lumber, 447,780 m^3 of fuel and 17,424 m^3 of Mangrove timber can be obtained. The necessary expenses to get them are estimated to be about $ 1,596,000 in all. If it is assumed that all the quantities of them could be sold, though it seems extremely difficult, their total value would amount to $ 1,900,000, when calculated on the basis of unit price of lumber, fuelwood and Mangrove timber in the market of the city of Ishigaki. Therefore the general average unit price of 1 m^3 of standing trees is only $ 0.56. At present in the western part of the Island there are about fifty charcoal burning kilns which inhabitants of the Island are using to make charcoal. So a part of standing trees calculated as firewood can be turned into charcoal. In spite of this, all the standind trees cannot be advantageously utilized from the economical point of view under the present condition. But if a plan is made to cut down and carry trees in order to make use of them, by gradually constructing farm roods, after completion of roads and harbor facilities, it will become extremely easy to utilize the said resources. In this case, it is estimated that about half of the all standing trees which are considered to be charcoal wood can be utilized as lumber, not only because some of them are useful as pulpwood, mine timber, sleepers and so on, but also because transportation expenses will become lower.

At any rate, as it is difficult as well as economically disadvantageous to cut down and utilize a large number of standing trees in a short time, it is necessary to make use of these valuable natural resources profitably, making an annual plan by district in putting development plans in practice.

V. Conclusion

In developing the agriculture of this Island, it is extremely impotant to establish a protection forest and a forest closely connected with agriculture in order to protect against typhoons and other climatic disasters.

About 90% of the whole area of Iriomote Island is covered with forest. Therefore agricultural development of the Island consists in the development of forests. Cutting of the forests under a reasonable plan and paying due consideration to the establishment of protection forests and farm forests are fundamental conditions to develop the agriculture in this Inland.

i) Protection Forest

Emphasis is put upon the arrangement of forest which are to be established within the cultivated land to protect against wind and salt spray so that agricultural disasters caused by typhoons or the monsoon may be prevented. Moreover, investigation about protection forests have been made for the purpose of securing the source of water supply, taking into consideration the conditions of rainfalls and topography.

(a) As most of the districts to be developed for cultivation are flats expanding along the seashore, forests to protect against wind and salt spray will be established along the coast-line of the agricultural districts. The width of the forest will be determined by the topographical conditions tnd the kind of forest, it is supposed here that forest be 50～200 m wide, with trees about 10 m high. 360 ha of the existing forests will be utilised, further 180 ha of land being newly planted with resistant trees, and thus the total area will be 540 ha.

(b) On this Island strong winds blow in various directions according to time and place, and therefore around the cultivated land there will be a principal forests to protect against wind, connecting forest zone in all directions like a net. These shelterbelts are variously apart from each other, differing in width as well, but heights of trees of 10 m to 15 m, intervals of 200 m to 300 m, and width of 20 m to 40 m are considered as standard. The total are required for shelterbelt is 1,150 ha, of which 690 ha will come from the existing forests, with the remaining 460 ha coming from new plantation of wind tolerance trees.

(c) When the amount of rainfalls, the topographical features and the geological conditions of the Island are taken into consideration, all the forests on the upper course of rivers should be designated as forests to conserve the source of water or forests for debris control and erosion control.

ii) Farm Forest

It is very important in farming for farmers to get fuels or a small quantity of timber from their forests, or to own grass-grown fields as the source of supply of fodder and fertilizer. For these purposes, 3,526 ha of farm forests will be established around the arable areas. Non-arable areas within the arable areas being utilized as forests for agriculture. These areas amount to 1,494 ha. Therefore, the total dimensions of the forests for agriculture will be 5,020 ha.

iii) Expenses for forestry work connected with farming.

The expenses for forestry work chiefly connected with farming such as for preparing protection forest and felling trees for development are as follows.

Expense for salt spray control Forest	167,000 $
Afforestafion;	122,000
Construction of side ditch;	45,000
Expense for shelterbelt	857,000
Afforestation;	260,000
Construction of side ditch;	597,000
Expense for felling trees for land for development	1,596,000
Total expense	2,620,000

The amount of $1,024,000, the expenses pertaining to forestry not including the expenses for tree felling, is represented by the per house amount of $246 in the case of 4,170 houses of farmers settled in the 16 districts.

VI. Summary

Iriomote Island is covered with a vast area of forests. At present the only districts which are not covered with forests are plains along the east, north and west coasts, rivers, cultivated land and residential sites which amound to

only 10% of the entire area of the Island. The greater part of forests, namely 85% of the whole area of the Island is owned by the state. The roll played by the forests in this condition with regard to clearing and farming is reviewed below.

i) It goes without saying that functions of forest are very important for headwater conservation and soil conservation. Although the land and climate of this Island are under an unfavorable condition because of the forests covering the entire Island, it can be said that the greater part of areas to be developed under the reclamation plan has been kept from decrease in productive power of the soil and devastation. In the future as well, farms to be developed along the downstream will be very effectively protected against damages of flood by keeping headwater conservation forests, forests for debris control and forest for erosion control. Therefore great care must be taken of conservation and maintenance of the forests not only within the raeas under the plan, but also outside them, until the development plan has been realized.

ii) It is very important in farming to make a forest for salt spray control in the Island of Iriomote where there are many areas to be reclaimed along the coast. Some places along the coast have become devastated fields, but not a few places are covered with tropical forests, and therefore it is necessary to make forests for salt spray control by planning to conserve coastal forests.

It requires a long time to make a new forest for salt spray control, but if an actual forest can be made use of effective protection can be expected against salt spray and wind from the beginning of the reclamation. Therefore special attention must be paid to the conservation of existing forests.

iii) As this Island is frequently attacked by typhoons and strong monsoons, it is considered as an indispensable condition to make a shelterbel of reasonable size in order to alleviate damage caused by winds.[1] It is to be expected that in putting the reclamation plan into force, protection against winds is effectively recured from the beginning of reclamation by planning to conserve actual forests as shelterbelts in cultivated land, because it requires more than several years at least to make a new shelterbelt with wind-resistant tree species in order to protect against winds. In an area for a grazing plan, it is advantageous to make a shelterbelt to be used as a compartment forest, a fence forest and a refuge forest or to make a proper shading forest.[2] In making these pasture forests, utilization of actual forests must be taken into consideration.

iv) It is essential in their living and farming for farmers to possess a forest for agriculture in order to be able to obtain timber, cordwood and brushes for their own use. Within areas to be developed, there are such forests as can satisfy this requirement. Therefore, by allocating these forests as farm forests of reasonable size, formation of forests for cordwood, forests for special use and meadws for fodder and compost must be considered.

v) Moreover, the fact that the greater part of the forests of this Island is owned by the Government makes it easier to put a reclamation plan into effect. Not only standing trees to be cut down within the areas to be reclaimed but also forests without can be utilized as fire-wood and construction lumber necessary for development. Besides, if development of the remaining national

forest remains to be carried out along with the agricultural development, seasonal surplus labor of farmers can be evenly utilized, thus bringing cash income to them. This advantage cannot be overlooked.

vi) Existence of forests has not only the advantages mentioned above, but also such disadvantages as a great deal of labour required for cutting and uprooting work, or difficulty in preventing damages by wild boars. And it is said that the national forests which cover the greater part of the Island is a great obstacle to the agricultural development there. In such a backward country as Iriomote Island, the possession of land in the form of national forests not only makes industrial development difficult, but also it is disadvantageous for management in view of securing of labour, demand and supply of forest products and all other respects even in developing the national forests themselves. Therefore suitable areas for reclamation and some additional areas in the national forests should be positively liberated from the national ownership, while a reasonable management plan should be established for the remaining forests.

vii) As there is an extremely abundant growing stock of standing trees in the areas to be developed, it will become very difficult to utilize the valuable natural resources, if there is no plan of cutting trees. Therefore, in putting the reclamation plan in force, the annual program of reclamation and cutting and utilization plan of standing trees should be established at the same time, while it is necessary to cut trees after construction of roads has been completed in order to dispose cut-down trees profitably.

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Plate 1. Seashore Forest for Salt Spray Control of *Garcinia spicata*, Hook. f. at Kamimotobu in Okinawa Island. (Phot. Mar. 1961)

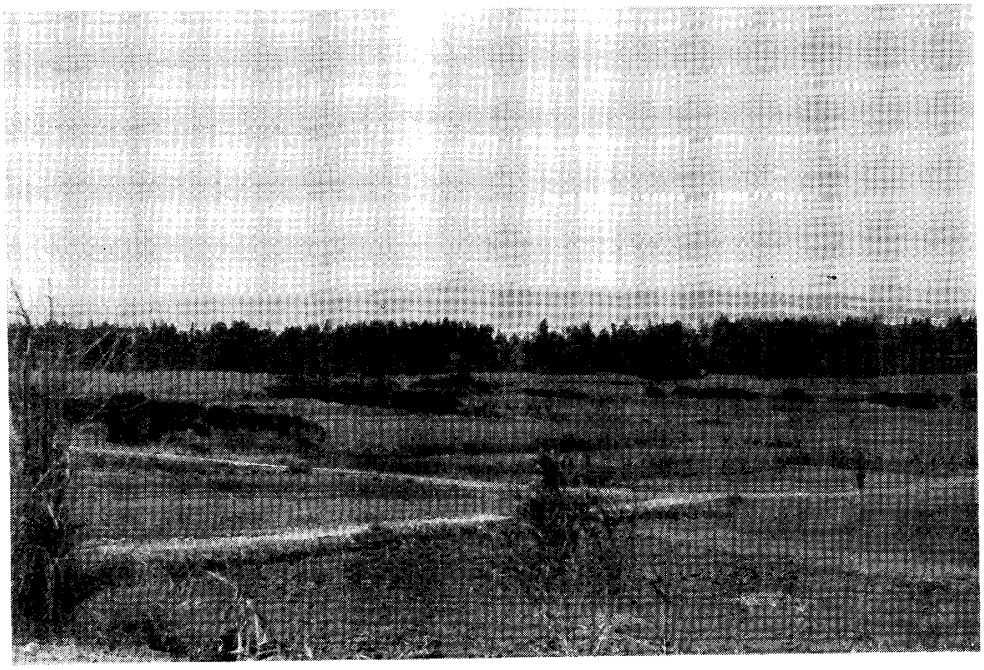

Plate 2. Seashore Forest for Salt Spray Control of *Casuarina equisetifolia*, J. et G. Forst. at Siirahama. (Phot. Mar. 1961)

Plate 3. Mixed Forest (*Casuarina equisetifolia* and *Calophyllum Inophyllum*) for Wind and Salt Spray Control at Hori in Kuroshima Island. (Phot. Apr. 1961)

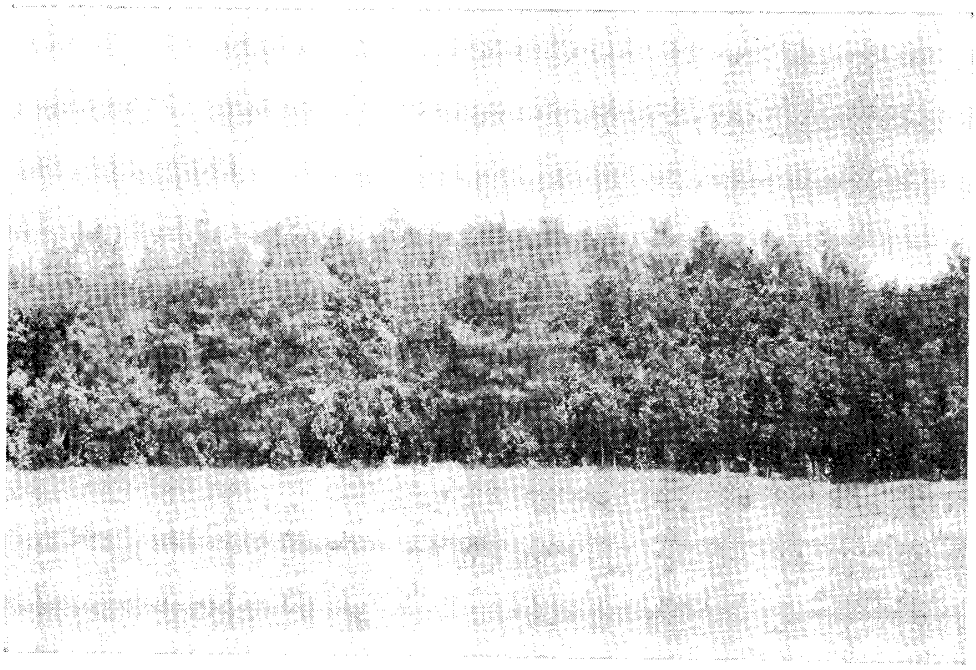

Plate 4. Seashore Forest for Salt Spray Control of *Pinus liuchuensis*, Mayr at Ohhara. (Phot. Apr. 1961)

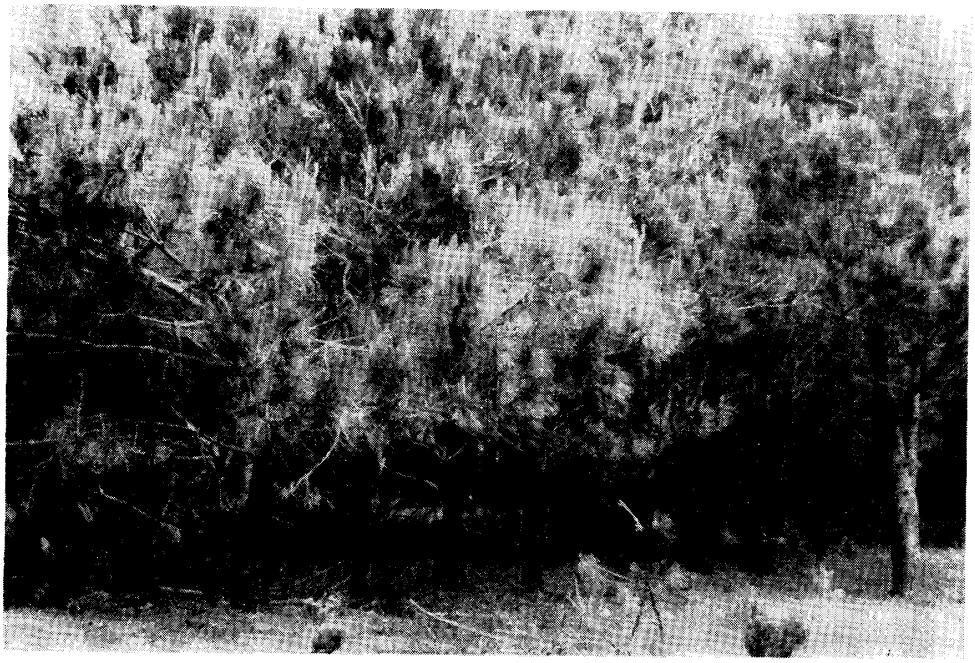

Plate 5. Shelterbelt Stand of *Calophyllum Inophyllum* at Iko in Kuroshima Island. (Phat. Apr. 1961)

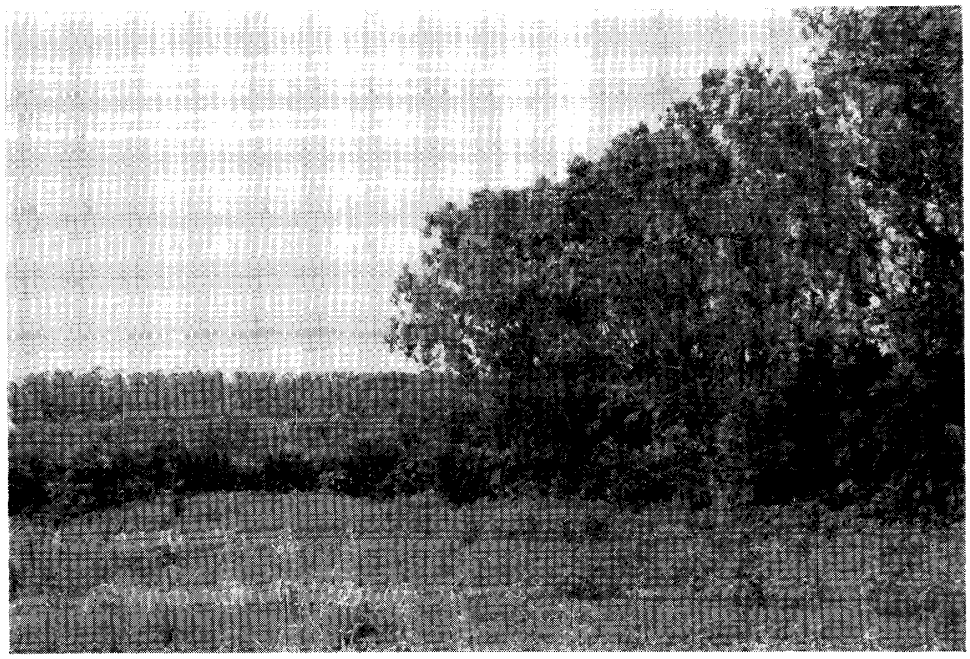

Plate 6. Mixed Forest (*Garcinia spicata* and *Casuarina equisetifolia*) Shelterbelt at Miyasato in Kuroshima Island. (Phot. Apr. 1961)

Plate 7. Shelterbelt Stand of Artificial *Calophyllum Inophyllum* Sowing in 1959 at Hori in Kuroshima Island. (Phot. Apr. 1961)

Plate 8. Shelterbelt Stand of Artificial *Casuarina equisetifolia* Planted in 1957 at Sumiyoshi. (Phot. Mar. 1960)

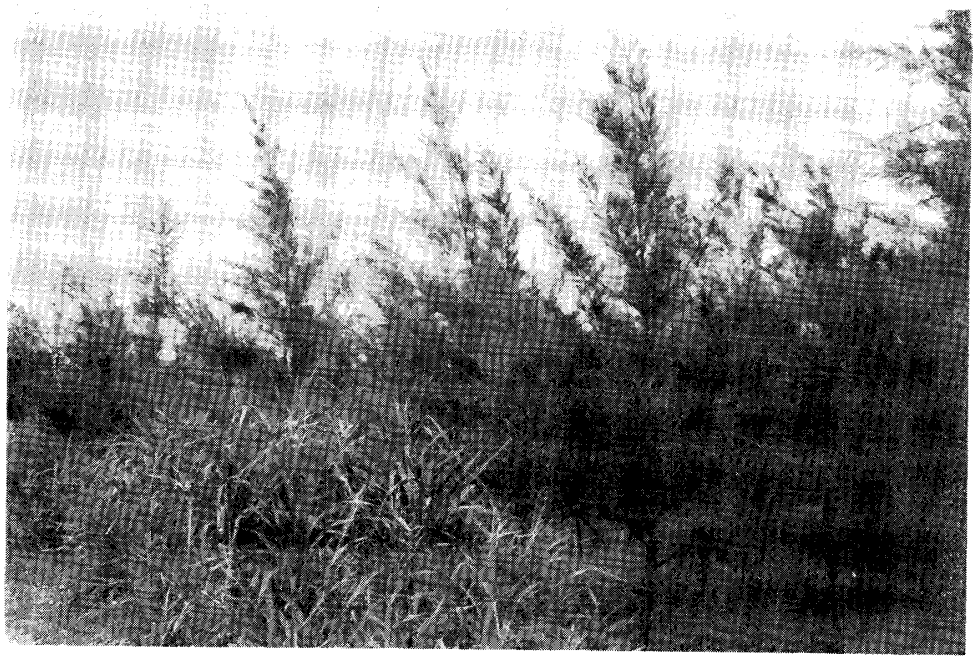

Plate 9. Windbreak Stand of *Calophyllum Inophyllum* at Miyasato in Kuroshima Island. (Phot. Apr. 1961)

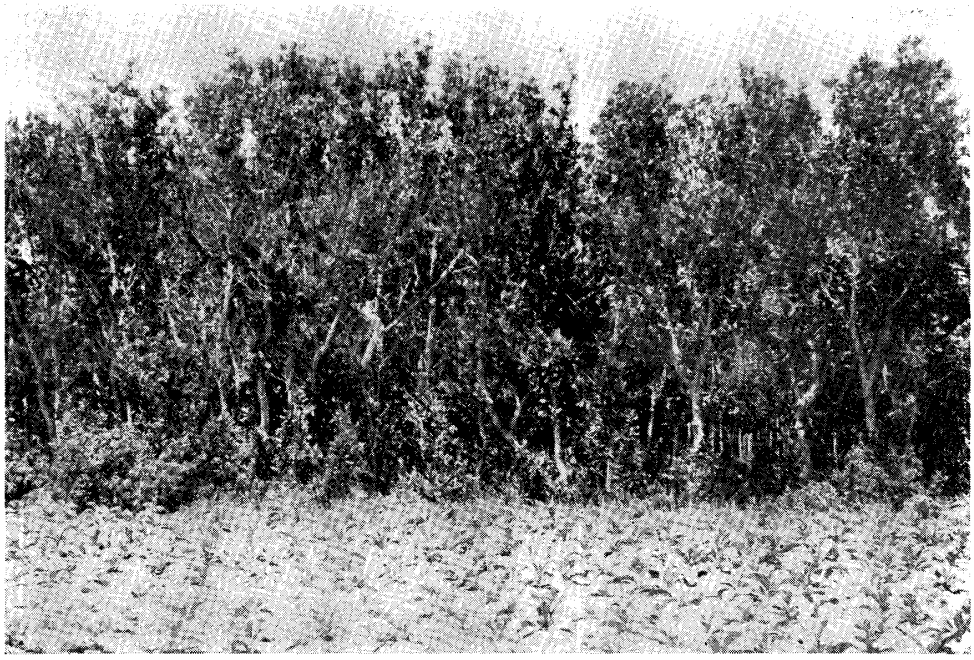

Plate 10. Windbreak Stand of *Pinus liuchuensis* at Nakijin in Okinawa Island. (Phot. Feb. 1960)

Plate 11. Fence for Wind Control of *Bambusa stenostachys*, Hack. at Nakura in Ishigaki Island. (Phot. Mar. 1961)

Plate 12. Fence for Wind Control of *Acacia confusa*, Merr. at Hanakiri in Miyako Island. (Phot. Mar. 1961)

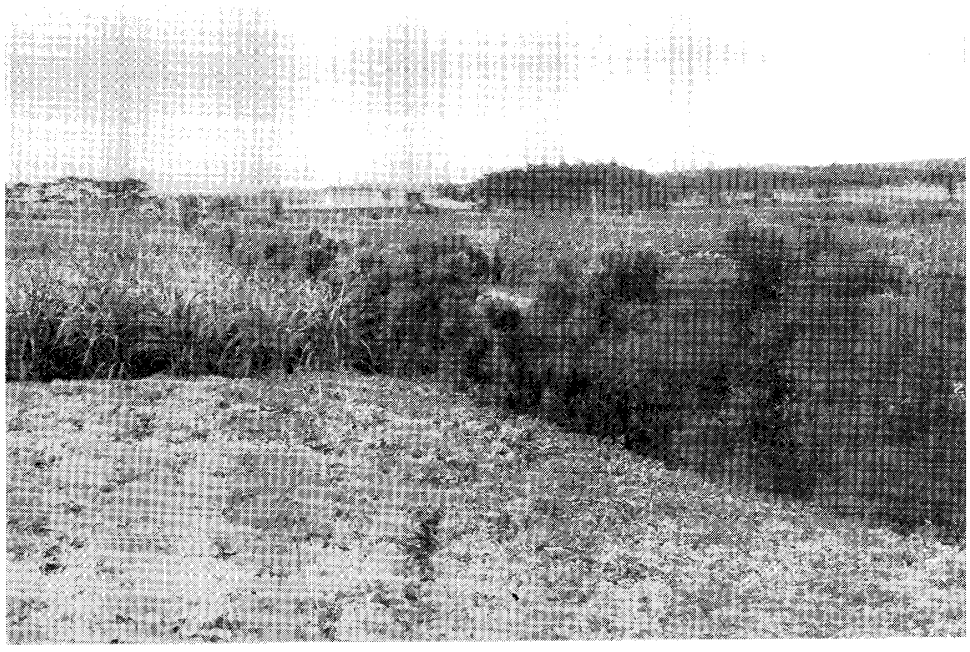

Plate 13. Palm Trees (*Ptychosperma elegans*, Blume) grown in the Tropical Hardwood Forest at Hoshidate. (Phot. Mar. 1961)

Plate 14. Mangrove (*Bruguiera gymnorrhiza*, Lam. *Rhizophora macronata*, Lam. *Kandelia Rheedii*, Wight et Brn. etc.) at the River Nakama. (Phot. Apr. 1961)

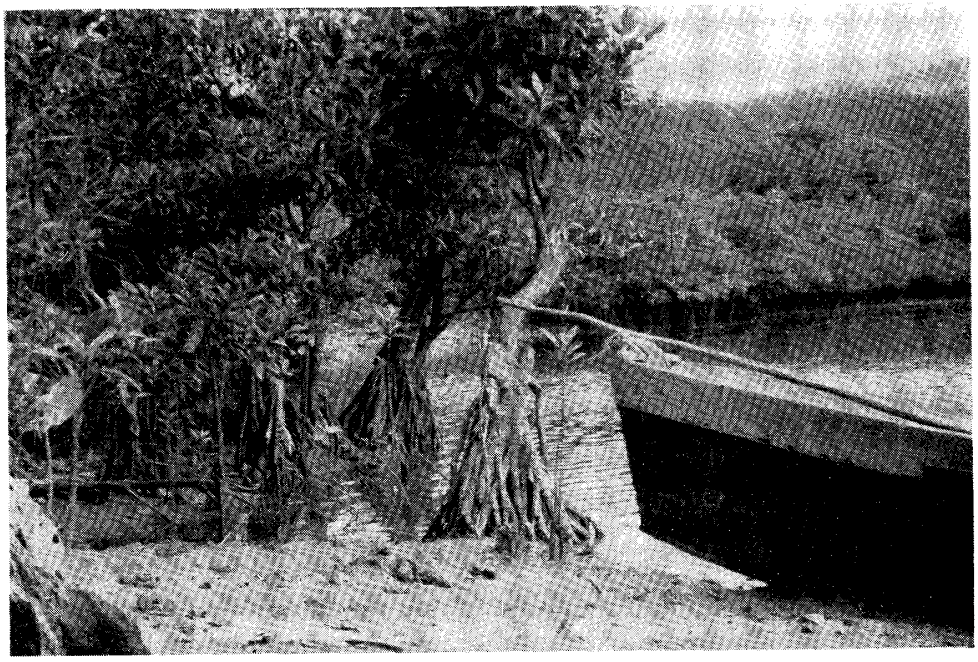

Plate 15. Brent Roots Tree (*Heritiera littoralis*, Alt.) at Komi. (Phot. Apr. 1961)

Plate 16. Aerial Roots Tree (*Ficus retusa*, L.) at Shirotate. (Phot. Apr. 1960)