Variation of Density of *Suaeda maritima* in Reed Marsh

by

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Introduction

At the mouth of the river Obitsu, *Phragmites communis* vegetation develops (Fig. 1). This vegetation is periodically submerged by flooding of sea water. Some halophytes are observed at two places, on the river beds (station A and B) and the bare ground behind small barrier beach (station C and D) (Fig. 2). The dominant annual halophytes found at these two places are *Suaeda maritima* and *Atriplex gmelinii*. The other places are the reed marsh covered by *Phragmites communis* and *Phacelurus latifolius*.

This marsh faces the Tokyo Bay. At the mouth of the bay, there is the cape of Futtsu. Owing to the cape the marsh is protected from heavy wave action.

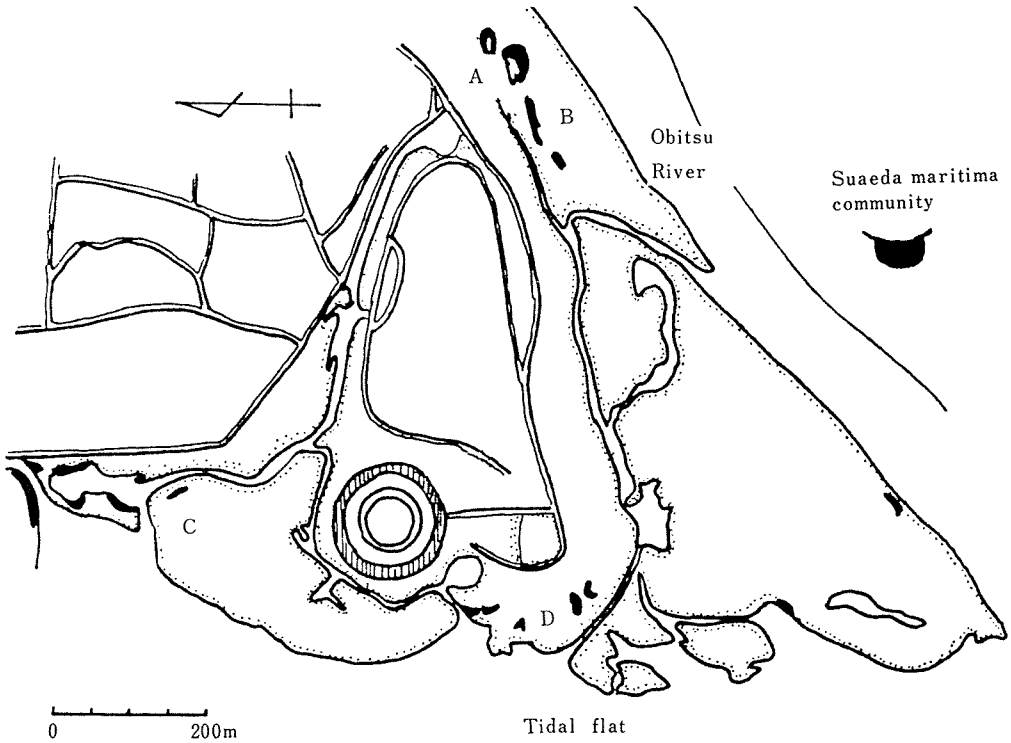

Fig. 2. Map showing distribution of *Suaeda maritima* communities in 1973 and situation of station A, B, C and D.

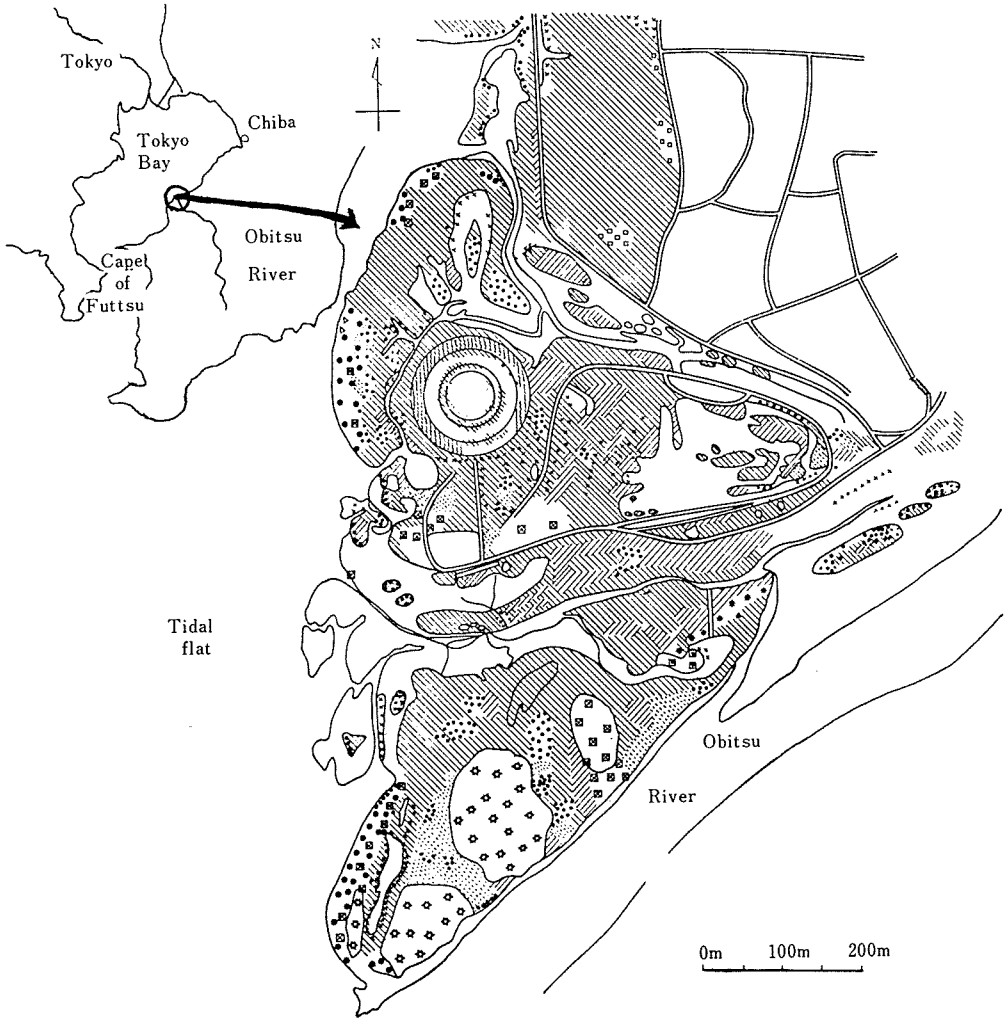

Fig. 1. Vegetation map of the salt marsh at the mouth of the river Obitsu.

Phragmites communis

Phacelurus latifolius

Imperata cylindrica var. *koenigii*

Ischaemum aristatum var. *glaucum*

Suaeda maritima
Suaeda asparagoides
Atriplex gmelinii
Atriplex hastata

Zoysia sinica var. *nipponica*

Carex scabrifolia

Carex pumila
Calystegia soldanella
Ischaemum anthephoroides
Zoysia macrostachya

Pinus thunbergii

Carex kobomugi

Pleioblastus chino

Celtis jessoensis

Zoysia japonica

Digitaria adscendens
Chenopodium album
Oenothera biennis

Typha latifolia

Pueraria lobata

This is the only salt marsh that remains in the coast of the Tokyo Bay, the other littoral areas were buried and turned to the manufacturing district. The opinion concerning the protection of this marsh expressed is by many naturalists now.

Ecological studies of the plants in this marsh are few (Nobuhara 1975, Nobuhara and Miyazaki 1978). The present paper deals with the decrease of *Suaeda maritima* by the invasion of *Phragmites communis*.

I. Results

At four stations A, B, C and D, permanent quadrats (1m×1m) were zonally set at right angles to the tide line on the boundary between *P. communis* and *S. maritima* zone. The numbers of plants in each quadrat (1m×1m) were counted from 1974 to 1977.

I Station A

Station A is the uppermost distribution of *S. maritima* along the Obitsu River. *S. maritima* zone is 3m wide between the quadrat No. 6 and No. 8 (Fig. 3). Behind the quadrat No. 8 is established *P. communis* community.

Permanent quadrats were set on April 1, 1975. As many dead plants of *S.*

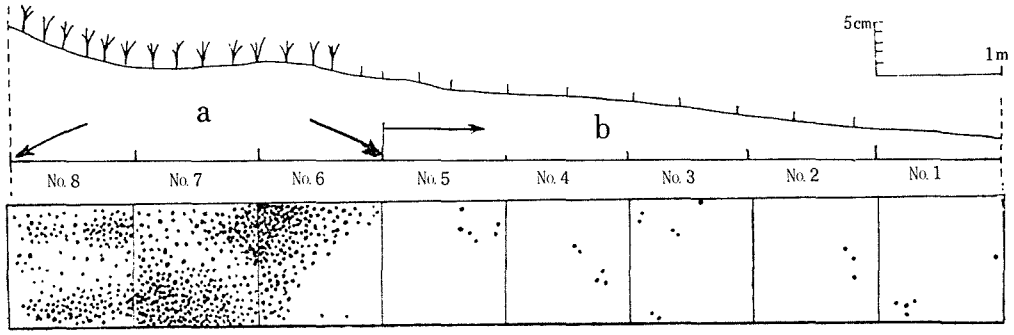

Fig. 3. Profile of station A and seedlings of *Suaeda maritima* appeared in each quadrat on Apr. 1, 1975.
a : *Suaeda* zone (spring tide zone)
b : Zone where a few seedlings temporarily appeared (neap tide zone)

Table 1. Variation of numbers of *Suaeda maritima* at station A (1m×1m).

Date \ Quadrat No.		0	1	2	3	4	5	6	7	8	Note
1975	Apr. 1	0	5	3	7	5	6	104	647	188	
	Apr. 20	0	0	1	0	0	0	120	858	163	
	May 5	0	0	2	0	0	0	69	813	210	
	Autumn	0	0	0	0	0	0	27	189	25	counted in the spring in 1976
1976	Apr. 3	2	1	1	3	3	8	503	3083	1602	
	Aug. 11	0	0	0	0	0	0	57	108	83	
1977	July 29	0	0	0	0	0	0	0	1	3	

Table 2. Variation of numders of *Phragmites communis* at station A (1m×1m).

Date \ Quadrat No.		0	1	2	3	4	5	6	7	8	Note
1975	Apr. 1	0	0	0	0	0	0	0	0	0	
	Apr. 20	0	0	0	0	0	0	0	0	0	
	May 5	0	0	0	0	0	0	0	0	0	
	Autumn	0	0	0	0	0	0	0	3	2	counted in the spring in 1976
1976	Apr. 3	0	0	0	0	0	0	0	1	7	
	Aug. 11	0	0	0	0	2	15	19	22	92	
1977	July 29	0	0	0	21	61	72	68	80	107	

maritima were seen then between the quadrats No. 6 and No. 8, it was known that this area had been a *S. maritima* zone in 1974 as well as in 1975. A few seedlings were observed on April 1, 1975 in front of the *S. maritima* zone with the width of 5 meters, but they almost disappeared on April 20. In the *S. maritima* zone, many seedlings appeared and most of them grew soundly.

In 1976, the *S. maritima* population changed in the same manner as in 1975. *P. communia* appeared first in the quadrats No. 7 and No. 8 in the autumn of 1975. Some of *P. communis* were seedlings and the others were shoots sprouted from the horizontal rhyzomes. In 1976, *P. communis* increa sed in number and expanded to 5m in width. However, *S. maritima* did not suffer any influences by the small density of *P. communis* till the summer,

In 1977, *P. communis* expanded also in the same way as the last year. In *S. maritima* zone, *P. communis* increased in number, and gained high density. As a result *S. maritima* was all but debilitated by the dense cover of *P. communis.*

II Station B

Near the station A, station B was chosen. In front of the *P. communis* zone, permanent quadrat was set in 1973. In this quadrat, the number of *S. maritima* was 301, and that of *P. communis* 29. On April 20, 1974, the number of *S.*

Table 3. Variation of number of *P. communis* and *S. maritima* at station B (1m×1m).

Date \ Quadrat No.		Species \ Quadrat No.	1	2	3	4	5	6	7	8	9
1975	Autumn	*Phragmites*	30	28	29	31	10	5	0	0	0
		Suaeda	0	2	0	0	3	15	10	6	0
1976	Apr. 4	*Phragmites*	—	—	—	36	30	11	0	1	0
		Suaeda	4	8	16	16	68	127	300	291	13
	June 1	*Phragmites*	54	38	57	63	—	—	—	—	—
		Suaeda	—	—	—	—	—	—	—	—	—
	Aug. 12	*Phragmites*	52	49	38	50	58	38	17	6	3
		Suaeda	0	0	0	0	0	0	0	7	0

maritima was 45, and on May 5, it was 1. In this way, the number of *S. maritima* decreased; on the contrary, that of *P. communis* increased from 29 to 31.

From 1975 to 1976, permanent quadrats were set in belt (Table 3). In 1975, the *S. maritima* zone was 4m wide, but in the next summer it disappeared by the invasion of *P. communis*.

III Station C

Station C was chosen behind the small barrier dune. On this barrier dune *P. communis* community was well established. In the *P. communis* community, some dune plants were observed, e. g. *Calystegia soldanella*, *Carex pumila*, *Messerchmidia sibirica*, and *Lathyrus maritimus*. Eight permanent quadrats were set in belt on and in front of the *S. maritima* zone in 1974. There were quadrats No. 7 and No. 8 on the *S. maritima* zone (Fig. 4).

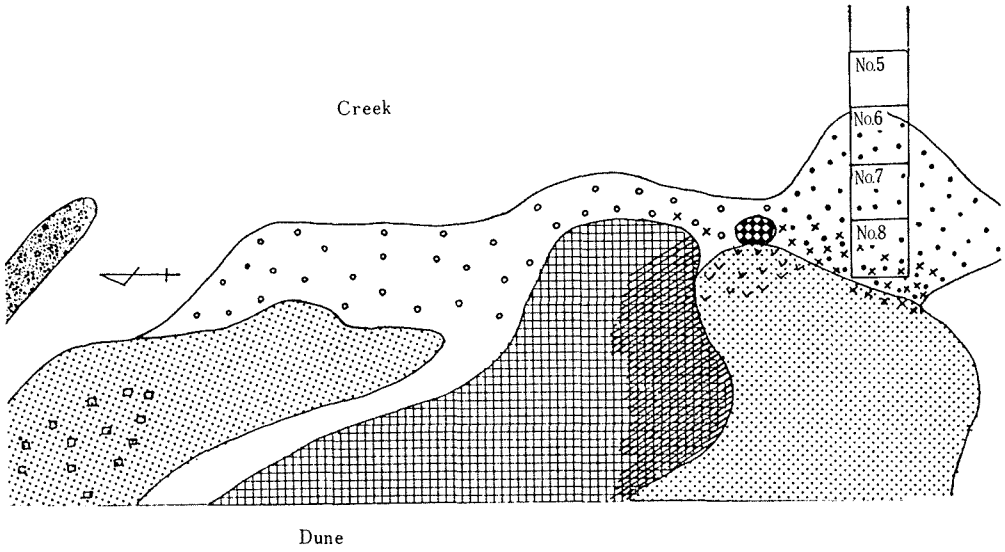

Fig. 4. Vegetation map of station C in 1973 showing situation of permanent quadrat.

Suaeda maritima
Suaeda asparagoides
Atriplex gmelinii
Carex scabrifolia
Carex pumila
Phragmites communis
Rosa wichuraiana
Messerschmidia sibirica
Echinochloa crus-galli
Lycium chinense

In 1974 in the *S. maritima* zone, many *S. maritima* and *Atriplex gmelini* were seen but in the autumn of 1975 *P. communis* advanced in the quadrats No. 7 and No. 8; in 1976, *P. communis* increased the shoot density. Because of this, in 1977 *S. maritima* and *A. gmelini* decreased in number and disappeared completly in 1978.

IV Station D

Station D has been protected by a small *P. communis* dune. By wave ac-

tion, this *P. communis* community often suffered some damage, and gathered sand. Owing to the damage, the growth of *P. communis* was not well, its density and reproductive ability by horizontal rhyzomes were low. On the lower back place of the *P. communis* community, many *S. maritima* have grown zonally. This *S. maritima* zone has kept its habitat under the protection against wave action and invasion of *P. communis*. Eleven permanent quadrats were set on March 26, 1978. Quadrat No. 1 was set in the *P. communis* community, No. 2 in the highest population of *S. maritima* zone, No. 3 in the front low density part of *S. maritima* zone. From quadrat No. 4 to No. 10, quadrats connected each other in belt at right angles to the tide line. These were set in the lower place where a few *S. maritima* seedlings were seen. Quadrat No. 11 was set on the lowest open place.

In the quadrat No. 1, from spring to summer, *S. maritima* was covered more and more by not only *P. communis* but also the other plants; consequently *S. maritima* decreased in number as time went by. In the quadrats No. 2, No.

Table 4. Variation of numbers of plants at station C (1m×1m).

Date	Species \ Quadrat No.	8	7	6	5	4	3	2	1
1974 Autumn	*Suaeda maritima*	257	357	0	0	0	—	—	—
	S. asparagoides	0	1	2	0	0	—	—	—
	Atriplex gmelinii	135	3	11	2	0	—	—	—
	Chenopodium glaucum	0	1	0	0	0	—	—	—
1975 Apr. 1	*S. maritima*	307	127	11	6	0	—	—	—
	A. gmelinii	137	14	5	0	0	—	—	—
1975 Apr. 20	*S. maritima*	310	140	7	0	0	—	—	—
	A. gmelinii	169	16	1	0	0	—	—	—
1975 Autumn	*S. maritima*	465	68	0	0	0	—	—	—
	A. gmelinii	45	0	0	0	0	—	—	—
	Phragmites communis	7	3	0	0	0	—	—	—
1976 Apr. 3	*S. maritima*	691	54	0	3	0	0	3	2
	A. gmelinii	54	0	0	0	0	0	0	0
	P. communis	6	3	2	0	0	0	0	0
	Carex scabrifolia	4	9	0	0	0	0	0	0
	Gramineae seedling	1	0	0	0	0	0	0	0
1976 Aug. 12	*S. maritima*	393	2	0	0	0	0	0	0
	A. gmelinii	52	0	0	0	0	0	0	0
	P. communis	21	38	30	0	0	0	0	0
	C. scabrifolia	55	111	19	0	0	0	0	0
	Phacelurus latifolius	2	0	0	0	0	0	0	0
1977 May 8	*S. maritima*	a few	a few	0	0	0	0	0	0
	A. gmelinii	a few	a few	0	0	0	0	0	0
	P. communis	15	14	54	22	8	0	0	0
	C. scabrifolia	some	many	a few	0	0	0	0	0
	Pha. latifolius	11	14	0	0	0	0	0	0

Table 5. Variation of numbers of plants at station D in 1978 (1m×1m).

Date	Quadrat No. / Species	1	2	3	4	5	6	7	8	9	10	11
Mar. 26	*Suaeda maritima*	—	3300	—	79	68	10	10	5	2	3	0
	Phragmites communis	—	2	—	0	0	0	0	0	0	0	0
May 7	*Suaeda maritima*	200	—	333	40	25	1	2	2	1	0	0
	Phragmites communis	12	—	0	0	0	0	0	0	0	0	0
	Atriplex gmelinii	15	—	0	0	0	0	0	0	0	0	0
	Atriplex hastata	143	—	0	0	0	0	0	0	0	0	0
	Carex scabrifolia	45	—	0	0	0	0	0	0	0	0	0
	Sonchus oleraceus	5	—	0	0	0	0	0	0	0	0	0
June 25	*Suaeda maritima*	10	2358	207	27	12	0	0	0	0	0	0
	Phragmites communis	21	17	0	0	0	0	0	0	0	0	0
	Atriplex gmelinii	9	5	0	0	0	0	0	0	0	0	0
	Atriplex hastata	64	0	0	0	0	0	0	0	0	0	0
	Carex scabrifolia	55	0	0	0	0	0	0	0	0	0	0
	Sonchus brachyotus	12	0	0	0	0	0	0	0	0	0	0
	Digitaria sanguinalis	3	0	0	0	0	0	0	0	0	0	0
Aug. 9	*Suaeda maritima*	6	1617	158	17	12	0	0	0	0	0	0
	Phragmites communis	19	18	0	0	0	0	0	0	0	0	0
	Atriplex gmelinii	8	3	0	0	0	0	0	0	0	0	0
	Carex scabrifolia	many	0	0	0	0	0	0	0	0	0	0
	Sonchus brachyotus	11	0	0	0	0	0	0	0	0	0	0
	Atriplex hastata	31	0	0	0	0	0	0	0	0	0	0

3, No. 4 and No. 5, many seedlings of *S. maritima* appeared on March 26. As they grew the number of plants decreased gradually, some of them have attained their full growth. The mortality rate was within the extent from 51% to 82%. In the quadrats No. 6, No. 7, No. 8, No. 9 and No. 10, some seeds sprouted, but disappeared before long.

It seems that the disappearance is due to the washing by the flooding of neap tide. The salinity of surface soil water in the quadrat No. 1, No. 2, No. 3, No. 4, No. 5, No. 6, No. 7, No. 8, No. 9, No. 10 and No. 11 was 0.40%, 3.18%, 4.27%, 1.25%, 3.04%, 4.52%, 4.67%, 5.09%, 5.55%, 2.66% and 3.13%, respectively, on March 26, 1978. Between the *S. maritima* zone (quadrat No. 2, No. 3, No. 4, No. 5) and the zone of disappearance (quadrat No. 6, No. 7, No. 8, No. 9, No. 10), difference of salinity is obscure. From this result, it seems that the disappearance of seedlings is not due to the high salinity.

V Influence of *Phragmites communis* to *Suaeda maritima*

When *P. communis* advances to the *S. maritima* zone, it exerts bad influence upon the growth of *S. maritima*. At two places where *P. communis* was much or little, the growth of *S. maritima* was compared. Under the leaf layer of *P. communis*, *S. maritima* became slender and had few leaves. The *S. maritima* communities establish themselves at the place of relative light intensity of more than 60%.

Table 6. Various relative light intensity in *Phragmites* community and the growth (cover degree and height) of *Suaeda maritima*.

Dominant species	Relative light intensity on *Suaeda* layer (%)	Cover degree (%)		Plant height (cm)	
		Suaeda maritima	*Phragmites communis*	*Suaeda maritima*	*Phragmites communis*
Suaeda maritima	90	80	35	71	189
	80	75	40	63	203
	61	75	35	66	188
	58	70	25	52	200
	76	50	20	48	182
	75	45	25	43	178
Phragmites communis	60	35	50	58	197
	57	35	80	57	180
	55	45	60	61	187
	51	20	75	32	163
	43	45	60	43	175
	40	30	65	45	173

Table 7. Comparison of No. of young *Suaeda* leaves under dense cover with those under thin cover of *Phragmites*.

Height of *Suaeda* (cm)	No. of leaves	
	Cover of *Phragmites*	
	Thinly	Densely
More than 30	28.3	8.0
25 ~ 29	15.8	—
20 ~ 24	11.2	6.8
12 ~ 19	7.8	5.1
9 ~ 11	5.2	—
Less than 9	2.0	2.2

II. Discussion

Chapman (1976) pointed out the significance of successful establishment before the seedling will be washed away by tide. *Salicornia* seedlings on low marsh, where there is daily flooding, have high mortality rate, but on higher marsh, where there is flooding only during spring tide, have low rate (Wiehe 1935). The same phenomenon was seen in this investigation about the decrease of *Suaeda maritima* seedlings. However, the process of the successful anchorage of seedlings could not be observed. At station A, quadrat No. 6, No. 7 and No. 8 lie in the spring tide zone, the other quadrats in the neap tide zone. At station B, quadrat No. 9, at station C, from quadrat No. 5 to No. 1, at station D, from quadrat No. 6 to No. 11, lie in the neap tide zone. From the data obtained at station D, it seems that the soil salinity is not the limiting facter for advance of *Suaeda* to

neap zone. From these observations, Chapman's theory may be supported.

Suaeda maritima is distributed in two places, one is the river bed, the other behind *Phragmites* dune, in this salt marsh. These places are the open ground where *Phragmites* communities used to occupy. *Phragmites communis* is weak for the water movement. It seems that *Phragmites* community was destroyed by the water movement of river flood in the former place, and in the latter place, by the sea wave action. When these wave actions come often, *Phragmites* marsh turns into the open ground on the dry river bed, and into the dune on the coast respectively.

The river Obitsu is not the big river, and the Tokyo Bay is protected from the heavy wave by the cape of Futtsu. It seems that some years ago, before 1973, the river bed suffered from the disastrous flood, and the coast from the wave action. Then *Phragmites* communities were destroyed on the river bed and on the coast, and replaced by *Suaeda* communities. During this investigation, the reed marsh did not suffer damage by the disastrous river flood and the high sea wave. It was only the station D suffered from feeble wave action. Thevefore, *Phragmites* being suffered injury by the wave, *Suaeda* can maintain its habitat every summer.

Summary

In the reed salt marsh, *Suaeda maritima* gradually becomes sparse and disappears ultimately with the invasion of *Phragmites communis*. When the relative light intensity decreases down to less than 60% by the cover of *Phragmites communis*, *Suaeda maritima* suffers bad influence.

In front of the open places of the *Suaeda* zone, some seedlings of *Suaeda* appear in spring but disappear before long. It seems that the disappearance is due to the washing away by the flood of tide.

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