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Review

Typical Coastal Vegetation of Korea

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Abstract : It was found that 14 coastal habitats in South Korea have comparetively natural vegetation. The habitats were classified into three types - intertidal flats, sand dunes, and estuaries. There were four intertidal flats, five sand dunes and five estuaries. Except for *Cynodon dactylon* and *Tetragonia tetragonoides*, all of the main halophytes and sand dune plants were found in the habitats. These two species were mainly distributed on the southern coast. This study identified coastal vegetation, such as pure stands of *Suaeda japonica* on intertidal flats, mixed halophyte communities around the high-water mark, pure stands of *Vitex rotundifolia* on stable sand dunes, mixed communities dominated by *Carex kobomugi* on unstable sand dunes, and pure stands of *Phragmites communis* in estuaries. The types of coastal vegetation may depend on sediment types, the inundation time of seawater and the stability of sediments.

Key words : coastal vegetation, *Suaeda japonica*, estuary, halophytes, intertidal flats, *Phragmites communis*, sand dune, *Tetragonia tetragonoides*.

1. Introduction

Vegetation type is affected by a climate and edaphic factors, and changed by abiotic or biotic disturbances. After a disturbance, the vegetation recovers along with time elapsed. The factors affecting the vegetation formation process on coasts differ from those on lands (Chapman 1964). Factors affecting coastal and sand dune vegetation are the inundation time of periodic seawater, the variation of soil salt contents with time and location, the influence of freshwater, and the stability of the sediment surface against to waves, tides and sea winds (Chapman 1964; Ranwell 1972; Beeftink *et al.* 1985).

The influences of these factors vary with the topography and sediment types of seashore. The coastline of South Korea forms a rias coast and the ratio of a real to a straight coastline length is large. Spits are many and vary even in size, so directions and intensity of waves and winds arriving at the coastline can vary in a narrow area. The particle size of seashore materials varies from clays to rocks. This heterogeneous environment in small areas makes vegetation to grow in a small patchy form. In cases where particle size is small and the soil surface is vulnerable to waves and winds, the vegetation can be rapidly changed.

In tidal flats and coastal sand dunes, vegetation not only increases the stability of the surface soil and landscape, but also provides animal habitats. The varied vegetation generated by these microenvironments increases species diversity in coastal ecosystems. Therefore, vegetation has a key role in the coastal ecosystems.

On the south and west coasts of Korea, intertidal flats are large and numerous. Recently, many reclamation projects have been conducted in these intertidal flats, so these areas have decreased abruptly. The coastline changes from sinuous to straight embankments. Sea sands are dredged for civil engineering. Reclamation projects and sea sand dredging alter the direction and intensity of currents, and the consequent erosion and deposition of sediments. Vegetation is reformed continuously corresponding to the intensity of these impacts. Moreover, vegetation is formed in the areas formed during short inundation times below

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the high-water mark, or on sand dunes which are vulnerable to developments for seaside resorts. Most of sand coasts have been developed into seaside resorts in south Korea. Therefore, natural sand dune vegetations remains only in a few areas. Conservation plans and ecological studies for the natural sand dune vegetations are urgently needed.

The coastal vegetation study in Korea was begun by Hong (1956). He reported on the halophyte communities formed at the intertidal flats in Incheon, and regarded the *Suaeda japonica* population as the typical vegetation in this area. Yim (1961) and Kim *et al.* (1975) studied the continuum structure of vegetation with the gradient of soil salt contents at the intertidal flats in Incheon. In these studies, *S. japonica* and *Suaeda maritimus*, *Limonium tetragonum* were counted as typical halophytes. In the 1980s, many vegetation topics on intertidal flats, reclaimed lands and coastal sand dunes were widely studied. Of these, vegetation with the gradient of soil salt contents and the classification of plant communities by plant sociological methods were studied at the intertidal flats on the west coast of Korea (Kim *et al.* 1982; Kim and Lee 1983; Ihm 1987; Kim and Ihm 1988; Ihm *et al.* 1995). Through these studies, relationships between halophyte communities and sediment properties, and community structures in intertidal flats were partly clarified. On the contrary to intertidal flats, studies on coastal sand dune vegetations were carried out on the west coast (Yim 1961; Lee and Chon 1983, 1984a), the south coast (Oh 1970; Kim *et al.* 1986), the east coast (Lee and Chon 1984b; Jung and Kim 1998) and Jeju Island (Park and Lee 1969), but they were meager in details. Because the vegetation of reclaimed lands is not natural and readily changes due to desalination after a few years, it differs from natural coastal vegetations, but the relationships between plant communities and the soil properties of the former are similar to those of the latter. Many studies on the vegetation of reclaimed lands have been conducted (Min *et al.* 1989; Min and Kim 1997a, 1997b, 1999a, 1999b, 2000). The results from two different habitats (intertidal flats and reclaimed lands) clarified the vegetation in saline areas. However studies on population dynamics of halophytes and the coastal ecosystem are few.

The aim of this paper is to introduce the coastal vegetation of intertidal flats, estuaries and sand dunes in south Korea, by location, vegetation types and species composition. We collected the data from 1996 to 2000, except in Jeolla province.

2. Results and discussion

Spatial distribution of coastal vegetation

In South Korea, the 14 localities with coastal vegetation were selected as shown in fig. 1. The vegetation areas per locality are roughly over 10,000 m^2 and the vegetation remains natural, even though they are partially disturbed by human activities.

On the east coast, sand dunes are long and narrow due to strong waves along the coastline. The sediments of the intertidal zone are mainly composed of sands, pebbles and/or rocks. The land side of the coast is steep and rocky. Plains and lowlands are used as croplands or villages. Shores composed of sands are used as public beaches. Coastal vegetation remains in areas out of bounds to

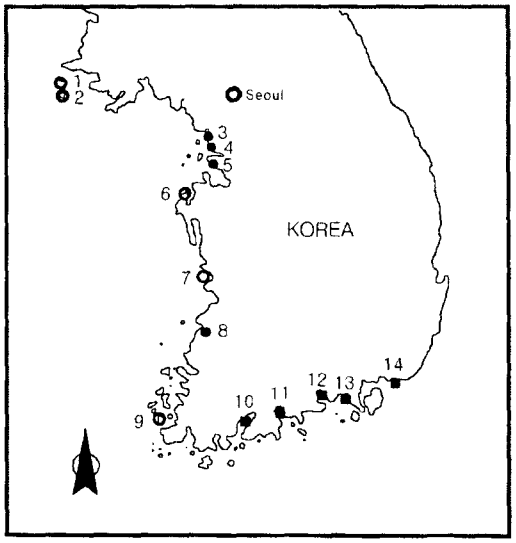

Fig. 1. Locations of main intertidal flats and sand dune vegetation. Open circles, solid circles and solid rectangles indicate sand dunes, intertidal flats and estuaries, respectively.
(1) Baengnyeong-myeon, Ongjin-gun, Incheon-si, (2) Daecheong-myeon, Ongjin-gun, Incheon-si, (3) Sorae, Siheung-si, Gyeonggi-do, (4) Namyang Bay, Hwasung-gun, Gyeonggi-do, (5) Daebudo, Ansan-si, Gyeonggi-do, (6) Sindu-ri, Wonbuk-myeon, Taean-gun, Chungcheongnam-do, (7) Biin-myeon, Seocheon-gun, Chungcheongnam-do, (8) intertidal flat Gomso Bay, (9) Ui-do. Docho-myeon, Sinan-gun, Jeollanam-do, (10) Boseong Bay, Boseong-gun, Jeollanam-do, (11) Suncheon Bay, Suncheon-si, Jeollanam-do, (12) Seomjin River, (13) Sacheon Bay, Sacheon-si, Gyeongsangnam-do, (14) Nakdong River, Busan-si.

unauthorized personnel by military facilities, and they are 2-3 m in width and 50-100 m in length.

On the west coast, waves are weakened by many spits, tributaries or large rivers streaming into the sea. Therefore, small soil particles are deposited as sediments in intertidal areas and the vegetation in the estuaries are affected by brackish water. However, due to the remarkably different tidal marks between ebb and flood, the sediments are unstable. Westerly winds in winter are strong and this energy moves sands to the land side. These sand particles cover the sand dune vegetation in winter. If the coastline is straight, the sand dune will be eroded by strong waves and the sand dune vegetation will disappear. The vegetation on intertidal flats or sand dunes are change able.

Reimold and Queen (1974) and Chapman (1975) suggested that the vegetation of the intertidal flats on the west coast is included in the Sino-Japanese group. The main species consisting of the vegetation are *Limonium japonicum*, *L. tetragonum*, *Suaeda japonica*, *Puccinellia kurilensis*, *Triglochin maritima*, *Salicornia brachystachya*, and *Atriplex gmelini*. We also agree with their suggestion.

Vegetation in intertidal flats

In the intertidal flats, vegetation are located in four localities such as Sorae, Namyang Bay, Daebu-do and Gomso Bay (Fig. 1). The main factors affecting vegetation formation are inundation times by sea water and current speed. In Sorae, sea water flows in and out through a big sinuous channel. Halophytes grow in the area which sea water directly influences. Because sea water flows slowly, the area covered by plants differs in inundation times by altitude. The surface of the sediments is greatly indented by tiny creeks. In most of the intertidal flats, *S. japonica* grows. Additionally, around the high-water mark or on the convex, *Aster tripolium*, *Artemisia scoparia* and *Carex scabrifolia* are distributed in irregular patches.

In Namyang Bay, the coastline is over 5 km, and an arm of the sea penetrates far into the land. The sediments of intertidal flats are composed of muds, and creeks are divided into several branches. The sediment type at the high-water mark is silts or fine sands. An area over 3 km^2 is covered with halophytes. Reasons why vegetation forms in broad intertidal flats include: shortening of inundation times due to the dam under construction in the outer sea, deposition of suspended particles and ascending altitude, and increasing freshwater influences on plants. In most of the areas *S. japonica* grows as in sorae. The density and plant heights of this species are inversely proportional to the distance from the high-water mark. Below the high-water mark, patch sizes and species composition of vegetation is not regular. The main vegetation species in this area are *S. japonica, Phragmites communis*, *C. scabrifolia*, *L. tetragonum* and *Zoysia sinica*. Each species is distributed on an exact altitude of sediments and pure stands form a sharp strip structure. In small areas, many halophytes grow and a typical coastal vegetation is formed. Therefore, this area is excellent as a study site for the population dynamics of halophytes and the interactions between physical factors and plants.

In Daebudo, the sediments are composed of silts and the surface of the intertidal flats is even. The *S. japonica* population is formed over 2 km^2 area. *Z. sinica* and *A. scoparia* grow around the high-water mark in a mixed patch form. Considering the deposition of particles, the area of vegetation may eventually increase. Gomso Bay consists of an arm of the sea penetrating far into the land and the estuaries of several small rivers. The sediments are mainly muddy. The intertidal flats near the land are used as a prawn nursery. The *S. japonica* population were formed in a large area in the past, but at present, it remains in only a small area. Inundation time, organic matters and sediment types affect proper habitats for halophytes. The productivity and species diversity of invertebrates living in the muddy bottom were very high in the past.

Vegetation in sand dunes

Sand dune vegetation is formed at the straight coastline in which sands are supplied by currents and winds. On the west coast of Korea, sand dunes are often developed in westward coasts. Typical sand dune vegetation is located in Baengnyeongdo, Daecheongdo, Sinduri, Biin Bay and Uido as shown in (Fig. 1). In addition, Seungbongdo, Sapsido and several uninhabited islands have undisturbed vegetation in a narrow area. The sand dune in Baengnyeongdo is very long and stable. *Vitex rotundifolia* makes up a pure stand 7 m wide and 200 m long. Vegetation composed of this species is regarded as the climax of a heathland succession in Korea. This vegetation is undisturbed at present, but may be disturbed by human impacts in the near future by developments as a public beach. There are two sand dunes in Daecheongdo. One is very large and planted with pine tree *Pinus thunbergii*. The other is narrow and long, and its sediments are unstable. But its vegetation is not disturbed. Dominant species is *Carex kobomugi*. Besides this, *Elymus mollis*, *Messerschmidia sibirica*, *V. rotundifolia*, *Glehnia littoralis* and *Calystegia soldanella* grow in a mixed form.

A pure stand of *V. rotundifolia* may be a formed in the near future, but the coast became under a development as a public beach in 1999.

The sand dune of Sinduri is encircled by two long capes running out into the sea at two ends. The sediments are composed of sand particles. At present, fine sand particles move from sea to land by winds, especially in winter. Therefore, the surface of the sand dune is unstable and vegetation changes from time to time. Also, human impacts (e.g. resort facilities, living quarters and pasturage) have impacts on the vegetation. The domiant species growing in the sand dune are *C. kobomugi*, *E. mollis*, *M. sibirica*, *V. rotundifolia*, *G. littoralis*, *C. soldanella*, *Cynodon dactylon*, *Ischaemum anthephoroides*, *Lathyrus japonica*, and *Rosa davurica*. Most of the plant species growing naturally on the sand dune of Korea have also been found in Sinduri.

A narrow and long sand dune is formed on the Biin Bay. The slope below the high-water mark is steep and vulnerable to waves. *P. thunbergii* grows on the inland side of the sand dune. The sand dune vegetation is formed between the *P. thunbergii* forest and the high-water mark. In this area, the sand dune plants such as *C. kobomugi*, *E. mollis*, *L. japonica*, *C. soldanella* and *Carex pumila*, and the glycophytes of *Imperata cylindrica* var. *koenigii*, *Bromus japonicus*, *Agropyron tsukushiense* var. *transiens* are found. This sand dune may also be disturbed by either natural or human impacts. The sand dune of Uido is formed in the direction of south to north. Two long spits from the two end points penetrate far into the sea. The sand dune is protected by these spits and its vegetation is natural. The vegetation area is 700 m long and 100 m wide. The main species are *I. anthephoroides*, *V. rotundifolia*, *Zoysia macrostachya*, *C. soldanella* and *M. sibirica*. This area is an appropriate study site for sand dune plants.

Vegetation in estuaries

On the south coast, the coastline is long and complex and the land is mainly composed of a rock face. Coastal vegetation is formed at an estuary which penetrates far into the land. The sediments of this area are composed of muds because of weak waves, and the influence of freshwater is relatively high. Also, the inundation time by seawater is short and the current is speedy. The locations in which appreciable vegetation is formed are Boseong Bay, Suncheon Bay, the estuary of the Seomjin River, Sacheon Bay and the estuary of the Nakdong River (Fig. 1). Except in Sacheon Bay, the dominant species of coastal vegetation is *P. communis*. The reason why *P. communis* grows dominantly in these areas is the result of environmental fitness to this species. That is, as described above, mud is commonly high in field capacity and water to the root system is sufficient for plant growth. Also, freshwater and the organic matters derive from the inland and *P. communis* itself raises the growth of this species. Because *P. communis* is larger in root biomass and taller in height than other species, this species dominates when it competes with others. *C. scabrifolia* and *Scirpus planiculmis* grow poorly within the *P. communis* population and form pure stands only on the periphery of the latter. The estuary vegetation of Sacheon Bay is similar to that of the western intertidal flats. The vegetation is formed narrowly and long along the two riversides. There is no human impact on the vegetation. The vegetation is still natural.

Dominant halophytes and their geographical distribution

Halophytes and sand dune plants can be classified into four groups:

1) plant species growing on intertidal flats of mud or fine sand are *S. japonica*, *Z. sinica*, *P. communis*, *C. scabrifolia* (or *C. rugulosa*), *T. maritimum*, *Scirpus triqueter*, and *S. planiculmis*.

2) around the high-water mark, *L. tetragonum*, *A. scoparia* (or *A. fukudo*), *A. tripolium*, and *S. herbacea* grow with the intertidal flat plants.

3) *Sonchus brachyotus* and *Phacelurus latifolius* inhabit in the areas where the sediments are muds and where there is no direct influence of sea water.

4) on the sand dunes, there are *Salsola komarovi*, *A. gmelini* (or *A. subcordata*) of annual herbs; *E. mollis*, *C. dactylon*, *I. anthephoroides*, *C. kobomugi*, *C. pumila*, *T. tetragonoides*, *L. japonica*, *C. soldanella*, *M. sibirica*, and *G. littoralis* of perennial herbs; and *R. rugosa* and *V. rotundifolia* of woody plants.

Most species of the four groups commonly grow in the intertidal flats and sand dunes of South Korea regardless of latitude. This is likely due to the difference of latitudes between the north and the south which is about 4° (34.3-38.5°N). Among them, *C. dactylon* and *Tetragonia tetragonoides* are mainly distributed on the southern coast of Korea, and have a north limiting line (Figs. 2 and 3).

Except islands, the geographical distribution of *C. dactylon* is shown in fig. 2. This species is distributed in Jeolla province, rarely in Sinduri, Chungcheongnamdo in the west coast, and Gyeongsang province, rarely in

Donghae city, Gangwondo on the east coast. This species grows on unstable sand dunes and is mainly reproduced by stolons which run on the soil surface. Roots penetrate 15 cm in depth and stolons grow a few meters per year. Because the plant height is below 30 cm and biomass is relatively little, this species is unfavorable in a competition with others. Also, this species grows at the nearest area to seawater and is the pioneer on newly formed sand dunes. Therefore, this species forms small patches on bare sand dunes and its population varies year by year in the same area. The main factor affecting the distribution of this species is probably the moisture content of the surface soil.

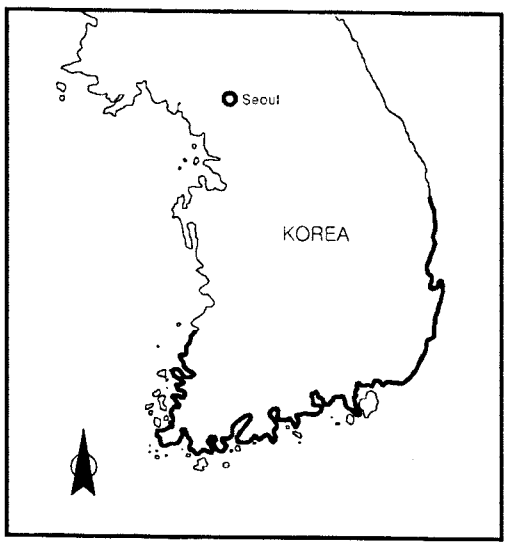

Fig. 2. Geographical distribution of *Cynodon dactylon* in Korea.

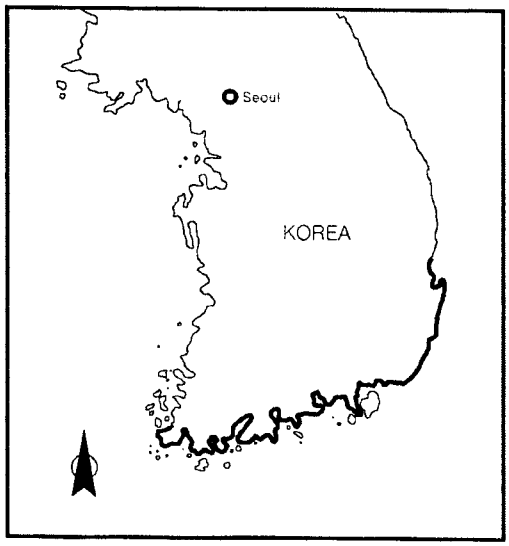

Fig. 3. Geographical distribution of *Tetragonia tetragonoides* in Korea.

The geographical distribution of *T. tetragonoides* is shown in fig. 3. This species is mainly distributed on the south coast of Jeollanamdo and Gyeongsangnamdo, partly in Sijindo, Chungcheongnamdo on the west coast and rarely in Sogcho, Gangwondo on the east coast. This species is a perennial and succulent plant which grows on sand dunes or pebbles above the high-water mark. Also, reproduction is carried out not by vegetative propagation but by seeds (Lee 1999). An individual plant produces 10-20 seeds of a relatively large size per year. Because of the harsh environment of the seed bed, only a small number of seeds might germinate. The patch population is small and irregular.

By the fact that the two species mentioned above are distributed mainly on the south coast, it is assumed that they need a warm temperature climate for over-wintering of the vegetative parts. Generally, the south coast is regarded as a warm temperature forest zone (Yim 1977), and the distribution area of the two species is similar to counterpart forest.

Typical zonation patterns of coastal vegetation

On intertidal flats and sand dunes that have little disturbance by humans, the typical types of coastal vegetation in Korea are shown in fig. 4.

The intertidal flats where there is no influence of freshwater, and where the inundation period by seawater is below 8 times per day are vegetated by *S. japonica* (A-1, A-3 of fig. 4). The density and plant heights of this population decrease proportionally to the distance from land. At the high-water mark, this species is tall in plant heights and is high in density. Also, its color varies from green to red in proportion to soil salt contents or sea water influences. The density of this species is various, ranging from 1 to 700 inds./m^2. There is no plant on the banks of creek. This phenomena may be related to seed dispersal. That is, the currents of ebb and flow interfere with embedding and germination of seeds in sediments.

Z. sinica grows on the convex area of intertidal flats (A-2 of fig. 4). *Z. sinica* population is often formed around the high-water mark. This species prefers sands to muds. *A. scoparia* and *L. tetragonum* often grow within patches of *Z. sinica*. By this fact, three species are believed to prefer a similar habitat. The *C. scabrifolia* (*C. rugulosa*) population follows the *S. japonica* population to the high-water mark (A-4 of fig. 4). This species forms either a

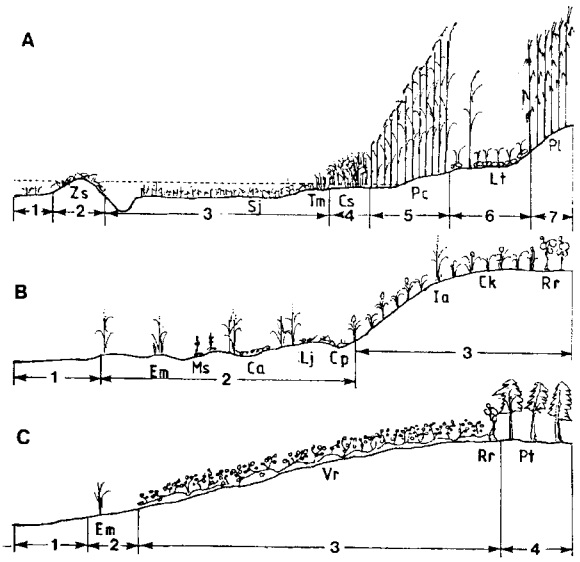

Fig. 4. Typical zonation patterns of coastal vegetation in the intertidal flats and sand dunes of South Korea. Number indicates vegetation.
(A) intertidal flat, (B) unstable sand dune, (C) stable sand dune
Ca; *Calystegia soldanella*, Ck; *Carex komarovi*, Cp; *Carex pumila*, Cs; *Carex scabrifolia*, Em; *Elymus mollis*, Ia; *Ischaemum anthephoroides*, Lj; *Lathyrus japonica*, Lt; *Limonium tetragonum*, Ms; *Messerschmidia sibirica*, Pc; *Phragmites communis*, Pl; *Phacelurus latifolius*, Rr; *Rosa rugosa*, Sj; *Suaeda japonica*. Tm; *Triglochin maritimum*, Vr; *Vitex rotundifolia*, Pt; *Pinus thunbergii*, Zs; *Zoysia sinica*.

pure stand or mixed community with *P. communis*. This species is 30-50 cm in height, 5-10 cm in rhizome depth, and 30 cm in root depth. *T. maritimum* grows around or in the *C. scabrifolia* population. *T. maritimum* is 20 cm in height and 10 cm in root depth. Because this species reproduces a short rhizome, populations form dense and circular patches in the early stage, but sparse and diverse ones in later stages after elapsed time.

The *P. communis* population follows the *C. scabrifolia* one. The height of *P. communis* is 40 cm on the periphery of the population but increases as it shifts toward land, reaching 250 cm at outlets of freshwater. Plants over 300 cm can grow in the estuary where many organic matters flow in with the freshwater (A-5 of fig. 4). The *P. commuis* population in equilibrium is 100-200 inds./m^2 in density and 2,500 g · DW/m^2 in maximum biomass. The roots and rhizomes of *P. communis* spread to 50 cm in depth but sometimes to 200 cm. Many species grow around the high-water mark. There are *T. maritimum*, *Z. sinica*, *C. scabrifolia*. *L. tetragonum*, *A. scoparia*, *A. tripolium*, and *P. communis*. The patch sizes, plant heights and biomasses of these species depend upon the influence of freshwater. That is, there are *A. scoparia* and *A. tripolium* in xeric areas, *T. maritimum* in surface of freshwater, *C. scabrifolia* in 10-20 cm depths, and *P. communis* at th 40 cm depth. Even though freshwater flows on the sediment surface, it influences root systems of deep sediments by gravitation. *P. communis* forms a narrow and long population along freshwater ditches.

Small patches of *A. scoparia* (*A. fukudo*), *L. tetragonum*, *A. tripolium*, *S. herbacea*, and *Z. sinica* are formed above the high-water mark (A-6 of fig. 4). These areas have no direct fresh or seawater influence, and they are high in salt and low in water contents of the sediment. This environment is adverse to *P. communis*, *T. maritimum*, and *C. scabrifolia*. Even though the former are weaker than the latter in a competition, the former can probably grow in these areas. Because *A. scoparia* and *A. tripolium* demand especially, a high intensity of sunlights, these species can't grow under the shade of other plants. *Phacerulus latifoilus* grows in area where there is no direct sea water and high soil salt content. This species is similar to *P. communis* in plant heights and biomass per unit area, but dissimilar in root system which is distributed to a 30 cm depth. This species growth is affected by a moisture content of the surface soil. The potential for vegetational reproduction by rhizome is high but it is vulnerable to soil moisture. In the southern area of Korea, this is a dominant species (Kim and Ihm 1988).

As previously described, most of sand dunes in Korea are unstable due to erosions and deposition from waves and sea winds. The vegetation is dependent upon the stability of the sand dune. In this paper, we suggest that the vegetations is divided into two types according to the stability of the sand dune (Figs. 4B and C).

First, a typical vegetation type on the unstable sand dunes is shown in B-1 of fig. 4. *S. planiculmis*, *Z. sinica*, and *C. scabrifolia* can grow, but normally there is no plant, because there is a strong wave. The topography of the high-water mark changes from time to time and the vegetation of this area is very irregular (B-2 of fig. 4). Dominant species in this area are *C. soldanella*, *C. pumila*, *E. mollis*, *L. japonica*, *M. sibirica*, and *G. littoralis*. These species produce many seeds. But germination rates are low under natural conditions of harsh environments. Under favorable conditions, many seedlings appear around the maternal plants. Generally, these species reproduce vegetatively by rhizome or by roots.

The root systems of *C. soldanella*, *C. pumila*, *E. mollis*, and *L. japonica* are within a 30 cm depth and spread a few meters per year. The direction of the spread of the root systems is related to soil moisture content, forming a guerilla-type. In xeric conditions, roots and the above ground parts die. These species are adapted to some extent for the deposition of sands. But the plants die by exposure of root system to air, in case the sand dune erodes. Because the root system of *C. pumila* is especially located at 5 cm depth, this species is very vulnerable to soil erosion. The roots of *M. sibirica* and *G. littoralis* are straight and grow up to 1 m of length in case of sand depositions, but grow horizontally in case of erosion. These species mostly reproduce by seeds.

By shifting from the high-water mark to land, *C. kobomugi* forms the population with a sparse density (B-3 of fig. 4). The height of this species is about 25-40 cm. Its shoots bend in a sparse density but are straight in a high density. These forms are related to the reception of sunlights (Ishikawa and Kachi 1998). The maximum above ground biomass of this species amounts to 200 $g \cdot DW/m^2$. This value might be large for its height. The rhizomes of *C. kobomugi* spread freely upward or horizontally depending on the movement of sands. This is regarded as the fittest species of the all sand dune plants (Lee 1999). The reproductivity or viability of its rhizomes are high and strong. In the *C. kobomugi* population, *I. anthephoroides*, *R. rugosa*, *G. littoralis*, *C. soldanella*, and *Scutellaria strigillosa* grow to form mixed communities. These communities are followed by glycophytic ones.

Second, on stable sand dunes, *V. rotundifolia* forms pure stands (C-2 of fig. 4). Because this species is a shrub and, a long time is needed for forming the pure stand. *C. kobomugi* or *C. soldanella* can grow in this population but *V. rotundifolia* excludes other herbacious plants and pure stand of this species are maintained for a long time. There are *C. soldanella* and *E. mollis* on the seaside (C-1 of fig. 4) and *P. thunbergii* on the landside (C-3 of fig. 4) of this population. The former grows in a narrow area and its population is very changeable. The latter is followed by a land vegetation. The reason why *V. rotundifolia* is the climax species is because this species is tolerable to high salt content in the sediments and strong sea winds, and it has a high growth rate.

3. Conclusion

Of the factors affecting formation of coastal vegetation, salt is the most important factor. And the contents of fresh or seawater, stability of sediments and inundation time also influence coastal vegetation. The influence of these factors varies within a small area and it results in a diversity of vegetation.

In South Korea, most of coastal vegetation has recently been seriously degraded. The 14 localities which have relatively natural coastal vegetation were found and described. These areas are classified into three different habitats - intertidal flats, sand dunes and estuaries. Typical types of coastal vegetation depend on sediment types, inundation time of sea water and stability of sediments. There are four intertidal flats, five sand dunes and five estuaries.

Except *Cynodon dactylon* and *Tetragonia tetragonoides*, all of the main halophytes and sand dune plants are distributed on the coast of South Korea. These two species are mainly distributed on the southern coast and their distribution area is consistent with a warm temperature forest zone.

Generally, vegetation is pure stands of *Suaeda japonica* on intertidal flats, mixed halophyte communities around the high-water mark, pure stands of *Vitex rotundifolia* on stable sand dunes, mixed communities dominated by *Carex kobomugi* on unstable sand dunes, and pure stands of *Phragmites communis* at estuaries.

The coastal vegetation has been disturbed by human impacts that damage coastal habitats. For restoration of coastal vegetations, the influences of fresh and seawater, the intensity of waves and winds, and the stability of sediments should be comprehensively considered. Ecological restoration of degraded coastal ecosystems may also be focussed on the control of some factors affecting a formation of coastal vegetation.

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