INTRODUCTION

Where the land meets the oceans and seas it is called the *seashore* or *beach.* The beach begins in the sand dunes above the high tide mark, the farthest point where the sand has been carried by wave action. The beach extends to the depth beyond which the wave action does not have sufficient force to move the sand particles. That is the point where the waves break.

The Psammophytes are plants, which are adapted to grow successfully in sandy areas. Along coastal Karnataka the beaches form the major habitats for Psammophytes. The coast is indented with numerous river mouths, lagoons, bays, creeks, promontories, cliffs, spits, sand dunes and long beaches. There are about 90 sandy beaches along coastal Karnataka, which form the major habitats for coastal Psammophytes plants.

Vegetation of the beaches: The beach or strand area is characterized by maritime climate, salt spray, and sand blast by winds and azonal soil with a low organic content. The prevailing climate along the shore of Karnataka is sub-humid. Although a number of species may be associated with the sea beaches only some species show fidelity to the beach or strand habitat.
Beach Vegetation*: The beaches are carpeted with beach vegetation otherwise called as strand Vegetation, mainly consisting of berbs to arborealtrees. This vegetation is mainly observed along the Karwar & Mangalore coast, where the beaches are wide and extensive.*

Beach Plantations: All along the beaches rectangular shaped, characterized with cherry red tone features were identified as beach plantations, comprising of Casuarina, grown under afforestation programme to protect the coast. They were predominantly seen along the Mangalore Udupi, Honnavar & Karwar area.

Other Vegetation: It comprises of swamp/marsh / coconut plantation. Scrub vegetation, within the confluence of the wetland, related to the phenomenon of regression of the sea. They may be sites of older mudflats, which are under the sea in the age past.

Beaches of Coastal Karnataka: There are also 90 beaches with varying aesthetic potential. Among these, the beaches at Someshwar-Ullal, Malpe, St. Mary Island, Belekeri and Karwar have excellent potential for international tourism. Om Beach and Kudle Beach of Gokarna are few others to this list. About 22 beaches are considered unfit for such use due to coastal erosion, human settlements and activities linked to port/harbour, industries and fisheries.

Problems of beaches of Karnataka: The major problems that are detrimental to the beach ecosystems of Karnataka are the following:

1. High density of population
2. Coastal erosion
3. Littering of beaches
4. Poor sanitary conditions
5. Disappearance of native vegetation

Beach Survey: Selected beaches representing all the districts of coastal Karnataka (Dakshina Kannada, Udupi and Uttara Kannada) have been surveyed. The beach survey was

done more intensively in Dakshina Kannada and Udupi districts, on account of the flatter terrain, and more number of sandy beaches. Uttara Kannada coast is very hilly, the promontories often breaking the continuity of sandy beaches. As our survey was confined to psammophytic plants, which grow only in sandy areas, we have not considered the rocky parts coast. Moreover, in Uttara Kannada, most beaches of Karwar have come under the jurisdiction of the Project Seabird Naval Base, a high security zone, and therefore could not be brought under the current study.

Some notable plant species for beach restoration

Pandanus spp. (fam: Pandanaceae), Calophyllum inophyllum (fam: Clusiaceae), Borassus flabellifer (fam: Arecaceae), Morinda citrifolia (fam: Rubiaceae), Pongamia pinnata (fam: Fabaceae), Erythrina variegata (fam: Fabaceae), Canavalia spp. (fam: Fabaceae), Ipomoea pes-caprae (fam: Convolvulaceae), Spinifex littoreus (fam: Poaceae), Cyperus pedunculatus (syn: remiera maritima) (fam: Poaceae)

CHAPTER-1
BEACHES: HABITATS OF COASTAL PSAMMOPHYTES

Where the land meets the oceans and seas it is called the *seashore* or *beach.* The word 'beach' is used by most people to the sandy area that separates the sea from the land. In fact this sandy area is only a part of the beach system. The beach begins in the sand dunes above the high tide mark, the farthest point where the sand has been carried by wave action. The beach extends to the depth beyond which the wave action does not have sufficient force to move the sand particles. That is the point where the waves break.

From the point where the sand dunes are stabilized to a certain extent, the *backshore* region of the beach starts and extends down to a sudden change in slope, known as the beach *scrap*. The backshore generally contains one or more horizontal sloping portions called *berms*. From the scrap, the beach slopes seawards and is known as the foreshore. The foreshore extends from the high water to the low water line, and may have continuous slope or a low tide terrace. Beyond the low tide level is the offshore, which is always submerged-Figure1.1 (Mukherjee, 1996).

The U.S. Environmental Protection Agency (1998) defines a beach as "the area of unconsolidated material, such as sand, pebbles, or rocks, that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves)." In other words, a beach is the sandy, pebbly, or rocky shore of a body of water. The water body may be even a lake or estuary.

1.1 Formation of dunes and dune fields

Sand dunes are narrow but important areas of sand that lie between the sea and the land. Dunes are associated with characteristic natural plant communities. Dunefields are formed above the beach as dry sand blows inland. An impressive dunefield of New Zealand stretches 130 kilometres from Paekakariki to Patea on the west coast of the North Island, and up to 19 kilometres inland. Wide, gentle-sloping beaches are framed by fore dunes, formed when wind-blown beach sands become trapped by plants and driftwood on the beach. If there is a ready supply of sands on the beach, more dunes may develop in front of the original. The dunes further back may be stabilised by plants, or blown inland if they fail to retain a good plant cover.

Vegetated sand dunes are very effective for coastal safety. They protect the coast from flooding and erosion from waves. These dunes absorb the erosive energy of waves and tides, generated by cyclones and storms, and are reservoirs of sand to replenish the beach during periods of wave erosion. Vegetation on the dunes traps and holds sand blown from the beach aiding dune build-up and stopping sand from being blown inland (McHarg, 1972; Arun et al, 1999). Plants that grow in sandy places are known as *psammophytes*.

The sand dunes form a buffer that is sometimes built up by accretion of more sand and eroded at other times. This may happen cyclically by various natural forces and phenomena including climatic change. The changes along the shoreline caused by storms and climatic vagaries are of short-term nature, and the shoreline may recover within decades. Sea level rise due to climatic changes can change the position of the shoreline for ages. The dune vegetation helps in keeping the coastal land free from erosion. Any damage to the dune system cause serious disaster to the inner land by erosion, which could be difficult to

redeem. Stabilized sand dunes, natural safety barriers of beaches, are the contribution of psammophytes, at no cost to human economy. These plants may be herbs, shrubs or trees, or creepers or even fungal filaments, which aggregate sand particles.

Coastal lands and sediments are in fact constantly in motion. Breaking waves transport the sand along the coast. They also transport the eroding sand one area and deposit on another adjacent beach. Tidal cycles carry sand onto the beach and bring it back to the surf. Sediments are carried to the coast by rivers, which results in building deltas into the open water. Storms cause deep erosion in one area and leave thick overwash in another (Venkataraman, 2003). A management strategy for the coast, which has the highest population density, and developmental pressures, needs a thorough understanding of the dynamics of the land-sea interaction.

1.2 Micro-environment of sandy beaches

Coastal sand dunes, the world over, have been considered as a specific ecosystem due to several common environmental features. They constitute a variety of microenvironments due to shifting nature of sands and various physical processes. Plants establishing on coastal sand dunes are subjected to several environmental fluctuations that affect their growth, survival and community structure. The most important factors include temperature, desiccation, low moisture retention, soil erosion, sand accretion, soil salinity, salt spray, changes in organic matter and pH (Arun et al., 1999; Moreno-Casasola, 1982; Maun, 1994).

Among the dune plants of Karnataka coast are *Spinifex littoreus*, a hardy spinous grass, which spreads by runners. Along with it grow a sedge *Cyperus arenarius*, and other spreading herbs *Launea sarmentosa, Sesuvium portulacastrum* etc. The dunes form a natural habitat for the ivy *Ipomoea pes-caprae* and a leguminous creeper *Canavalia rosea.* Notable of the shrubs and trees, very effective in beach protection, are *Pandanus* spp., *Calophyllum inophyllum*, *Erythrina variegata, Morinda citrifolia* etc. The plantations of the exotic *Casuarina,* raised in many places along the coast, are effective in shore protection, although they are not adequate replacements for indigenous floral elements integral to the beach ecosystem. The coastal dunes provide home and food for several small animals such as insects, spiders, butterflies and moths and lizards. The animals in turn provide food for coastal birds.

Figure 1.1. A horizontal sand dune (berm), on backshore of Uppunda beach, stabilized by psammophytes Ipomoea pes-caprae (green creepers) & Spinifex littoreus (in front).

Figure 1.2. Continuous sloping foreshore at Belekeri beach.

1.3 Threats to beach ecosystem

The beach is a sensitive, dynamic environment that provides habitat for a variety of plants and animals and microorganisms. Excessive use of the beach can lead to the gradual degradation of habitat. The beach vegetation and coastal sand dune system throughout the world are under increasing threat from pressures of population, developmental activities, tourism etc. Whereas the dunes are adapted to natural coastal processes, they are fragile and easily damaged by human activities. Along the Karnataka coast, local historical accounts reveal that there was good vegetation once upon a time and making stone barriers was not needed to safeguard from sea erosion. The seaward face of the sand dunes was well carpeted with grasses, sedges and creepers and the dunes more inland covered with characteristic shrubs and trees. The relic vegetation present today along the beaches is indication enough of their rich vegetational history.

Today substantial portions of the natural vegetation have perished almost everywhere due to direct removal sand and other alterations of dunes, trampling, grazing by cattle, or hacking for fuel. As population pressure increased, agricultural fields were carved out in sand dunes and habitations mushroomed leaving not much interphase between the sea and the land. The protective action of this valuable buffer zone diminished substantially, in most places, necessitating artificial protection measures like sea walls made of stones. These stone barriers are detrimental to the functioning of beach as an ecosystem. The walls often interfere with natural plant succession along the beaches; they reduce the aesthetics of the coast and hamper promotion of coastal tourism. The seawalls also are expensive to build unlike the protection to life and property freely provided by natural dunes stabilized by local vegetation.

Frequent boat traffic too close to the shoreline, can cause excessive wave action that can lead to beach erosion. Trash dumped from boats can be washed up onto the beach, posing a threat to human and marine species. When boat sewage is not disposed of properly, pathogens and nutrients can enter the water, degrading water quality.

Pollution of coastal environments threatens the use of beaches as an economic, recreational, and aesthetic resource. Impacts can result from activities occurring on the beach itself or from points within the coastal watershed that drain to an area of the beach. Marine debris, such as litter left on the beach after a picnic, is an example of a local impact. Some typical impacts from activities farther up in the watershed include poor water quality from excessive nutrients (in the form of fertilizers draining from lawns or agricultural fields within the watershed); and from litter washed into storm drains and eventually reaching the beach. Litter can make it unsafe to walk on the beach; pathogens or algae blooms can make it unsafe to swim; and other pollutants can make it unsafe to eat the fish or shellfish caught from the waters (U.S. EPA, 1998).

Marine debris is trash floating on the ocean or washed up on beaches. It comes from many sources, like beachgoers, improper disposal of trash on land, storm water runoff to rivers and streams, ships and other vessels, and offshore oil and gas platforms. Marine debris can seriously affect wildlife, the environment, people, and economy. Communities can lose considerable income when littered beaches must be closed or cleaned up.

An excessive amount of nutrients from land -based sources such as failing septic tanks, sewage treatment plants, boating wastes, deposition from air, industrial organic waste

discharge, and contaminated runoff from fertilized farms or yards or from animal feeding operations can adversely affect the beach. Some of these impacts include harmful algal blooms and fish kills. Outbreaks of the toxic microorganism *Pfiesteria piscicida* have been linked to excessive nutrients in the affected waters.

Pathogens threaten human health and cause beach closures. The most frequent sources of disease-causing microorganisms, or pathogens, are sewage overflows, polluted storm water runoff, sewage treatment plant malfunctions, boating wastes, and malfunctioning septic systems. Swimming in or ingesting waters contaminated with pathogens can result in human health problems such as sore throat, gastroenteritis, or even meningitis or encephalitis. Pathogens can also contaminate shellfish beds.

India has a 7516 km long coastline of which the mainland has 5422 km, Lakshadweep 132 km and Andaman and Nicobar Islands 1962 km. Nearly 250 million people live within a distance of 50 km from the coast. The coastal area is assuming greater importance in recent years, owing to increasing human population, urbanization and accelerated developmental activities. More than half of the Indian coast is sandy. Beach/spit as a major ecosystem/habitat category cover 1465 sq km of the coast. Beach vegetation covers 290 sq. km and coastal dunes cover 2509 sq km (Venkataraman, 2003).

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CHAPTER – 2
PSAMMOPHYTES OF COASTAL KARNATAKA

Karnataka's coastline extends over a length of 320 km. The coast is indented with numerous river mouths, lagoons, bays, creeks, promontories, cliffs, spits, sand dunes and long beaches. There are about 90 sandy beaches along coastal Karnataka, which form the major habitats for coastal psammophytic plants. Because of high density of population and various developmental pressures the beaches of Karnataka are being subjected to soil erosion. It is estimated that 60 km of beach (19% of total length of shoreline) is confronted with appreciable or severe erosion (*State of the Environment Report and Action Plan – 2003*).

The psammophytes are plants, which are adapted to grow successfully in sandy areas. Along coastal Karnataka the beaches form the major habitats for psammophytes. Along the sandy beaches the psammophytes have to cope up with also high salinity. There are not many works on the beach vegetation of Karnataka. However, glimpses of the vegetation are found in various coastal ecological works by Rao (1971), Rao and Sastry (1972, 1974), Rao and Sherieff (1992), Rao and Meher Homji (1985) did some good work on the strand plant communities of the Indian sub-continent. Arun et al. (1999) published a small account on the coastal sand dune plants of Karnataka with special reference to legumes. By far, the most outstanding work on the beach vegetation of Karnataka coast is of Rao and Sherieff (2002).

The beach is an area of distinct physiographic unit and forms a unique ecosystem of the coastal zone. The term "strand" is applied to this zone in place of the commonly used term "beach". The part of the beach that lies between the ordinary low and high tide is considered as "foreshore" and that part of the relief immediately beyond the high water mark constitutes the "backshore". The width of the foreshore in Karnataka varies from few to 200m, and the backshore width ranges from 100 to 600 m (Rao and Sherieff, 2002). The Karnataka shoreline is classified as strand shoreline, Cliffed shoreline without a beach and cliffed shoreline with a beach. Shifting sand dunes are of very rare occurrence along the coastline.

2.1 Vegetation of the beaches

The beach or strand area is characterized by maritime climate, salt spray and sand blast by winds and azonal soil with a low organic content. The prevailing climate along the shore of Karnataka is sub-humid. Although a number of species may be associated with the sea beaches only some species show fidelity to the beach or strand habitat (Rao and Sherieff, 2002).

On the basis of 49 beaches surveyed for vegetation during the current study and based on existing accounts the notable fidelity species of the sandy beaches of Karnataka are the following:

a. Sand binding creepers and spreading herbs: Plants of this category are very tolerant of the exposed conditions of the beaches and high salinity. These plants spread along the sand rooting at nodes. They could be seen from the tree line along the backshore to almost the high tide mark. Notable species are *Ipomea pes-caprae* (Figure 2.1), *Spinifex littoreus* (Figure 2.2), *Launea sarmentosa*, *Hydrophylax maritima* (*Remiera maritima*), *Cyperus pedunculatus*, and *Canavalia rosea* (Figure 2.3). Along with them may be found smaller spreading herbs like *Sesuvium portulacastrum* (Figure 2.4), *Euphorbia hirta*, *Glinus oppositifolius* (Figure 2.5) etc. *Cassytha filiformis* (Figure

2.6), an orange to yellow coloured parasitic twiner is sometimes plentifully present along with the creepers forming thick mats. All these species play major role in arresting the movement of sand; they can tolerate burial in sand to certain extent.

b. Erect herbs: Notable of the many herbs associated with the exposed part of the beach, more towards the land are: *Aerua lanata* (Figure 2.7), *Alternanthera sessilis* (Figure 2.8), *Boerhaavia diffusa, Borreria articularis, Dacytloctenium aegyptium, Sporobolus virginicus, Pedalium murex, Crotalaria retusa* (Figure 2.9), *C. verrucosa* (Figure 2.10), *Urginia indica, Crinum asiaticum* (Figure 2.11) etc.

c. Rainy season herbs: Profusion of herbs appears along the sea beaches when the salinity is lowered during the rains. Most of these flower and fruit during September-November period and complete there life or persist for longer time in shade and in wet spots. Some of them perennate also by their underground parts. These include *Acrocephalus hispidus, Corchorus capsularis, Cyperus* spp. *Emilia sonchifolia* (Figure 2.12), *Epaltes divaricata, Vernonia cinerea* (Figure 2.13) *Eragrostis amabilis, Achyranthes aspera* (Figure 2.14) *Evolvulus alsinoides* (Figure 2.15), *Fimbristylis* spp., *Geissaspis cristata, Hedyotis herbacea, Leucas aspera* (Figure 2.16)., *Lindernia* spp., *Melothria corchorifolia, Murdannia spirata, Polycarpaea corymbosa, Pycreus pumilus, Sesamum indicum, Waltheria indica* etc. Most of these are not fidelity species and they are herbs with wider distribution other than in beaches also.

d. Shrubs: Some shrubs are, characteristically, part of the beach flora. Of these *Scaevola taccada* (Syn: *Scaevola sericea*) (Figure 2.17-18) is mainly in the beaches of Dakshina Kannada-Udupi region and *Vitex trifolia* (Figure 2.19) mainly in Uttara Kannada beaches. Some of the widespread shrubs like *Vitex negundo, Calotropis gigantea* (Figure 2.20) and *Clerodendrum inerme* (Figure 2.21) also occur along the beaches towards the landward side. *Pandanus odoratissimus* (Figure 2.22-23) is a spectacular species along the seashores of the State. With its bushy habit and stilt/prop roots it plays very important role in shore protection.

e. Climbers: A woody leguminous climber *Derris trifoliate* (Figure 2.24) occurs along some of the beaches. In fact it is more common element associated with the mangrove community. *Gloriosa superba* could be seen occasionally amidst the bushes, particularly in Uttara Kannada. *Cucumis sativus* (Figure 2.25), a cultivated cucurbit, the fruit of which is used as vegetable, is seen wild (probably an escape from cultivation) in Dandbagh beach of Karwar. The wild snakegourd, a rare climber of medicinal value and wild relative of the cultiavated snakegourd *Trichosanthes anguina* is seen in Apsarknonda beach. *Dioscorea bulbifera* is found in many beaches.

f. Trees: Characteristic trees along the beaches are *Calophyllum inophyllum* (Figure 2.26-27), *Erythrina variegata, Ficus racemosa, Pongamia pinnata,* etc. *Thespesia populnea* (Figure 2.28) and *Morinda citrifolia* (Figure 2.29) are occasionally present in some of the beaches. The exotic *Casuarina equisetifolia* (Figure 2.30) is very adapted to the beaches and plantations of this species are raised in several coastal areas. The more recent introduction to the beach trees is another exotic *Acacia auriculiformis.*. The palmyra palm *Borassus flabellifer* is found close to the sandy shores of Dakshina Kannada and Udupi districts. A couple of small trees are found in the Ramangindi beach of Kumta taluk in Uttara Kannada.

A general checklist of the beach plants and their talukwise distribution are furnished in the Table 2.1. It is, by no means, an exhaustive checklist. In fact the beaches need to be surveyed more intensively and seasonally to get a more complete data on their vegetation.

Table 2.1. Psammophytic (beach) vegetation of coastal Karnataka

Sl. No.	Species	Family	MLR	MLK	UDP	KUN	BHT	HNR	KMT	ANK	KRW
1	Hygrophila schulli	Acanthaceae						P			
2	Justicia procumbens									P	
3	Rungia parviflora				P						
4	Sesuvium portulacastrum	Aizoaceae	P	P	P	P					
5	Achyranthes aspera	Amaranthaceae	P	P	P	P					P
6	Aerva lanata		P	P	P	P					
7	Alternanthera sessilis		P	P	P	P					
8	Crinum asiaticum	Amaryllidaceae		P	P	P					
9	Agave americana					P					
10	Anacardium occidentale	Anacaediaceae				P			P		
11	Odina wodier					P					
12	Alstonia scholaris	Apocynaceae							P		
13	Cerbera manghas							P			
14	Rauwolfia tetraphylla					P					
15	Colocasia esculenta	Araceae							P		
16	Borassus flabellifer	Arecaceae	P	P	P	P			P		
17	Calotropis gigantea	Asclepiadaceae				P		P		P	
18	Acanthospermum hispidum	Asteraceae				P	P	P			
19	Ageratum conizoides					P	P				P
20	Blumea virens			P	P	P					
21	Chromolaena odorata		P	P	P	P	P	P	P	P	P
22	Eclipta prostrata		P		P	P				P	
23	Elephantopus scaber								P		
24	Emilia sonchifolia		P		P	P	P	P		P	
25	Epaltes divaricata							P	P		
26	Launea sarmentosa		P	P	P	P		P	P	P	P
27	Tithonia diversifolia					P					P
28	Tridax procumbens					P					
29	Vernonia cinerea		P	P	P	P	P	P	P	P	P
30	Wedelia biflora		P	P	P	P				P	P
31	Dolichondrone spathacea	Bignoniaceae									P
32	Heliotropium indicum	Boraginaceae				P					
33	Cereus peruvianus	Cactaceae				P					
34	Lobelia alsinoides	Campanulaceae								P	
35	Cleome viscosa	Capparaceae			P						
36	Polycarpaea corymbosa	Caryophyllaceae			P	P		P		P	
37	Casuarina equisetifolia	Casuarinaceae	P	P	P	P	P	P	P	P	P
38	Calophyllum inophyllum	Clusiaceae	P	P	P	P		P	P	P	P
39	Terminalia arjuna	Combretaceae								P	
40	Terminalia catappa					P					
41	Commelina diffusa	Commelinaceae				P				P	

42	Cyanotis cristata		P	P	P	P					
43	Cyanotis papilionacea						P	P		P	
44	Murdannia dimorpha									P	P
45	Murdannia spiratia							P		P	P
46	Murdannia versicolor							P	P		
47	Evolvulus alsinoides	Convolvulaceae						P			
48	Ipomoea calycina										P
49	Ipomoea muricata		P		P						
50	Ipomoea pes-caprae		P	P	P	P	P	P	P	P	P
51	Ipomoea pes-tigridis										P
52	Ipomoea sepiaria										P
53	Ipomoea sp							P			
54	Coccinia indica	Cucurbitaceae									P
55	Mukhia maderaspatna							P			
56	Trichosanthes cucumerianus							P			
57	Bulbostylis barbata	Cyperaceae	P*	P*	P*						
58	Cyperus arenarius		P	P	P	P	P	P	P	P	P
59	Cyperus castaneus							P		P	P
60	Cyperus compressus		P		P			P			
61	Cyperus difformis							P		P	
62	Cyperus pedunculatus		P	P	P	P					
63	Cyperus rotundus		P		P						
64	Cyperus stoloniferus		P		P					P	
65	Cyperus sp					P					
66	Elaeocharis atropurpurea							P			
67	Fimbristylis acuminatus							P			
68	Fimbristylis aestivalis									P	
69	Fimbristylis argentea							P			
70	Fimbristylis crystallina									P	
71	Fimbristylis griffithii									P	
72	Fimbristylis polytrichoides							P			
73	Fimbristylis tetragona									P	
74	Fimbristylis woodrowii							P		P	
75	Fimbristylis sp.		P			P		P	P	P	
76	Fuirena ciliaris							P		P	
77	Pycreus polystachyos					P		P		P	
78	Pycreus pumilus							P		P	
79	Schoenoplectus lateriflorus		P			P		P		P	
80	Shoenoplectus sp.							P			
81	Dioscorea bulbifera	Dioscoreaceae				P	P				
82	Dioscorea sp.							P			
83	Eriocaulon cinereus	Eriocaulaceae						P			
84	Eriocaulon xeranthum							P			
85	Excoecaria agallocha	Euphorbiaceae							P		
86	Euphorbia atoto		P*		P*						
87	Euphorbia hirta					P					
88	Phyllanthus fraternus				P*						
89	Phyllanthus reticulatus		P			P		P		P	P
90	Ricinus communis					P					

91	Sapium insigne							P	P		
92	Trewia nudiflora					P					
93	Acacia auriculiformis	Fabaceae				P					P
94	Alysicarpus moniliformis						P				
95	Alysicarpus ovalifolius									P	
96	Canavalia rosea		P	P	P	P					
97	Cassia tora									P	
98	Crotalaria filipes					P				P	
99	Crotalaria retusa					P		P		P	P
100	Crotalaria striata					P					P
101	Crotalaria verrucosa				P	P	P			P	P
102	Derris trifoliata					P		P			
103	Desmodium triflorum							P			
104	Erythrina variegata				P	P				P	
105	Geissaspis cristata							P			
106	Mimosa pudica					P					
107	Pongamia pinnata					P			P		P
108	Smithia sensitiva									P	
109	Zornia diphylla										
110	Flacourtia sepiaria	Flacourtiaceae				P					
111	Scaevola plumierii	Goodeniaceae	P*								
112	Scaevola taccada		P		P	P					
113	Acrocephalus hispidus	Lamiaceae	P		P		P	P			
114	Acrocephalus indicus			P							
115	Hyptis suaveolens					P					
116	Leucas aspera					P	P	P	P	P	P
117	Leucas lavandulifolia			P	P	P*					
118	Leucas sp							P			
119	Pogostemon sp										P
120	Cassytha filiformis	Lauraceae	P	P	P	P	P			P	P
121	Utricularia albo-cerulea	Lentibulariaceae						P			
122	Gloriosa superba	Liliaceae					P		P	P	
123	Urginea indica				P			P	P	P	P
124	Strychnos nux-vomica	Loganiaceae								P	
125	Rotala malampuzhensis	Lythraceae						P			
126	Sida acuta	Malvaceae	P		P	P					P
127	Thespesia populnea				P	P					
128	Glinus oppositifolius	Molluginaceae	P	P	P	P					
129	Ficus racemosa	Moraceae				P			P		
130	Syzygium caryophyllata	Myrtaceae				P			P		
131	Boerhaavia diffusa	Nyctaginaceae	P		P	P	P	P		P	
132	Ludwigia hyssopifolia	Onagraceae	P			P					
133	Ludwigigia perennis							P			
134	Pandanus odoratissimus	Pandanaceae	P		P	P		P	P	P	
135	Pedalium murex	Pedaliaceae					P	P		P	P
136	Sesamum indicum						P	P		P	P
137	Cynodon dactylon	Poaceae					P	P	P		P
138	Dactyloctenium aegyptium		P	P	P	P	P	P		P	P
139	Digitaria bicornis				P						

140	Echinochloa colona							P	P		P
141	Eragrostis riparia		P	P	P						
142	Eragrostis tenella				P						
143	Eragrostis unioloides		P					P		P	
144	Eragrostis sp					P					
145	Ischaemum indicum				P						
146	Isachne globosa						P				
147	Isachne miliacea									P	
148	Mnesithea laevis							P			
149	Nesaea prostrata							P			
150	Panicum repens		P	P	P						P
151	Panicum psilopodium									P	
152	Paspalum conjugatum						P			P	P
153	Paspalum vaginatum		P		P						
154	Paspalidium sp								P		
155	Perotis indica				P					P	
156	Sacciolepis indica							P			
157	Shoenoplectus sp.										
158	Spinifex littoreus		P	P	P	P	P	P		P	P
159	Sporobolus virginicus		P	P*					P	P	
160	Zoysia matrella			P*	P*						
161	Polygonum sp					P					
162	Zizyphus mauritiana	Rhamnaceae				P					
163	Borreria articularis	Rubiaceae	P	P	P	P	P	P	P	P	P
164	Hedyotis corymbosa			P	P	P				P	
165	Hedyotis herbacea							P	P	P	
166	Hydrophylax maritima		P		P						
167	Ixora coccinea							P			P
168	Morinda citrifolia			P		P		P	P		
169	Pavetta indica										P
170	Plectronia parviflora							P		P	
171	Buchnera hispida	Scrophulariaceae								P	
172	Lindernia ciliata		P					P			
173	Lindernia crustacea		P					P			
174	Lindernia oppositifolia							P			
175	Lindernia rotundifolia							P			
176	Lindernia sp							P	P	P	
177	Microcarpa minima							P			
178	Striga sulphurea									P	
179	Torenia lindernioides							P			
180	Datura metel	Solanaceae				P					
181	Physalis minima						P	P			
182	Waltheria indica	Sterculiaceae				P				P	
183	Tacca pinnatifida	Taccaceae									P
184	Corchorus acutangulus	Tiliaceae			P		P			P	
185	Triumfetta rhomboidea									P	
186	Grewia microcos									P	
187	Clerodendron inerme	Verbenaceae	P	P	P	P	P	P	P	P	P
188	Lippia nodiflora		P	P	P	P					

189	Premna corymbosa			P	P	P		P		P	P
190	Stachytarpheta indica		P								
191	Vitex negundo					P	P	P	P		
192	Vitex trifolia					P			P	P	P
193	Vitis trifoliata	Vitaceae								P	P
194	Xyris pauciflora	Xyridaceae						P		P	
195											

Note: Taluk-wise presence from primary surveys (P). Based on other literature (P)*
Abbreviations: MLR: Mangalore; MLK: Muki; UDP: Udupi; KUN: Kundapur; BHT: Bhatkal, HNR: Honavar; KMT: Kumta; ANK: Ankola; KRW: Karwar

Photographs of Sand Binders

Figure 2.1: Ipomoea biloba

Figure 2.2. Spinifex littoreus showing fruiting body in centre

Figure 2.3. Canavalia rosea (Photo: Sivan)

Figure 2.4. Sesuvium portulacastrum

Figure 2.5. Glinus oppositifolius

Figure 2.6. Cassytha filiformis on Ipomoea pes-caprae

Figure 2.7: Aerva lanata (Photo: Kunhikrishnan)

Figure 2.8: Alternanthera sessilis (photo: Gundappa)

Figure 2.9. Crotalaria retusa

Figure 2.10. Crotalaria verrucosa

Figure 2.11. Crinum asiaticum

Photographs of Seasonal herbs

Figure 2.12. Emilia sonchifolia

2.13. Vernonia cinerea

2.14. Achyranthes aspera

(Photos 2.12 & 2.13. Kunhikrishan; 2.14. Ravikumar)

Figure 2.15. Evolvulus alsionides

Figure 2.17. Scaevola taccada – a shrub with great potential for beach protection

Figure 2.18. Scaevola taccada flowers

Figure 2.19. Vitex trifolia

Figure 2.20. Calotropis gigantea

Figure 2.21. Clerodendrum inerme

Figure 2.22. Pandanus at Kirumanjeshwar beach

Figure 2.23. The stilt roots of Pandanus

Figure 2.24. Cucumis sativus (Photo: Sivan)

Figure 2.25. Trichosanthes cucumerianus

Figures 2.26. Calophyllum inophyllum tree

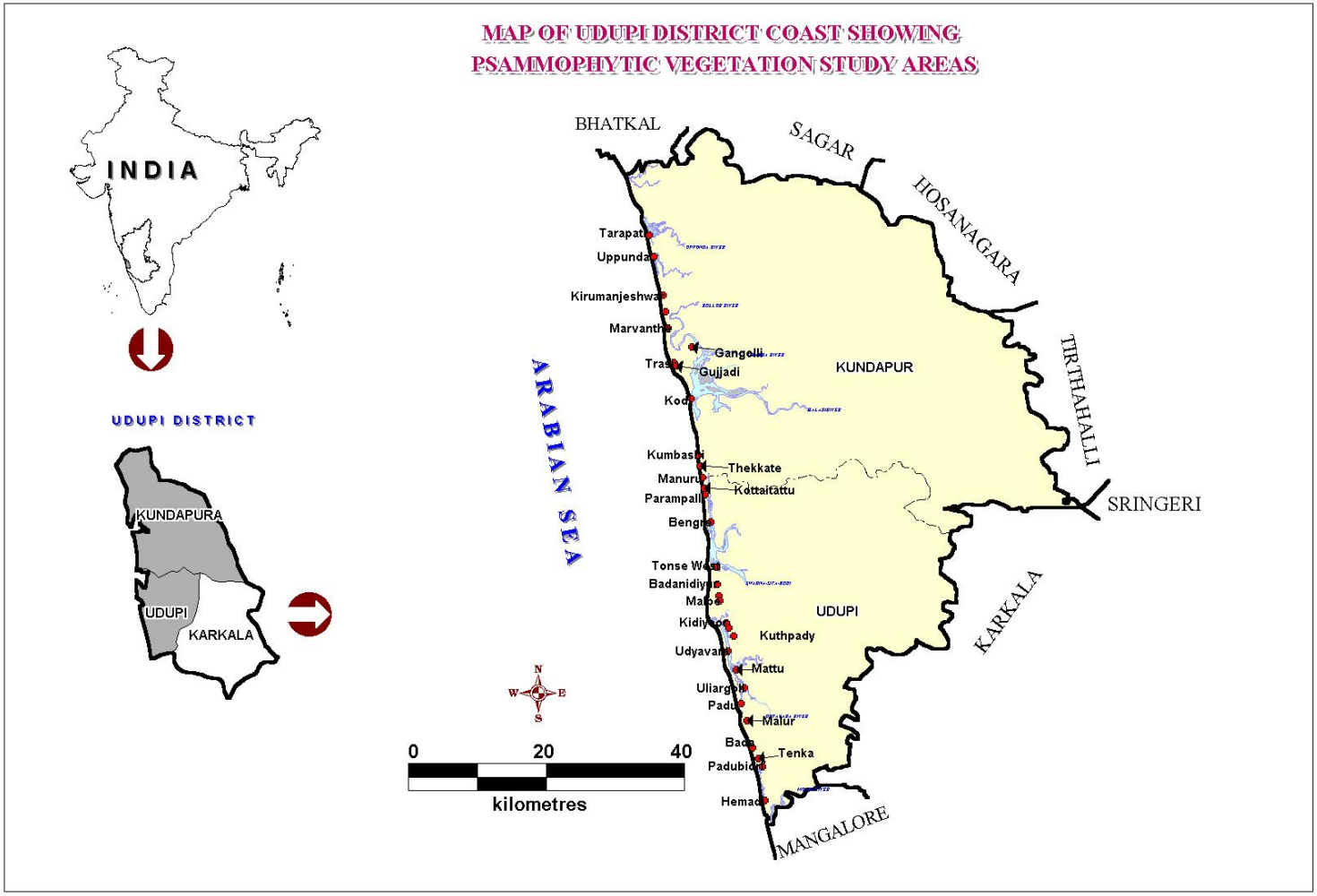
Figures 2.27. Calophyllum inophyllum flowers

Figure 2.28. Thespesia populnea (Photo: Ravikumar)

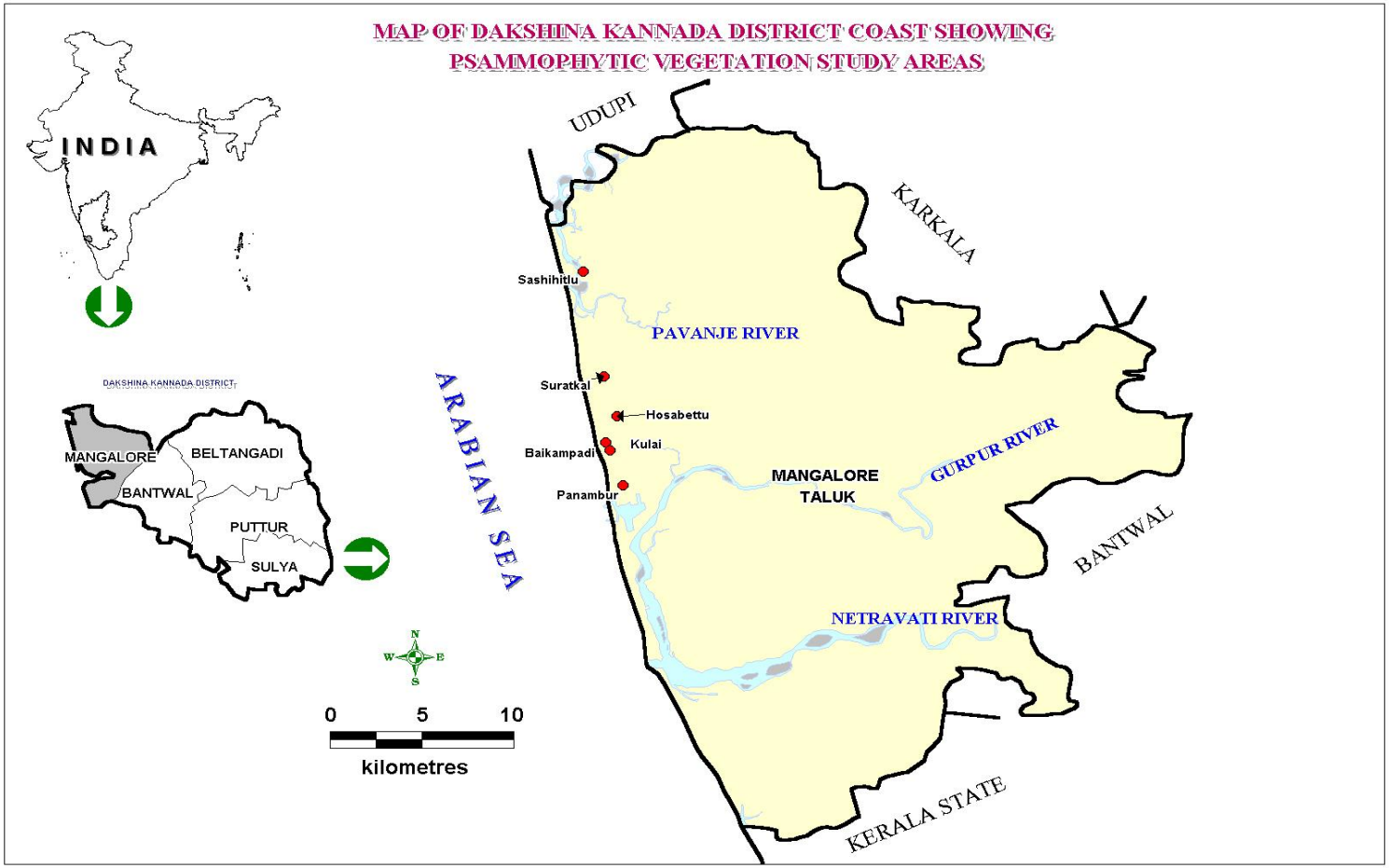
Figure 2.29. Morinda citrifolia

Figure 2.30. Casuarina plantation on backshore of Gagolli beach

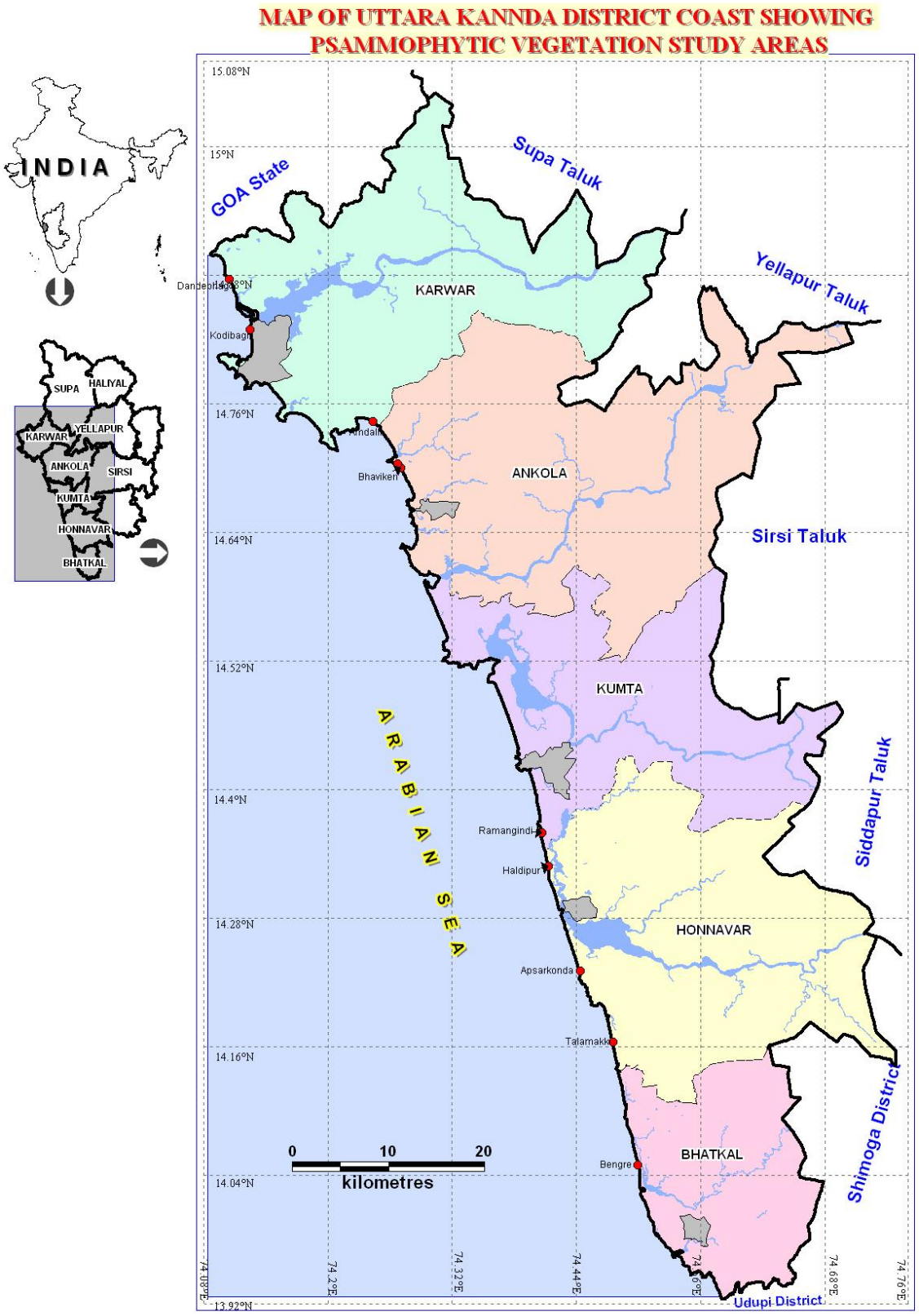
Map 2.1: Map of Udupi district showing Psammophytic vegetation in the study areas.



Map 2.2: Map of Dakshina Kannada district showing Psammophytic vegetation in the study areas.



Map 2.3: Map of Uttara Kannada district showing Psammophytic vegetation in the study areas.



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