

Sand dune formation, Biodiversity and ecological significance

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Venue: National Fisheries & Aquaculture
Training Institute
NAQDA, Kalawewa, Anuradhapura

Date: 27th to 30th of September 2018

- What are coastal sand dunes?
- Where are coastal sand dunes found in Sri Lanka?
- How do coastal sand dunes form?
- What lives in coastal sand dunes?
- Why are coastal sand dunes important?
- What threatens coastal sand dunes?
- How can help protect coastal sand dunes?

Nagarkovil Beach



A beach is a narrow/wide, gently sloping strip of land that lies along the edge of an ocean, especially between high- and low-water marks. Materials such as sand, pebbles, rocks, and seashell fragments cover beaches.

Nagarkovil Beach



A dune is a hill of loose sand built by aeolian processes (wind) or the flow of water. Dunes occur in different shapes and sizes, formed by interaction with the flow of air or water.



22:15 11/NOV/2016

Initial Dunes - Battalangunduwa

Coastal Dunes - Nagarkovil



Holocene coastal dune formation under a continuously fluctuating (SL) is an abnormal response to increasing storm frequency.

**Parallel dune ridges,
Palk Bay side at Mannar**



Coastal dunes in Mannar (Vegetated dunes)





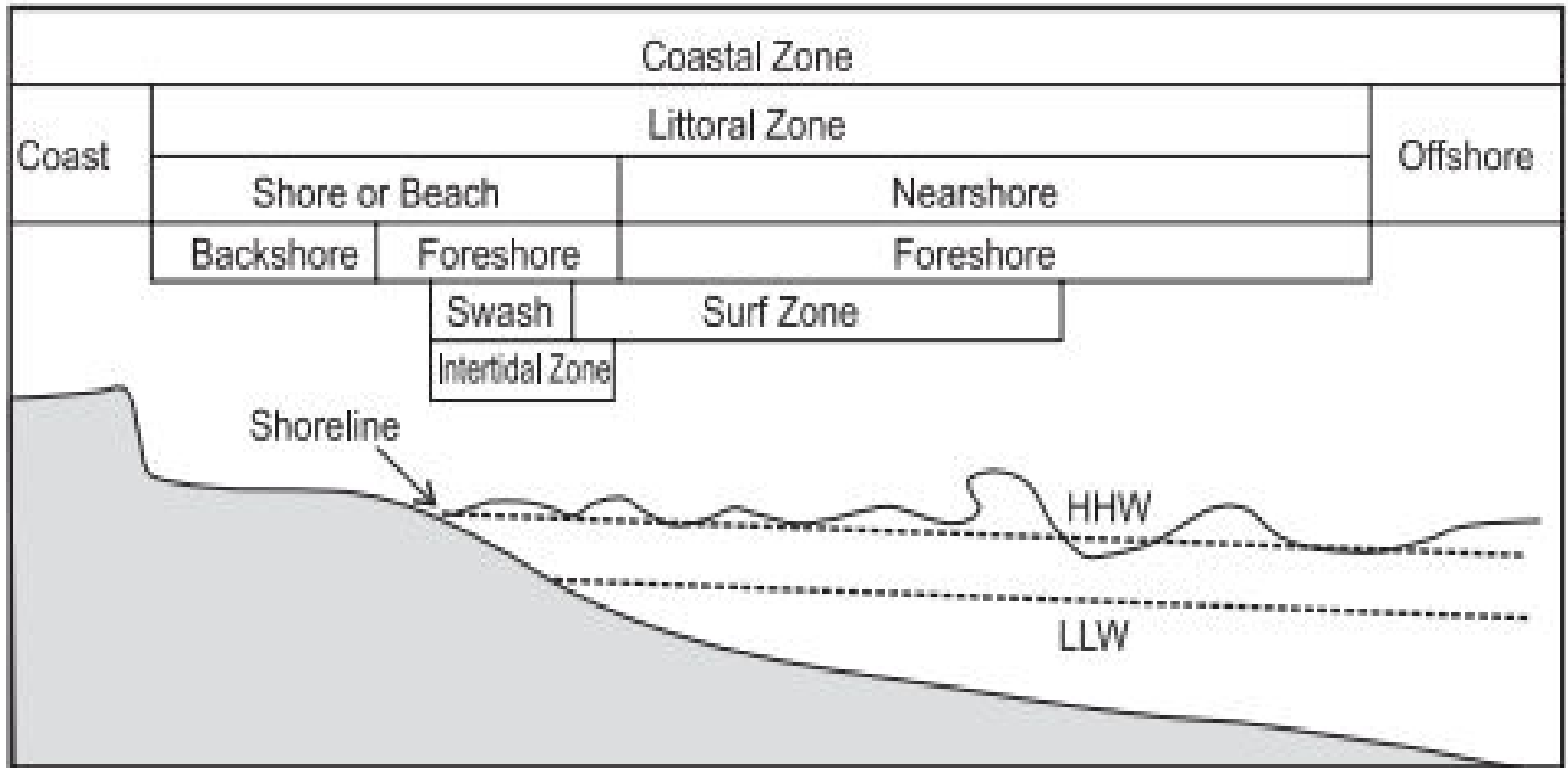
Hilltop palaeo (Pleistocene) dune ridge at Kudremalai



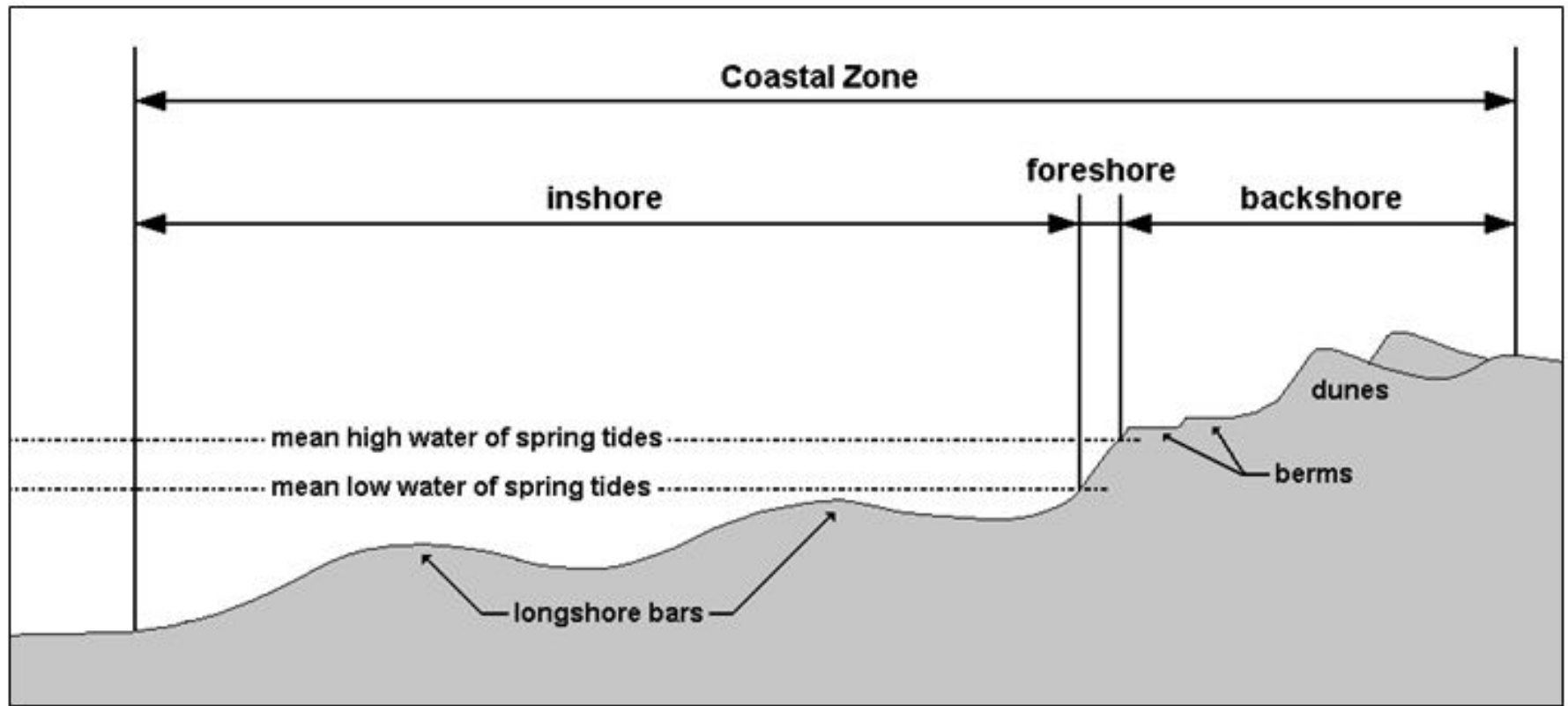
Hilltop Dunes - Kudremalai

What are the coastal sand dunes?

- **Sand dunes are small and sometimes quite big ridges or hills**
- **They form from wind blown sand that is initially deposited against an obstruction such as a bush, driftwood, dead animal or rock.**
- **Dunes are very vulnerable to erosion by natural processes and by human activity.**
- **The size and morphology of coastal dunes is dependent on the complex interaction between controlling winds, sediment supply, and the geomorphology of the nearshore and beach environment.**



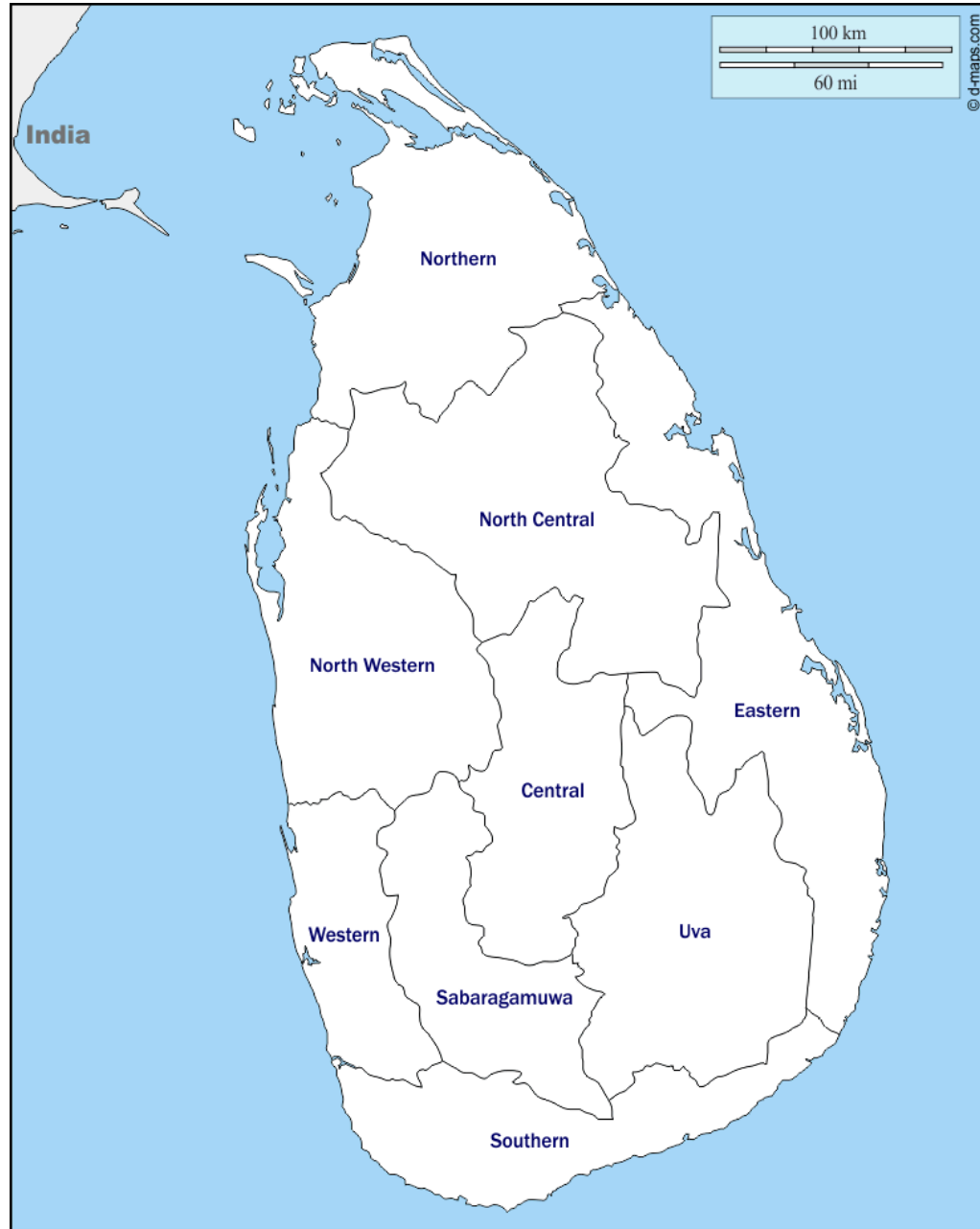
Sketch of a coastal zone and terminology used in a shore profile is significant to understand the extension from shoreline to the inland



**Main divisions and morphological sequence of a coastal zone.
The sketch shows that how establish the dunes in inland ?.**



Where are coastal sand dunes found in Sri Lanka?







- Tangalle to HMB, 2 - 5m
- HMB to Palatupana, 6 – 10m
- Platupa to Okanda, 8 – 10m
- Okanda, Panama, Sangaman Kanda, 6 – 16m
- Tirukkovi, Kalmunai, 5 – 11m
- Kalmunai , Kattankudi, 8 – 11m
- North of Batticaloa, South of Pasikuda to Trinco, 6 – 8m
- Kokila to Kankasanturei, 8 – 14
- Punaryne, 6 – 8m
- Mannar, 12 – 18m
- MalwaOya to Modaragam , 8 – 13
- Kudremalai Hilltop, 35m
- Kalpitiya, 8 – 10m
- Karukka, Toduwawa, Udappu, 8 - 10m
- Ambakandawila, Old 6 – 8m

How do coastal sand dunes form ?

A **dune** is a mound of **sand formed** by the wind, usually along the **beach** or in a *desert*.

Dunes form when wind blows **sand** into a sheltered area behind an obstacle.

Dunes grow as grains of **sand** accumulate. **Dunes** can also be **formed** by strong currents beneath the water.



An aerial photo captures sand dunes under shallow water near the Bahamas, in the Caribbean Sea. These dunes are created by water currents. Wind currents form sand dunes on land.

➤ What lives in coastal sand dunes?

- Coastal sand dunes form a natural barrier against wind and waves, protecting inland areas from damage due to storms.
- They also provide **habitat** for **plants** and animals, including rare and endangered species.
- The structure of sand dunes depends largely on stabilizing vegetation such as native dune grass.

Coastal dunes provide habitat for plants and animals, including rare and endangered species. The structure of sand dunes depends largely on stabilizing vegetation such as native dune grass.

About 33 Dune Plant Families in the Mannar Island

AIZOACEAE,
APOCYNACEAE,
ARECACEAE,
ASPARAGACEAE,
ASCLEPIADACEAE,
ASTERACEAE,
CACTACEAE,
CELESTRACEAE,
CONVOLVULACEAE,
CUCURBITACEAE,
CYPERACEAE, P

EBENACEAE,
EUPHORBIACEAE,
FABACEAE,
LAMIACEAE,
LAURACEAE,
LYTHRACEAE,
MALVACEAE,
MELIACEAE,
MORACEAE,
MYRTACEAE,
ANDANACEAE,

PEDALIACEAE
POACEAE
RHAMNACEAE
RUBIACEAE
RUTACEAE
SALVADORACEAE
SAPINDACEAE
SCROPHULARIACEAE
STERCULIACEAE,
TILIACEAE, and
VERBENACEAE

There are nearly 70 Plant Species can be identified from the Mannar Island

Fauna of the Northeastern Mannar area

- Total number of 67 faunal species was recorded at the Pesali area representing butterflies, reptiles, birds and mammals.
- This did not include any endemic species. Further, the faunal assemblage did not include any Nationally Threatened or rare animal species.
- Two species of birds observed at the site are listed as Nationally Near Threatened (IUCN & MENR, 2007).

The faunal assemblage recorded in the project area also included five species of migrant birds.

The mammals observed at the site included domestic and feral species.

The Thawalpadu (Mannar) site also contains mostly beach vegetation that supports a fairly rich faunal assemblage that comprised of mainly butterflies and birds.

In addition few species of reptiles and mammals *were also observed* at this site.

Total number of 71 faunal species was recorded at the Thawalpadu project area representing butterflies, reptiles, birds and mammals (IEE Report for heavy mineral mining Table – C.9.3a).

Two species of birds observed at the site are listed as Nationally Near Threatened (IUCN & MENR, 2007).

The faunal assemblage recorded in the project area also included seven species of migrant birds.

The mammals observed at the site included domestic and feral species.

➤ **Why are coastal sand dunes flora important?**

The dune vegetation show creepers to trees their diversity with different adaptations. The plants mainly use for:

- Collection of firewood near by inhabitants.**
- The plant supply timber, sticks, bushes etc.**
- Use plants for goats and cattle feeding**
- Use large number of plant species as medicinal plants**
- Floral habitat is highly valuable as breeding grounds for all dune animal species.**



Wide sandy beaches of the sand barrier along the coastal stretch between Komari Lagoon mouth and Murungatena (GPS Coordinates $6^{\circ}57'32''\text{N}$ & $81^{\circ}51'45''\text{E}$, Photos were taken on March 01, 2015).



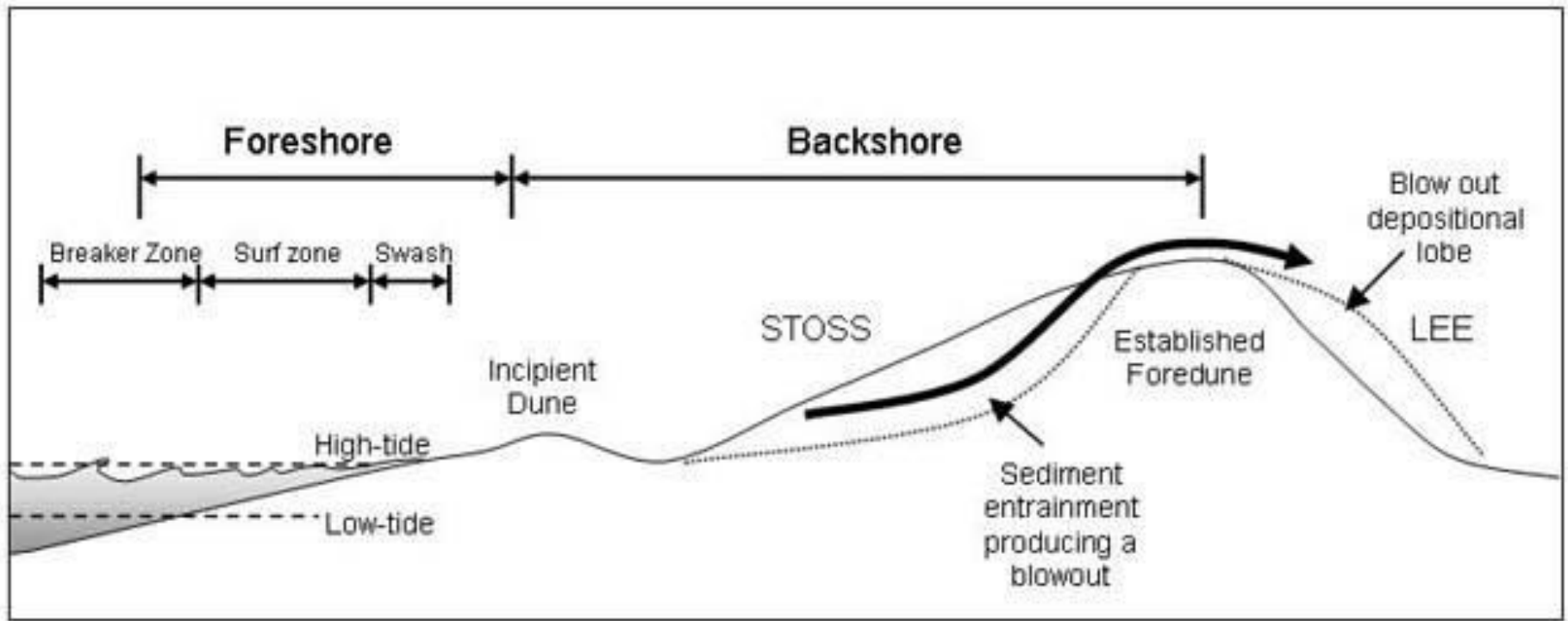
Contemporary beaches at Murungatena coastal stretch . Retreating this beach area up to permanent vegetation line during the Northeast monsoon and the 2nd Inter monsoon periods (Photos were taken on March 01, 2015).

**At the most basic level, dunes can be divided into those that form from the direct supply of sediment from:
the beach face (primary dunes), and
those that form from the subsequent modification of primary dunes (secondary dunes).**

A primary frontal dune (PFD) is defined as a continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes immediately landward of and adjacent to the beach.

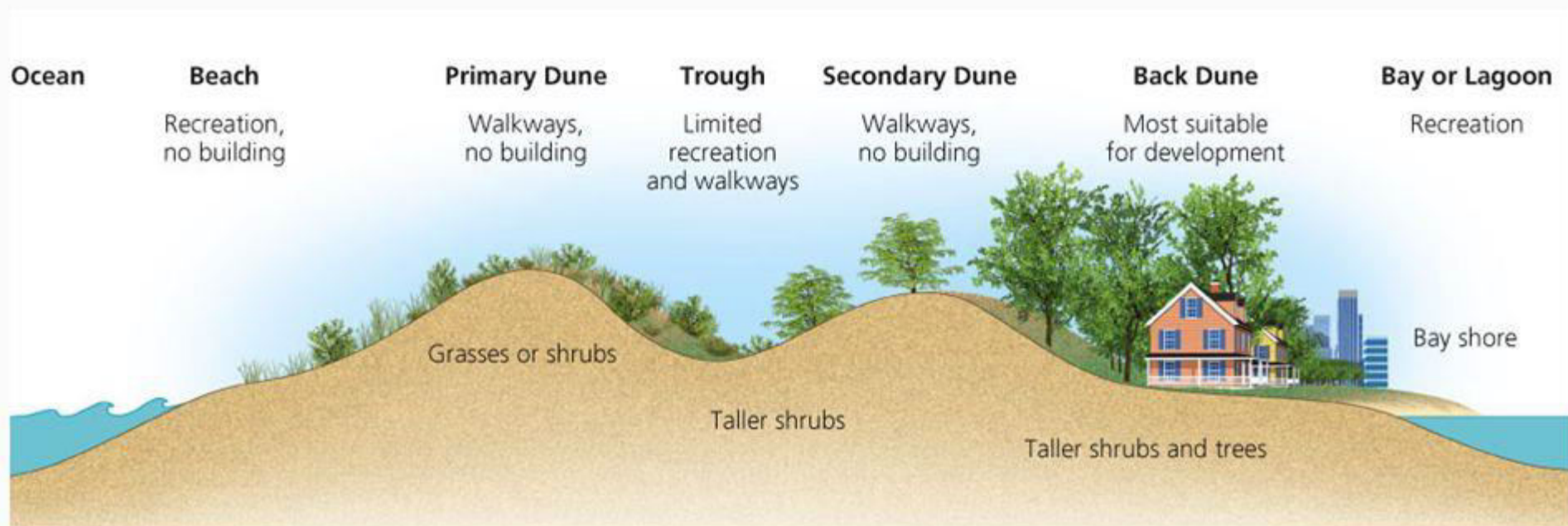
A **secondary dune** is “created by modification of the primary **dunes** or by transfers of sand inland from the position of the primary **dunes**(Psuty, 2008, p. 16).”

Secondary dunes (or rear **dunes**) are located farther inland (from the foredune or primary **dune**) and are not often directly exposed to marine influences.

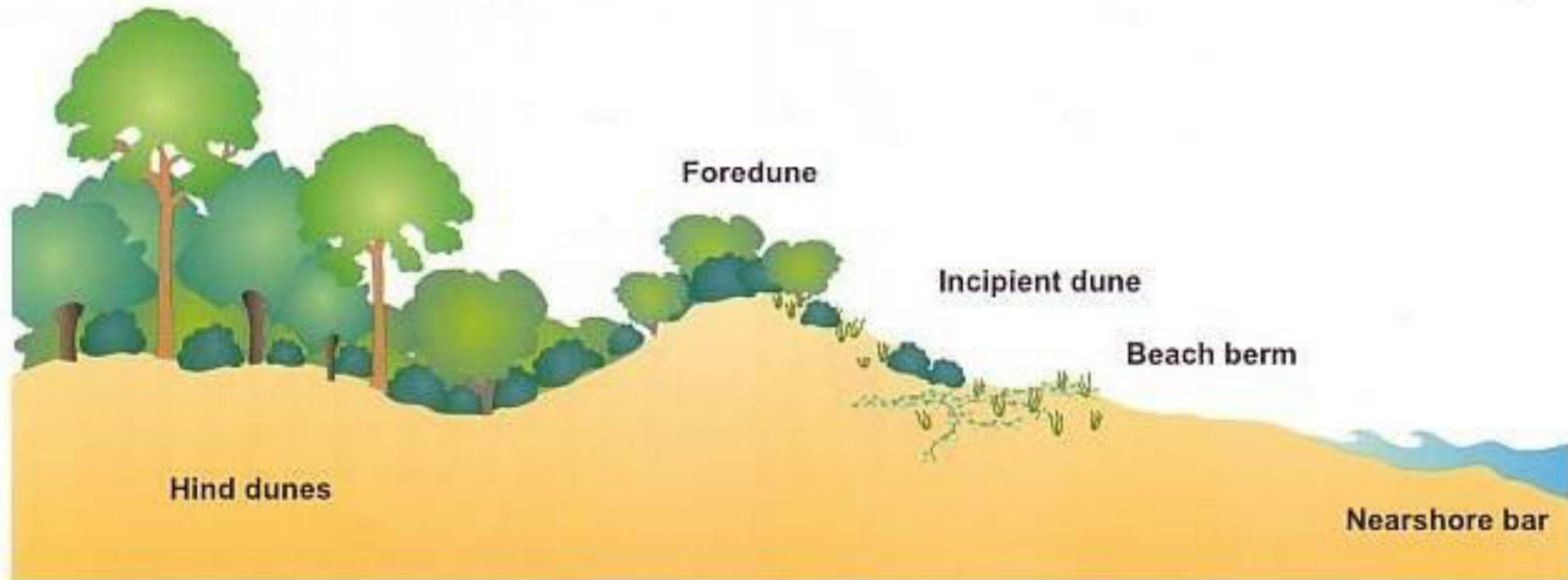


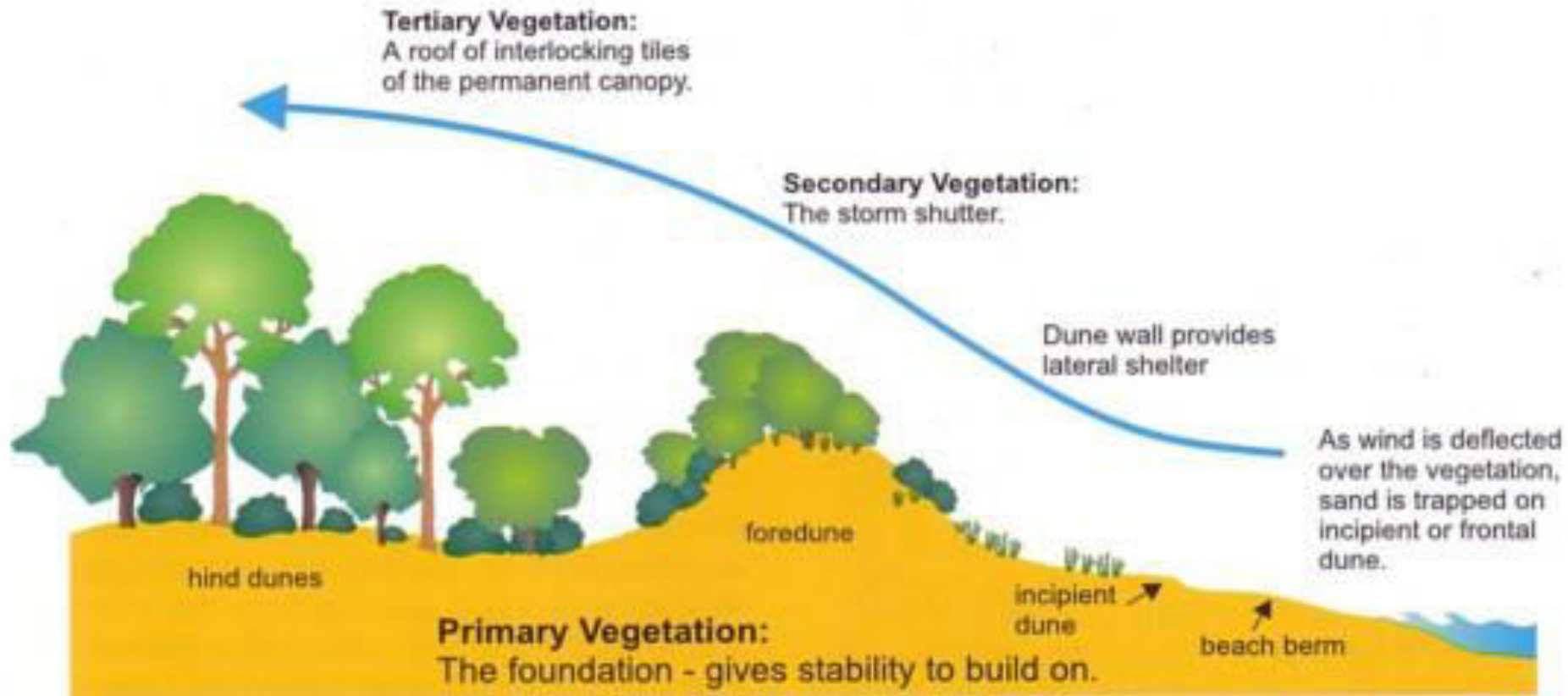
The beach-dune system showing the nearshore zone back-beach environment and the formation of an incipient foredune and established foredune.

Primary and Secondary Dunes



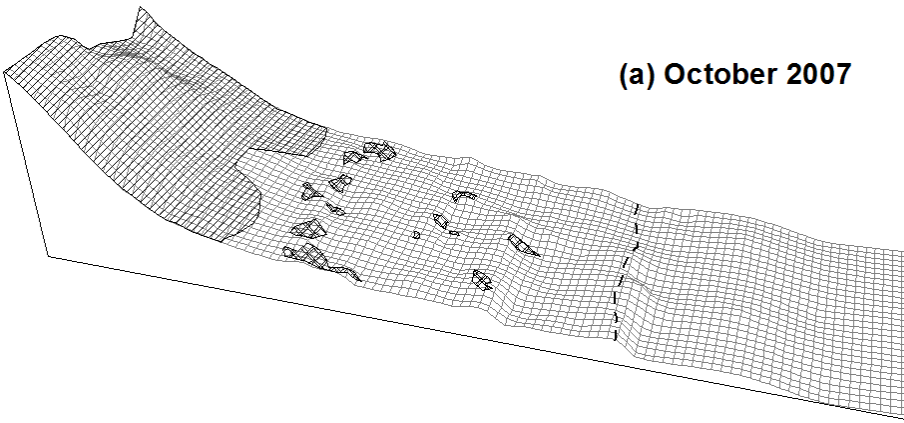
Stage 3 - Long-lived trees (tertiary species)



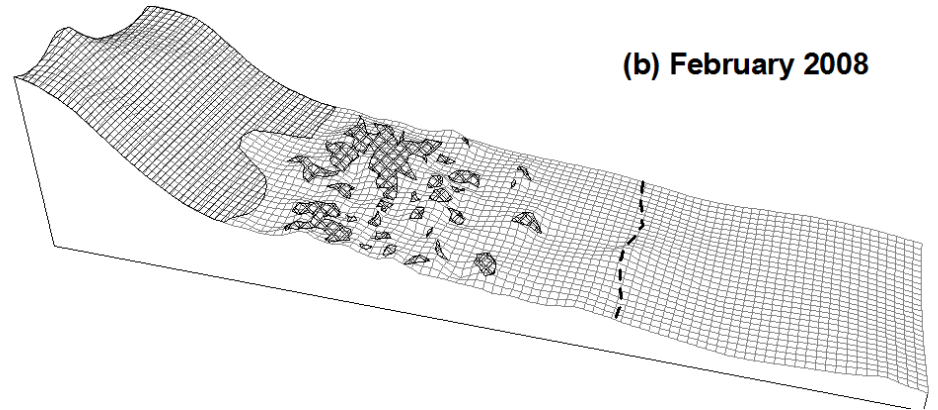


- The vegetation plays in the accretion cycle is wind protection, especially for the not so resilient Hind Dune vegetation.
- Wind generally blows in from the ocean. The first wall of defence is the primary vegetation found on the incipient foredune. The grasses try and hold much of the sand in place.
- The next line of defence is the secondary vegetation on the foredune. This is made up of sturdy shrubs that are resilient to the salty wind. The wind is deflected up and over foredune to move much of the strong salty wind over the not so resilient vegetation in the hind dune area.

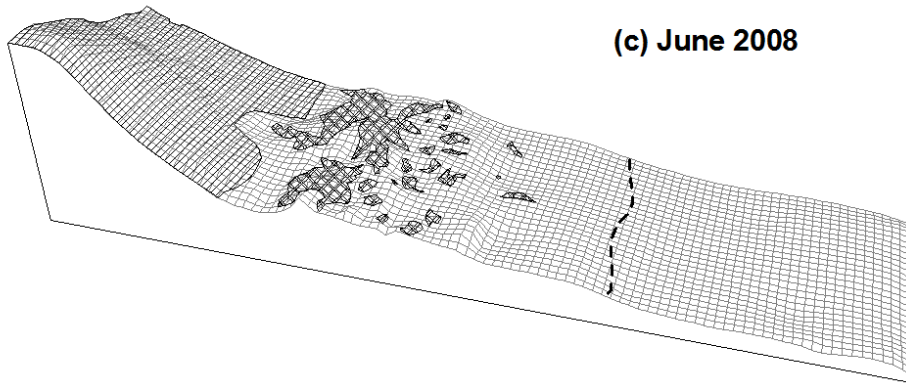
(a) October 2007



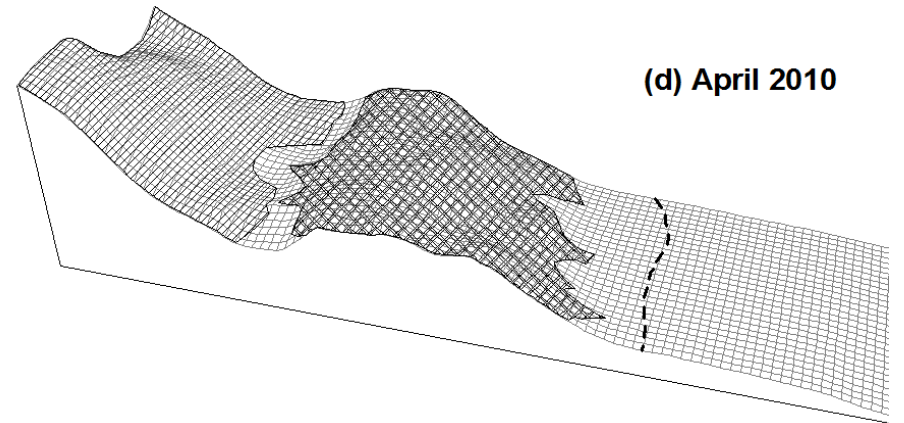
(b) February 2008



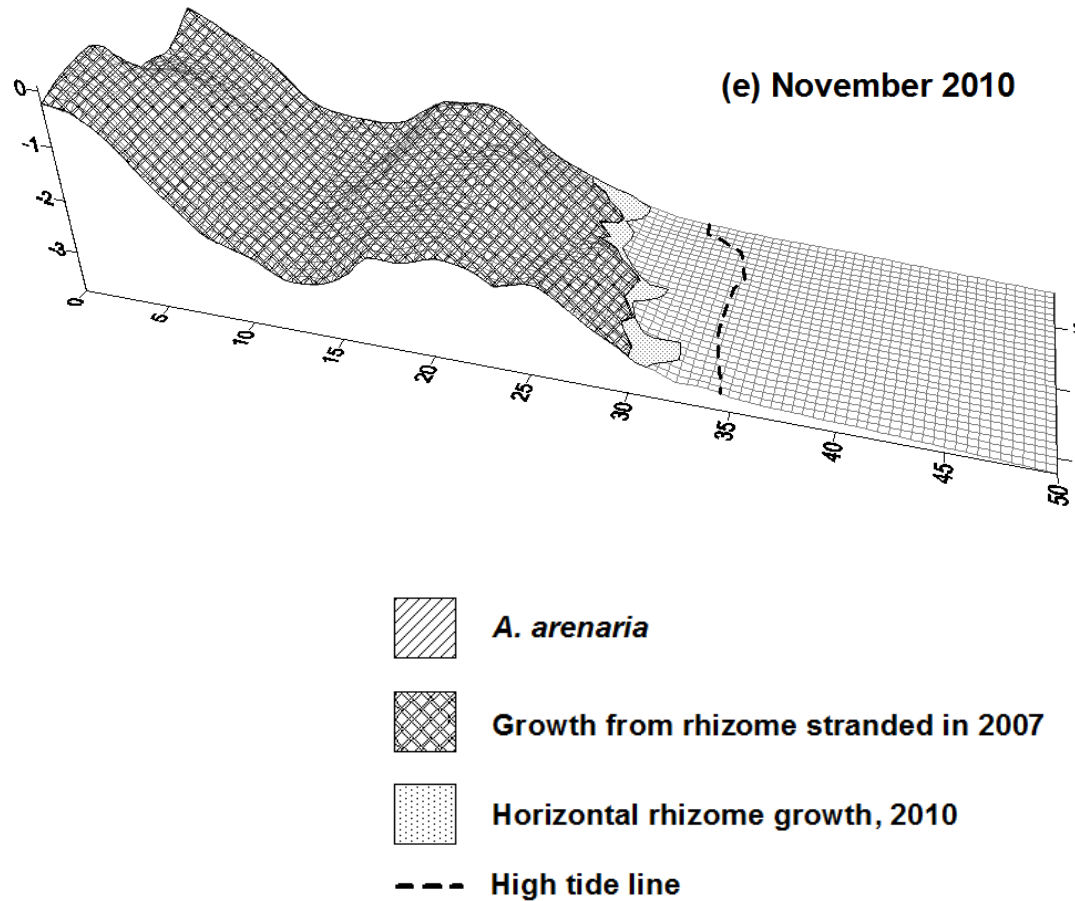
(c) June 2008



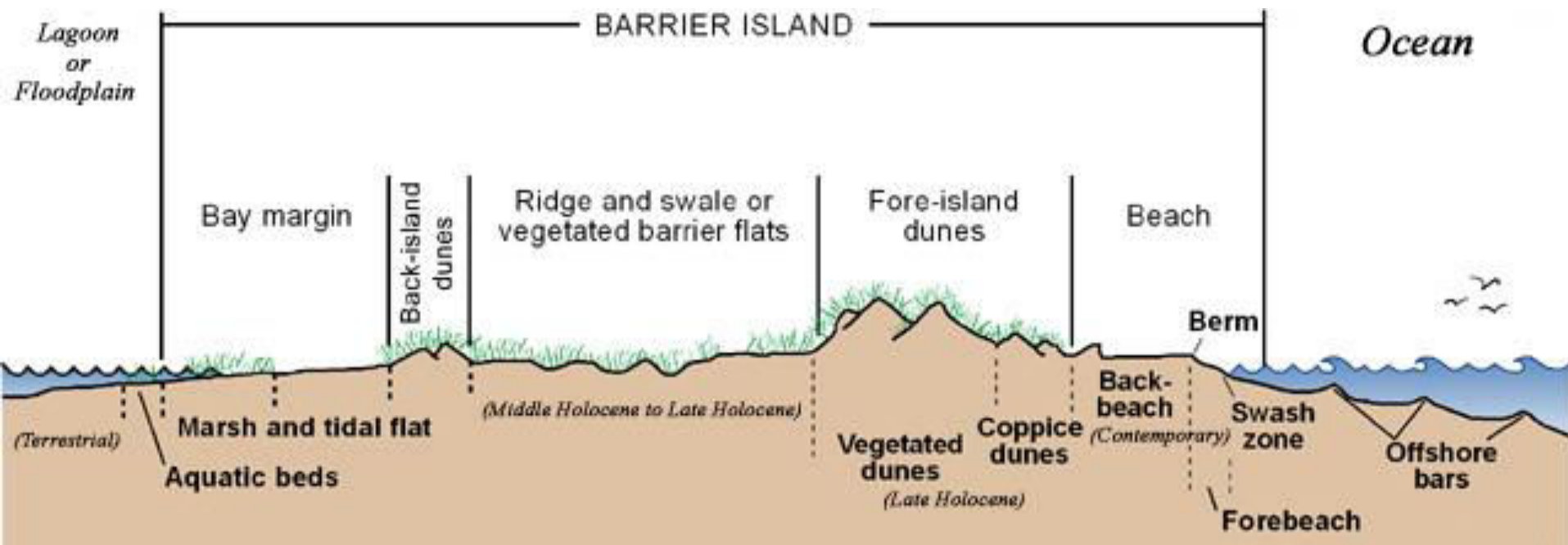
(d) April 2010



Terrain models of a section of the developing incipient foredune, October 2007 to November 2010 (Hilton and Konlechner, 1989).



Terrain models of a section of the developing incipient foredune, October 2007 to November 2010 (Hilton and Konlechner, 1989).



A typical evolutionary profile of a sandy (barrier) beach.

Based on morphological development of the foreshore and backshore areas (existing profile) show a series of landforms from coast to inland mainly;

(I) Contemporary beaches and coastline, (II) Incipient dunes and low dunes, (III) Holocene beach ridges with runnels, (IV) Beachrock reef patches (V) Lagoons, waterways and water holes.

Contemporary Beaches and Coastline in Mullativu Coast

Contemporary beaches and coastline means:

existing, occurring or changing feature or features at the same time; belonging to the same time.

Accordingly, contemporary beach and coastline in Sri Lanka are forming and changing due to monsoon wind pattern of the country.

- **During the 1st Inter-monsoon (March to April) and the Southwest Monsoon (May to September) accumulation of sands can be seen along the coast,**
- **Sometimes the beach is nearly 30-40m wide especially along the northeastern coast.**
- **During the Northeast Monsoon season (December to February) severe erosion is obvious in the area,**
- **During the inter-monsoons change the coastal configuration due to intermittently and fortuitous events and moderate processes are visible in the area (Photos 1.3 – 1.8).**



During the northeast monsoon the coastal erosion prevails and during the inter-monsoons wide beaches exist in the Mullativu coastal stretch (Photos were taken on September 23rd, 2017).



Contemporary beaches with low berms at 8°59'58"N 80°57'29"E east of Kokilai Lagoon. Advancing this Coastal Stretch since 1st Inter monsoon and Southwest monsoon periods (Photos were taken on September 23rd, 2017)..

Incipient foredunes

- **Incipient foredunes develop as sand accumulations.**
- **It is trapped by pioneer plant species between the line of high tide and the established foredune (Hilton and Konlechner, 2011).**
- **The evolution, ecological processes, aerodynamics, and morphology of incipient or new foredunes on the upper beach are significant feature along the sandy coast (Hesp 1989).**

Foredunes at Malala Coastal area



PM12:53 18/NOV/2016

The evolution, ecological processes, aerodynamics, and morphology four types of incipient foredunes may be distinguished, namely:

type 1, those initiated by shadow dune formation within zones of discrete individual pioneer annuals (e.g. *Cakile* spp.), and perennials (e.g. *Spinifex* spp.; *Ammophila* spp.);

type 2, those initiated by dunelet or hummock formation within discrete colonies of perennial grasses and herbs;

type 3, those initiated by sand deposition within laterally extensive colonies of pioneer seedlings; and

type 4, those initiated by sand deposition within a laterally extensive plant rhizome cover.

The seedlings may develop from marine-dispersed seed or local terrestrial sources. These sequences appear much the same in the study area.



Distribution of individual pioneer annuals (e.g. *Cakile* spp.), and perennials initiate on dunelet or dune hummock.

Most of the berms have been damaged by tractors, which use for beach seine (Photos were taken on September 23rd, 2017).

➤ What threatens coastal sand dunes?



Many berms and beachrock shoals have been damaged by beach seine fishermen (Photos were taken on September 23rd, 2017).



Many berms and beachrock shoals have been damaged by beach seine fishermen (Photos were taken on September 23rd, 2017).

Vegetated dunes at Nagarkovil

Borassus flabellifer





Phoenix pusilla

Phoenix pusilla



Ficus benghalensis

Variety of dune plants at Nagarkovil dune field

Borassus flabellifer

Flueggea leucopyrus



தலமான் ஸ்லாவென்சு புனிதவெள்ளை
பள்ளிக்கு சொந்தமானது
இவ்வாசனில்தான் இவ்வாசனிலே
பலவே வருவார்கள்.
THIS LAND BELONGS TO TALAMANNAR
SLAVERANCE CHURCH

புனிதவெள்ளை



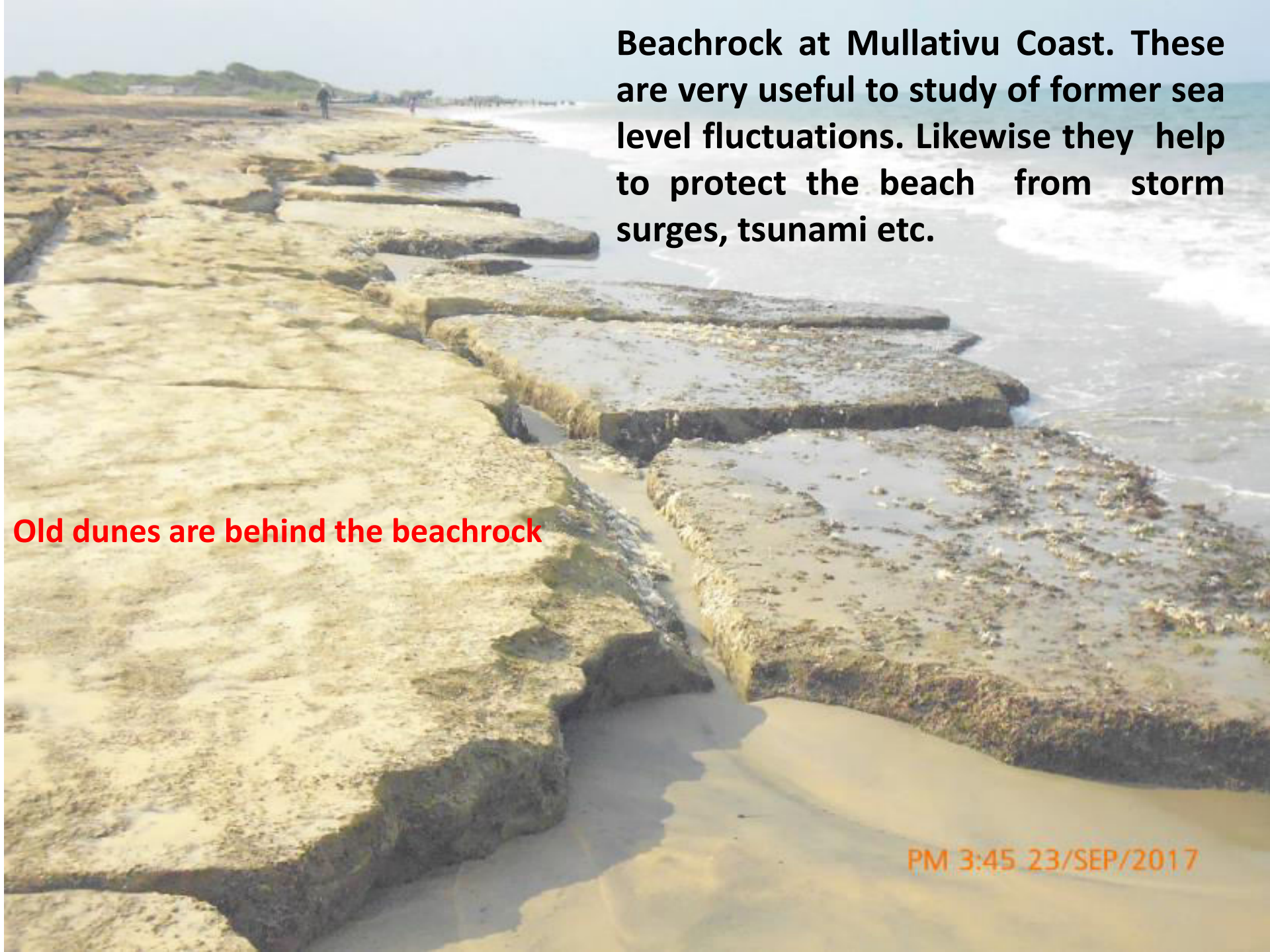
Dichrostachys cinerea

Dichrostachys cinerea

Borassus flabellifer







Beachrock at Mullativu Coast. These are very useful to study of former sea level fluctuations. Likewise they help to protect the beach from storm surges, tsunami etc.

Old dunes are behind the beachrock

PM 3:45 23/SEP/2017



PM 3:30 23/SEP/2017

Why are coastal sand dunes important



Pandanus tectorius

Sand dunes serve to protect inland areas from coastal water intrusion. They are able to absorb the impact and protect inland areas from high energy storms and act as a resilient barrier to the destructive forces of wind and waves.

Mullativu coast

Panama sand dunes



22-03-12/AUG/2016

**Panama sand dunes damaged by 26, December 2004 tsunami
and reconstructed dune ridge.**



Replanting

22:03 12/AUG/2018

A wide-angle photograph of a sandy dune landscape. The foreground and middle ground are covered with sparse, low-lying green vegetation interspersed with patches of light-colored sand. In the background, there are more dunes, some with denser green shrubs. A small, light-colored building is visible on a distant dune. The sky is a clear, pale blue.

Replanting sand dunes at Panama

22:05 12/AUG/2016



Spinifex littoreus, commonly known as beach spinifex, is a perennial grass and very useful for beach protection

23:20 12/AUG/2016

A man wearing a black hat, glasses, a white shirt, and a brown multi-pocketed vest stands in a sandy dune area with sparse green vegetation. He is holding a small plant with roots in his left hand and gesturing with his right hand. The background shows rolling sand dunes under a clear sky.

In support dune
formation,
conservation and
rehabilitation
visitors are
requared

22:47 13/AUG/2016



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In support of Sand Dune Conservation and
Rehabilitation Visitors are Requested

NOT TO ENTER THE SAND DUNE



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Coast Conservation and Coastal Resource Management Department



REHABILITATION OF SAND DUNE ECOSYSTEM

23:00 12/AUG/2016



23:16 12/AUG/2016



23:22 12/AUG/2016

Mullativu coastal area



Panama coastal area



Fishermen and other coastal dwellers obtain water from shallow wells along the incipient fore dune areas of Sri Lanka. The water volume and the quality depend on micro-geomorphology and the rainfall pattern.



**Water collection from sand dunes
for daily uses at Chillaw**

Sand dunes converted into farmlands – Kalpitiya, 1992



Sand dunes converted into farmlands – Kalpitiya, 1992

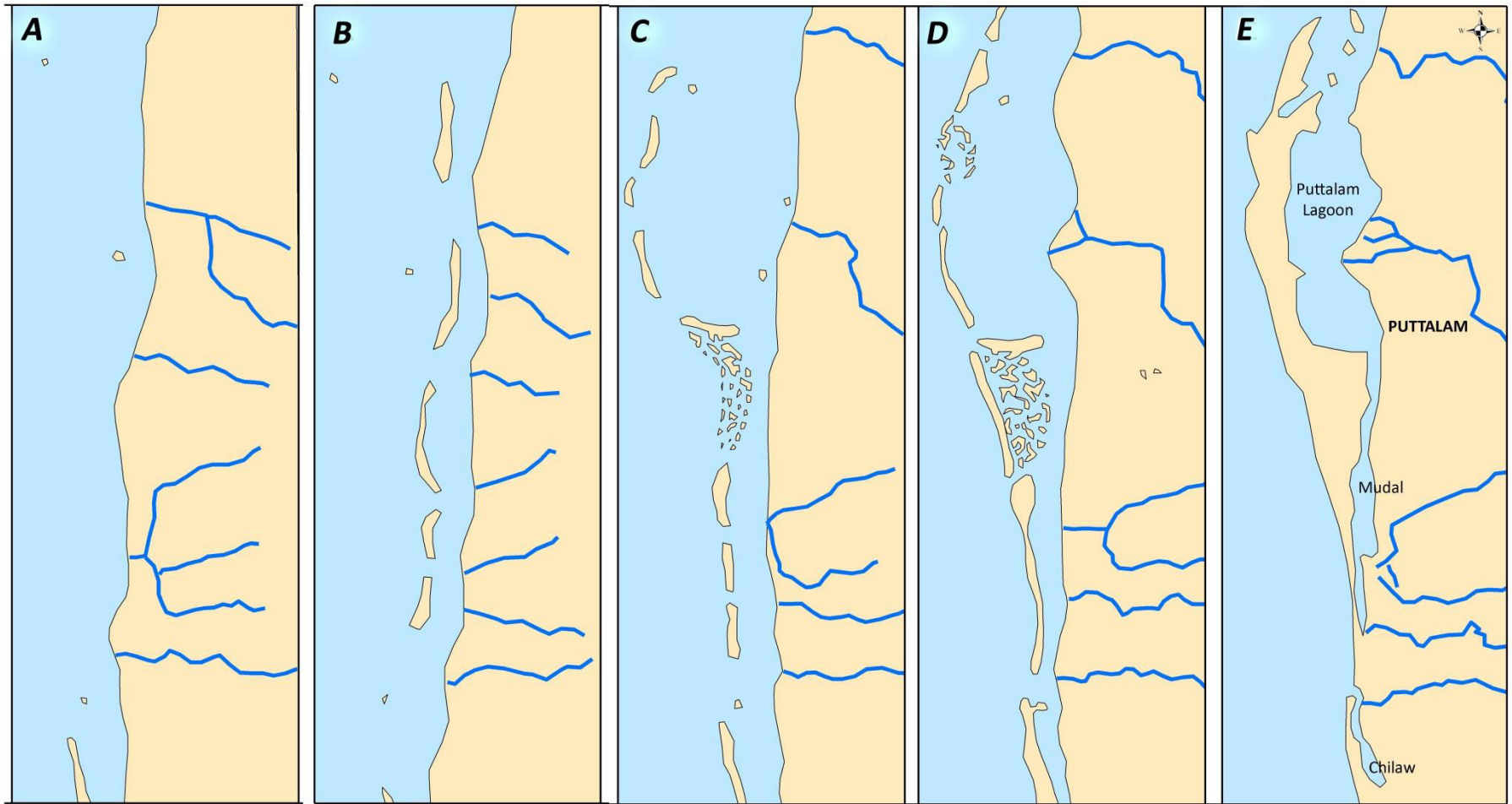


Brinjal plantation at Mullativu foredunes

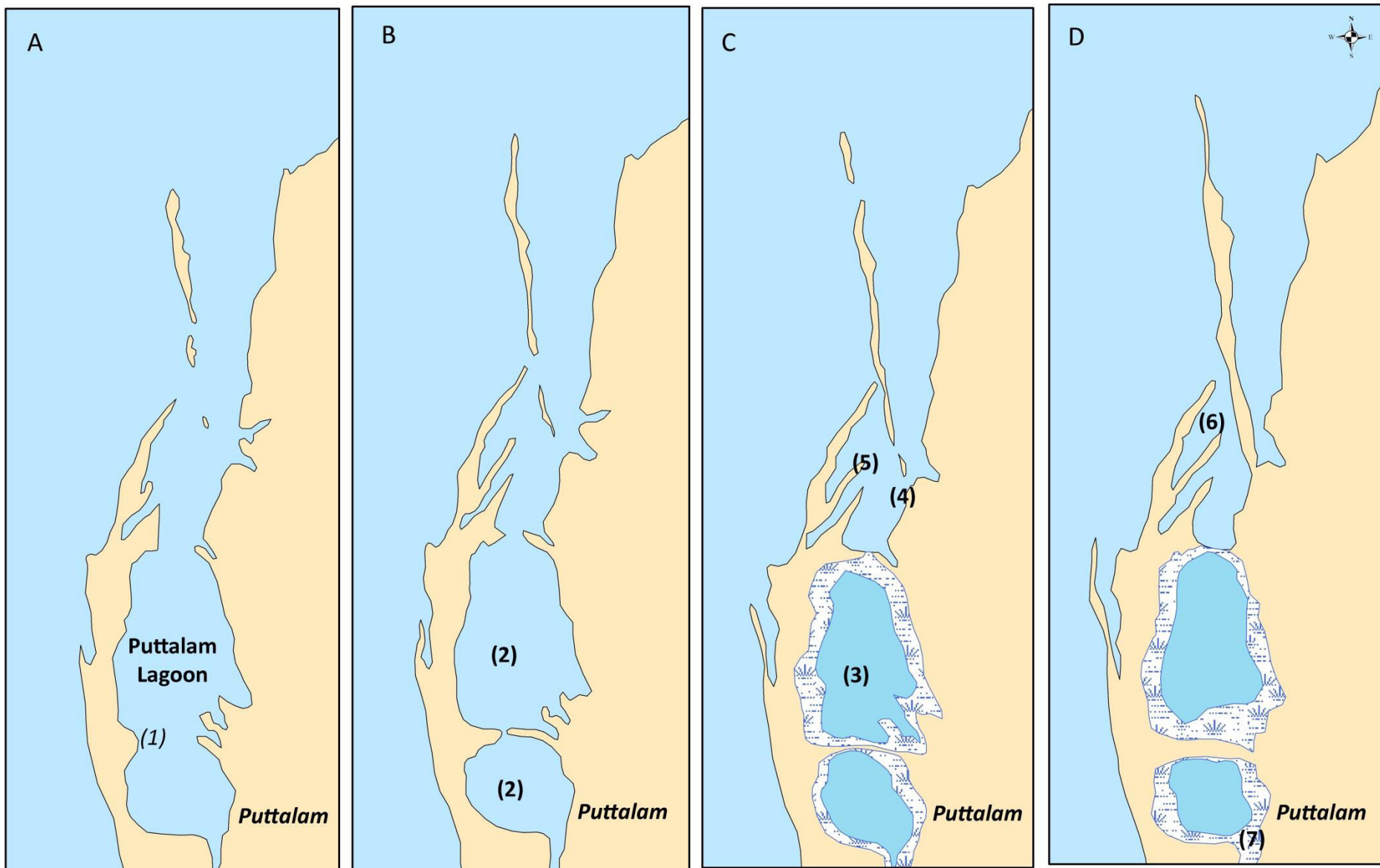


Encroachment of Dunes at Mannar





Growth stages in the coastal region between Chilaw and Puttalam lagoons. The Kalpitiya Peninsula covered with medium and high sand dunes.



Growth stages in the coastal region between Chilaw and Puttalam lagoons. The Kalpitiya Peninsula covered with medium and high sand dunes. (1) Present Puttalam Lagoon, (2) Closing up Puttalam Lagoon by cusped lowlands, (3) Formation of Puttalam Lake in the Kalpitiya Peninsula, (4) , (5) & (6) Formation of Kalpitiya "Lagoon" north of the respectively.

➤ **What threatens coastal sand dunes?**

- **Coastal sand dune systems are highly vulnerable to disturbance by trampling.**
- **Without the stabilizing vegetation, the sand is blown away and dunes disappear. This can leave the shoreline more prone to damage from storm surges. Invasive species are a major concern for the ecology of sand dunes.**
- ❖ **A natural barrier to the destructive forces of wind and waves, sand dunes are our first line of defense against coastal storms and beach erosion.**
- ❖ **They absorb the impact of storm surge and high waves sometimes tsunamis, preventing or delaying flooding of inland areas and damage to inland structures**

➤ How can help protect coastal sand dunes ?

Protect, Enhance or Construct Dunes: Sand dunes provide natural coastal protection against storm surge and high waves, preventing or reducing coastal flooding and structural damage, as well as providing important ecological habitat. They also act as sand storage areas, supplying sand to eroded beaches.

How you can help protect sand dunes

- Use formal access ways such as board walks, steps and marked tracks where provided
- Encourage friends and children to respect the dunes and not play on them – especially on the critically important seaward face of the dune
- Do not let livestock on dunes
- Do not light fires on dunes
- Do not dump personal household and garden refuse as it can spread weeds
- Keep dogs under control in order to protect nesting birds and other animals
- Do not drive motorcycles or 4WD's on dunes Start or get involved in some dune protection works at your local beach.
- Do not remove the dune sands from dune legally or illegally
- For more information about this contact DCC&CRM of Sri Lanka.



**Removing illegally sands from
dunes, Nagarkovil Area**





THANK YOU AND HELP to PROTECT OUR SAND DUNES

23:22 12/AUG/2016