Ecosystems and Their Elements

The following information will familiarize you with ecosystems and their elements. Your students will visit several habitats during their field study so as to understand ecosystems as a whole. The following are descriptions of four habitats, which together make up a coastal ecosystem. This information should be presented to students prior to their visit and will be reinforced during their field study.

The Ecosystem

An ecosystem is a unit consisting of living organisms of a particular habitat together with the physical, non-living environment in which they live. Living and non-living parts interact to form a stable system. All organisms and their habitats are part of this interconnected system. A salt marsh could be considered an ecosystem; it contains non-living elements like water, air, nutrients, and sediments as well as living plants, animals and fungi.

Energy and chemical cycles are two important components of an ecosystem. Energy flows through an ecosystem by transfer through food chains and webs. Chemicals cycle through water, soil, and air. Ecosystems depend on these energy and chemical cycles. The salt marsh and the estuary are two separate habitats. Although mutually interdependent, they are related because they help support each other. For example, the salt marsh supplies the estuary with nutrients from decaying plants and animals, which are washed to the estuary during high tides. Estuary animals consume these nutrients. Marsh banks and creeks offer estuary animals safety from sun, wind and predators. Fish hide under overhanging banks, and birds stay close to the marsh's edge during storms.

An ecosystem's physical and chemical characteristics determine the organisms that live there. The barrier beach ecosystem at Barney's Joy has interdependent habitats of beach, dunes, salt marsh, and estuary. The beach supplies dunes with sand and protects them from waves by dispersing wave energy along its gradual slope. Dunes, in turn, protect the salt marsh from strong winds that blow off the water. As these winds strike the dune "wall" they lose energy.

Within these habitats live many interdependent species. The estuary harbors juvenile species of invertebrates and fish because they have readily available nutrients from decaying salt marsh grasses. Intertidal and subtidal organisms feed on these nutrients. When they die, the remains wash up on the beach where they break down adding nutrients.

The Sandy Beach

In general, the land bordering a large body of water is called a beach or shoreline. Along the New England Coast, this transitional zone between land and sea is composed of many different materials. These materials include cobble, pebbles and sand, which were deposited by glaciers thousands of years ago.

The white sandy beach is the most familiar type of shoreline along coastal Massachusetts. The mineral quartz gives these beaches their white appearance. Upon closer examination, sand consists of colorful minerals and shell fragments. Minerals like magnetite, feldspar, and were once part of the Appalachian Mountains and were eroded by glaciers. Shell fragments were once part of whole shells.

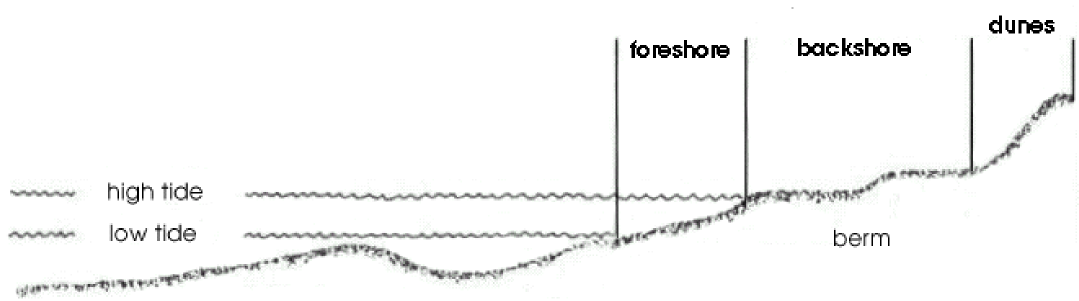
The sandy beach is an unstable, constantly changing environment. Forces like wind, waves, tides and currents change the beach shape. As winds and tides change with the seasons, the shape of the beach also changes. The gentle waves of summer tend to build a beach or berm until it is wide and almost flat, with only a slight incline. In winter, with increased winds and forceful waves, a beach is cut away, narrowing the berm and possibly creating a small, steep cliff face or scarp. Global warming may also cause beach erosion. As the polar glaciers melt with increases in temperature, there is a rise in sea level. In some areas on the outer Cape, beaches and beach cliffs are eroding at the alarming rate of 1.5 feet per year!

Organisms living in the beach must find shelter from the arid, hot, and usually salty conditions. Though the surface of the beach may appear desolate, in the sand and underneath the seaweed and shells there are numerous, tiny creatures, which bury themselves to take advantage of shade and trapped moisture. Their well-adapted appendages and streamlined bodies help them dive in and out of the sand in a matter of seconds.

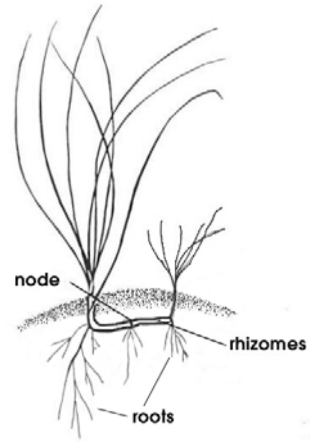
There are three distinct moisture zones created by the rise and fall of the tides. In the backshore, only salt spray, extreme tides and storm surges penetrate this desert-like zone. Dune plants may grow here depending on the amount of wind exposure. Camouflaged amphipods (sand fleas) take advantage of shells and seaweed that washed ashore to survive in this harsh zone.

A long line of seaweed and other debris usually marks the berm, also referred to as the crest or wrackline. This decaying matter harbors a number of creatures, including amphipods, flies, and beetles. These organisms help to recycle important nutrients into the ocean by decomposing the organic matter. Birds will forage in this area for insects.

In the foreshore, or intertidal zone, mole crabs, marine worms and surf clams adapt to the waves and tides by burying themselves. At the edge of the breaking waves, the mole crab leaps in and out of the sand while sweeping in microscopic plankton with feather-like. Horseshoe crabs lay their eggs in the sand during high spring tides.



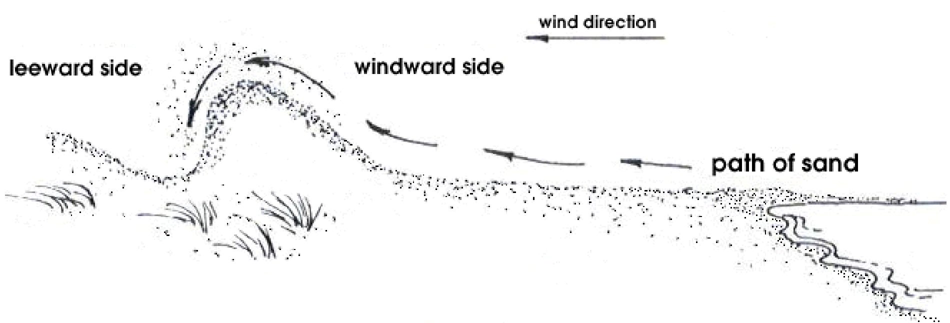
Coastal Dunes



Dunes are mounds of unconsolidated sediment deposited and eroded by wind. Along the coast, sand dunes range from 10 centimeters to 100 meters in height depending on age, wind conditions, grain size and amount of available sand. Plants stabilize and colonize dunes with their large network of **roots** and **rhizomes**. A rhizome is an underground shoot, or specialized stem that allows a plant to propagate.

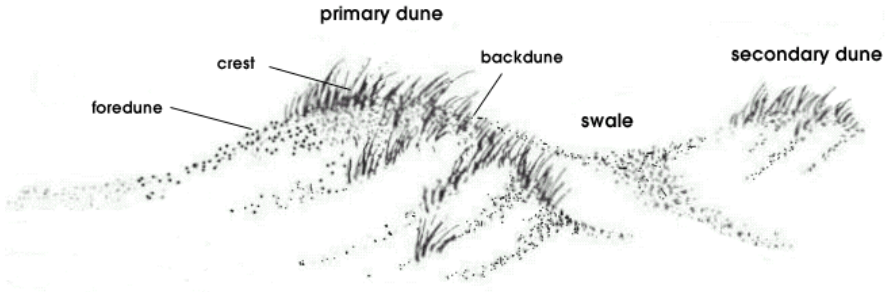
Coastal dunes are dynamic landforms that constantly shift and change. Dunes can lose and gain sand depending on wind speed and season. In summer, sand is moved from subtidal and intertidal zones up to the berm due to tidal currents. Wind action then moves this sand from the berm to the dunes. Any beach visitor who has put on suntan lotion during a windy day is aware of the wind's effect on the sand. In winter, the strong tidal currents pull berm sand to the subtidal zone while wind pushes berm sand onto the dunes. During large storms, when wind and waves are very strong, cuts can be made in the dune system.

Dune formation begins when a backshore obstruction, like driftwood, breaks wind speed, causing it to unload sand. This buildup continues, and eventually plants like beach spurge and seabeach orach colonize the mound. When *Ammophila breiligulata,* (the most dominant dune grass in our region) begins to take over, a dune can grow **one meter per year.**



Dune plants must tolerate adverse conditions including sand movement, strong winds, salt spray, and nutrient and moisture deficient soils. Many have adapted features to tolerate these conditions. Long roots help plants from being uprooted by strong winds and allow them to tap moisture deep below the sand's surface. **Tough, hairy leaves** and small flowers allow plants to conserve water. Some **nitrogen-fixing** plants, such as bayberry and beach pea, add nitrates to sand which helps support other plants. Beach grass must be covered by at least 3 centimeters of sand a year in order to continue growing vertically and spreading rhizomes. Its spike-like leaves have a tough outer covering that cannot be penetrated by salt. Other dune plants that are splashed by too much salt spray turn brown.

A sea-to-inland dune profile includes a foredune, crest, backdune, and swale. The slope of the foredune, normally between 30 and 34 degrees, is greater than backdune's slope (normally between 10 and 15 degrees), because of the way sand hits the windward side and rolls down the leeward side. The diversity of plants increases because of the decrease in wind and salt spray. The sun's rays bouncing off the sand are trapped in these convex pockets causing temperatures to increase dramatically. Dune systems may include primary, secondary and tertiary dunes.



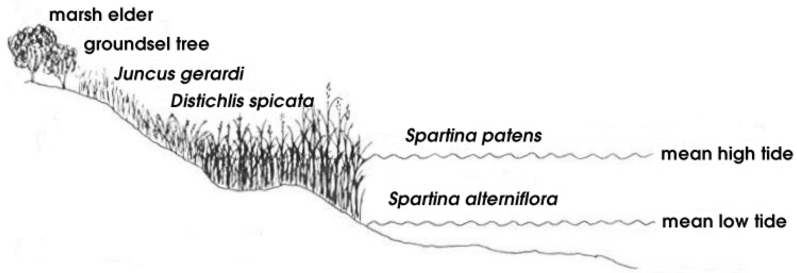
Dunes are fragile habitats because roots are easily damaged in sand. Human steps and tire tracks can break roots and consequently leads to dune erosion. Dunes protect the salt marsh, estuary and coastal homes from storm damage. For these reasons, there are laws limiting access through dunes to the beach. Programs to reestablish damaged dunes are also underway.

Salt Marsh

Dominated by salt and heat tolerant grasses, salt marshes are usually found along estuaries where they are protected from the direct impact of the ocean waves and currents. This muddy habitat is subject to the high and low tides that occur two times daily in our area. Nutrients from decaying salt marsh vegetation and animals are picked up by high tides and carried to the estuary where they form the **base of the nutrient cycle.**

Salt marshes migrate and grow vertically as much as one foot per year. Formation occurs when ***Spartina,*** the dominant genus of grass found in the salt marshes from Florida to the Gulf Coast of St. Laurence, takes root over the mud flats. During high tide, water moving over the mud flats carries sediment that is trapped by the grass blades. The building up of mud buries the vegetation, which responds by sprouting new shoots on top of the incompletely decomposed roots. In this way parts of the marsh, built up above the high spring tide mark, are taken over by land plants which can out compete the salt marsh grasses.

The Salt marsh zones, **high marsh**, **mid marsh** and **low marsh**, **creeks**, and **pannes**, have different levels of temperature, salinity and saturation. Saltwater cordgrass (*Spartina alterniflora*) found along the creeks and embayments, is more salt tolerant than the shorter Saltmeadow cordgrass (*Spartina patens*), found mixed with spike grass (*Distichilis spicata*) in the mid marsh. Saltwort (*Salticornia sp*.), a short succulent plant, is found in the high marsh and pannes where compact silt supports its shallow roots. The roots of the grasses are long and numerous and extend from rhizomes, a root-like underground stem which grows horizontally and sends up new shoots in the spring.



Spartina grasses are highly adapted to the harsh conditions in the salt marsh. Their long, thin leaves allow the plant to lose heat rapidly without evaporation during dry periods. Since salt marsh mud is rich in bacteria and poor in oxygen, these grasses have air tubes extending from stomata openings in the leaves to the roots, filling them with air. Too much time under water will destroy these grasses, which require exposure to air for at least half of their daily cycle.

In the high marsh, the sponge-like mud is less saturated. Pulmonate (having lungs) salt-marsh snails feed on algae with barbed tongues called **radula** and insects scurry around the grass bases looking for smaller insects and decaying matter to eat. In the low marsh, ribbed mussels burrow in the mud and filter feed at high tides while fiddler crabs hide from predators such as birds and larger crabs in tiny holes along channels.

Salt marsh habitat in the coastal United States is being destroyed at an alarming rate of 5,000 acres per year! Large storms destroy acres of salt marsh, but most of the destruction is carried out by human beings. In the past, salt marshes have been cut for winter hay and roof material, as well as being filled in and drained for building space. Even though this habitat is protected by the Wetlands Protection Act, there is still pressure to drain and fill wetlands for development.

Estuary

An estuary is a semi-enclosed body of water where freshwater from streams and rivers and saltwater from the ocean mix. This mix of fresh and saltwater is called brackish water. Most of the estuaries along the Atlantic coast of North America where established thousands of years ago when the last glaciers melted and the sea level rose, flooding river valleys.

River flow and tidal motion are factors that determine the amount of fresh and salt water mixing in an estuary. Salt water, with **35 parts of salt per thousand parts of water**, is heavier than fresh water, with zero parts of salt per thousand parts of water, and therefore sinks to the bottom.
At high tide, the inrush of seawater determines salinity; at low tide, salinity is determined by downstream river flow.

Salinity changes present major physiological challenges to marine organisms. When salinity shifts, organisms must be able to rapidly adjust their **ionic composition** of cellular fluids and total concentrations of dissolved materials. This process of regulating internal levels of dissolved materials (such as salt) is called **osmoregulation** and takes place between semi-permeable membranes in kidneys and skin.

Due to the lack of competition and high nutrient input from the salt marsh, the estuary supports a large population of commercially exploited species such as soft shell clams, quahogs and bluefish. For this reason, estuaries are called nurseries of the marine environment. Some species of fish that spawn offshore depend on the estuary for food and shelter during early life stages.

Juvenile bluefish, for example, begin their life cycle offshore, but migrate to bays and estuaries in the summer for most of their life cycle.

To avoid being expelled from the estuary during tidal flushing, fish and invertebrate larvae cling to the floor where water moves slowly. Animals like jellyfish, comb jellies and dinoflagellates that drift with the currents are usually flushed from the estuary during outgoing tides. Also called marine zooplankton, these creatures have specialized shapes that allow them to float in water.

Birds also flock to the estuary to feed. Mud and sand flats are dominated by small shorebirds such as sandpipers and plovers that feed on marine worms and insects. Larger birds, such as the great blue heron, hunt fish in the estuary channels and creeks.

For more information on estuaries, visit:

http://www.epa.gov/owow/estuaries/

http://www.epa.gov/NE/topics/ecosystems/estuaries.html