



**VA SEA**

# SHIFTING SANDS: COASTAL DUNES IN MOTION

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**Grade Level**

5<sup>th</sup> Grade

**Subject area**

General Science

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**Title** Shifting Sands: Coastal Dunes in Motion

**Focus** Students will use “before & after” dune profile graphics to determine how the dune has changed and hypothesize why this change occurred

**Grade Level** Grade 5

### **VA Science Standards**

**5.1** Student will demonstrate an understanding of scientific and engineering practices by:

- Asking questions and defining problems
- Planning and carrying out investigations
- Interpreting, analyzing, and evaluating data
- Constructing and critiquing conclusions and explanations
- Obtaining, evaluating, and communicating information

**5.8** Student will investigate and understand that Earth constantly changes. Key ideas include:

- Processes such as weathering, erosion, and deposition change the surface of the Earth; and
- Fossils and geologic patterns provide evidence of Earth’s change

**E.9** Student will investigate and understand that the conservation of energy and resources is important. Key idea include:

- Individuals and communities have means of conserving matter

### **Learning Objectives**

- ✓ Students will make observations about dune changes over time
- ✓ Students will use dune profile graphics to identify locations of dune growth and/or dune erosion
- ✓ Students will use data to hypothesize what types of events or natural forces contributed to dune changes
- ✓ Students will discuss the ecological and economic importance of coastal dunes

### **Total length of time required for the lesson**

60-80 minutes total; Advance preparation of lab materials – 5 minutes, Lab setup – 5 minutes, Introduction – 15 minutes, Activity – 30 to 45 minutes, Discussion – 15 minutes, Breakdown and clean-up – 5 minutes.



### Key words, vocabulary:

- **Ecosystem Services:** the benefits that humans receive from nature.
- **Erosion:** water, wind and other natural forces cause rocks and earth to wear away. These forces also move bits of rocks and earth to new places.
- **Deposition:** the process by which sediments (small particles of rock) are laid down in new locations
- **Dune crest:** the highest point on a dune
- **Dune heel:** where the dune ends on the landward side
- **Dune toe:** where the dune ends on the seaward side
- **Dune:** a hill or ridge of sediment piled up by the wind
- **Weathering:** a natural process that slowly breaks apart or changes rock. Heat, water, wind, living things, and other natural forces cause weathering.

### Background information

**Coastal dunes.** Coastal dunes are natural, protective features on beaches that buffer oceanside flooding impacts. Coastal dunes are topographic highs on the beach and are primarily composed of sand-sized sediment. They form when there is a source of sand (like the beach), wind strong enough to move the sand, and a means of causing the sand to be dropped or deposited. Sand is dropped by wind when the wind speed is reduced beyond the threshold required to move the sediment, or when the sediment hits a barrier. Barriers that typically form dunes, or help dunes grow or accrete, include small variations in beach topography, vegetation, seaweed, driftwood, litter, and sand fences. Coastal dunes protect against storm impacts such as storm surge, flooding, waves, and wind, by acting as a physical barrier between the beach/ocean and the land/infrastructure behind the dune. Their ability to protect landward infrastructure makes them highly valuable to coastal communities & beachfront property owners. Other ecosystem services dunes provide include filtering pollutants, providing refuge areas & habitat, providing locations for nesting sites for birds/turtles, providing a food source for beach critters, storing groundwater, trapping carbon, and providing areas for passive recreation such as sight-seeing and bird watching.

**Dune Changes.** Coastal dunes are dynamic features that are constantly changing. No dune stays the same forever! This is because many forces are acting upon the dune. Dunes change in response to weather, climate, human activities, & the ocean. On the most basic level, dune changes can be



categorized as dune growth (accretion) or dune erosion. Dune accretion occurs when sediment is added to the dune. Accretion can be vertical (dunes get taller) or horizontal (dunes get wider). Dunes along the US East Coast typically accrete in the summer from natural forces, such as strong winds pushing sand from the beach onto the dune, and from an increase in vegetation cover (which acts as a barrier trapping sand). Dunes can also accrete as a result of anthropogenic activities, as discussed below. Dunes weather when sediment is removed from any part of the dune. Dunes erode when the removed sediment is transported away from the dune. The key difference between weathering and erosion is that erosion requires the transport of sediment away from its starting place. Natural forces cause dunes to erode. When waves collide with the dune, they can cause the dune to erode by removing sediment and transporting it back to the beach or into the ocean. Waves can also totally knock down a dune if they are strong enough! Very strong winds can also cause dune erosion. Examples of anthropogenic dune erosion are described below.

***Anthropogenic management activities affecting dunes.*** Many coastal communities recognize the importance of dunes both ecologically and economically. Accordingly, coastal planners are constructing artificial dunes and/or encouraging the growth of natural dunes to increase coastal protection. Humans help dunes grow by physically adding sand to them (often using heavy machinery), adding barrier to increase sand trapping, or by preserving existing dunes through zoning regulations. Coastal communities might add sand fences or plant additional vegetation on the dunes to help increase sand trapping, which leads to dune accretion.

Though dunes are protective features, sometimes humans place higher value on beach access and development. These development activities often cause dunes to erode. Examples of activities that diminish the protectiveness of dunes include: constructing buildings/roads too close to dune or even on top of them, cutting a pathway through the dunes to access the beach, and physically lowering the dune height to increase ocean views. For a more complete list of anthropogenic activities that affect coastal dunes, see Nordstrom, K.F. (2015).

***Monitoring beach changes.*** Coastal scientists measure beach and dune changes over time to predict future changes. If we know what has happened in the past, we might be able to better predict what will happen in the future under similar conditions. Having accurate accounts of dune and beach changes allows communities to take action as needed to ensure that dunes are providing the functions they value. For example, if a community values infrastructure protection, it would be important for them to know the seasonal dune erosion/accretion rate. If the dune is eroding, they might elect to add sand fences or plant vegetation to encourage dune growth.

### **Student handouts**

- Shifting Sands: Coastal Dunes in Motion Worksheet.

### **Materials & Supplies**

- Computer and projector for accompanying PowerPoint
- Dry erase board/easel
- Pencils/markers



## Classroom Set up

- OPTION 1: Work through handout as a class using a projector. Students will need to be able to move about the classroom.
- OPTION 2: Students should work with partners or individually.

## Procedure

### Advance preparation of lab materials – 5 minutes

- OPTION 1: Arrange classroom so that students can move from one side of the room to the other.
- OPTION 2: Prepare lesson activity by printing dune worksheet in advance (one per student). These worksheets may be either printed for single-use or laminated for students to use repeated with dry erase markers.
  - Each group/student should have a copy of:
    - Shifting Sands: Coastal Dunes in Motion Worksheet. Ideally worksheet should be printed in color, but are usable in black and white.

### Introduction & PowerPoint

Begin the PowerPoint, *Shifting Sands: Coastal Dunes in Motion*.

- See slides for specific notes with suggested dialog and discussion
- Start with a “Free Write” after watching the time-lapse video linked on Slide 3. After a 3-minute free write, have an open discussion with the class to note the changes that occur to the dune. At a minimum, note that...
  - Waves are hitting dune causing it to break down (weather & erode)
  - Point out that large portion of lower dune breaks off (slumps) around 13 seconds after being hit by a wave (and again at 40 seconds)
  - There must have been some serious erosion before the camera started recording since the walkway isn’t connected to anything!
  - There are fences in the dune, which were put there by humans... This is an example of a coastal management
  - Houses in the foreground are fronted by coastal dunes, but house in the distant is not... And it’s completely surrounded by water!
- Ask students:
  - What do you know about beaches?
  - What do you know about coastal dunes?
- Discuss coastal dunes, where they are located, how they formed, and what ecosystem services they provide
  - Define coastal dunes as “a hill or ridge of sediment piled up by the wind”
  - Look at the pictures of different coastal dunes found on the US East Coast (Slide 5). Ask students to note any similarities and differences between these dunes.

- Possible answers: Similarities = made of sand, at the landward edge of the beach, vegetation; Differences = houses located close to dunes in top right image, sand is different colors, dunes themselves are different shapes
- Introduce that dunes are formed when there is a source of sand, wind strong enough to move the sand, and a means of causing the sand to be dropped by the wind. Tell students that dune formation is a natural process on most sandy beaches.
  - Provide examples of barriers that initiate dune formation.
    - Examples include plants, large shells, litter, drift wood, and sea weed
- Introduce the concept that coastal dunes change over time. Note that dunes are dynamic features that are always changing in response to human activities, climate, weather, & the ocean.
  - Types of dune changes = growth (accretion), weathering, & erosion. (See slides for more details).
  - Ask students to hypothesize how each of these forces (i.e., human activities, climate, weather, & the ocean) might change coastal dunes.
- Introduce concept of dune accretion & explain the difference between vertical and horizontal accretion
  - Vertical = sediment is added to the top of the dune, making it taller
  - Horizontal = sediment is added to the front or back of a dune, making it wider
  - Ask students if they can think of any reasons dunes would accrete
    - Possible answers: wind moving more sand onto the dune, more barriers to trap sand, humans putting sand on the dune themselves
  - Explain what causes dunes to accrete (See slides 10 & 11 for more detail)
    - Natural forces
    - Anthropogenic (human-caused) forces
- Introduce concept of dune weathering & erosion
  - Dune weathering = sediment is removed from any part of the dune
  - Dune erosion = sediment is removed from any part of the dune AND that removed sediment is transported away from the dune
  - Ask students if they can think of any reasons dunes would erode
    - Possible answers: storms, human development
  - Explain what causes dunes to erode (See slides 13 & 14 for more detail)
    - Natural forces
    - Anthropogenic forces
- Introduce why we should care about coastal dunes
  - Talk about the ecosystem services they provide, such as protecting infrastructure from storms, filtering pollutants, providing refuge or safe areas for critters, act as nesting sites for birds/turtles, provide a food source, store groundwater, trap carbon, and are areas for sight-seeing & bird watching.
    - Note that people who live on the beach particularly value their ability to protect homes & buildings from oceanside flooding



## Activity

- **OPTION 1:**
  - Explain to the class that as demonstrated in the slides, coastal dunes are very valuable to humans and the environment. Because of this, scientists track coastal dune changes over time to help predict future changes. Coastal communities want to make sure that their dunes are strong enough to protect infrastructure and continue to provide their superb ecosystem services.
  - Explain to the scenario to the class:
    - They are coastal scientists that have been asked to help monitor dune changes by a coastal community called Sea Breeze, USA.
    - The worksheet contains four before & after coastal dune profiles.
      - For each profile, the students need to identify how the dune has changed & hypothesize what force(s) caused this change.
      - Based on their observations, the students will formulate recommendations to the town of Sea Breeze, giving them advice on ways that they could prevent dune erosion and/or encourage dune growth.
  - Project the “before & after” dune image pairs one at a time.
    - Have students move to the right side of the room if they think the dune is growing.
    - Have students move to the left side of the room if they think the dune is eroding.
    - Have students come up to the projected image and point out where the dune is growing or eroding.
  - Have students discuss with a partner 3 recommendations that they would give to the town of Sea Breeze to help promote dune growth and prevent dune erosion.
- **OPTION 2:**
  - Split the class into pairs
  - Explain to the class that as demonstrated in the slides, coastal dunes are very valuable to humans and the environment. Because of this, scientists track coastal dune changes over time to help predict future changes. Coastal communities want to make sure that their dunes are strong enough to protect infrastructure and continue to provide their superb ecosystem services.
  - Hand out worksheet.
  - Explain to the scenario to the class:
    - They are coastal scientists that have been asked to help monitor dune changes by a coastal community called Sea Breeze, USA.
    - The worksheet contains four before & after coastal dune profiles.
      - For each profile, the students need to identify how the dune has changed & hypothesize what force(s) caused this change.
      - Based on their observations, the students will formulate recommendations to the town of Sea Breeze, giving them advice on ways that they could prevent dune erosion and/or encourage dune growth.
  - Have students work through the worksheet.





- Students will be asked to star locations of dune accretion and circle locations of dune erosion.
- Students will be asked to evaluate the evidence to determine what forces caused the dune changes.
- Have students discuss with their partner 3 recommendations that they would give to the town of Sea Breeze to help promote dune growth and prevent dune erosion.

#### Differentiate for different skill sets and time available

- Consider the following as modifications based on classroom and time for activity:
  - Eliminate 1-2 of the before & after dune profiles

#### Wrap-Up/Class Discussion

- As a class, discuss & list 3 unique recommendations that the students would give to Sea Breeze, USA.
- Suggested wrap-up questions and answers:
  - What types of dune changes did we see?
    - Answer: erosion & accretion
  - Was the accretion vertical or horizontal?
    - Answer: both
  - What were some of the forces controlling dune changes in Sea Breeze, USA?
    - Answer: anthropogenic erosion (humans built homes too close to the dune); anthropogenic accretion (humans installed sand fences on the ocean side of the dune, which added a barrier, helping to trap sand); natural erosion (storm/wave driven); natural accretion (wind)
  - Ask students to share why we should care about dunes, even if we don't live close to the beach
    - Answer: This is open ended, there are lots of reasons to care about coastal dunes! Encourage students to think broadly.

#### **Assessment**

For option 1, students will be assessed based on their classroom participation. For option 2, students will be assessed based on their performance on the worksheet questions.

#### **Extension**

An optional, hands-on extension activity can be found here: <https://littlebinsforlittlehands.com/coastal-erosion/>. This is a beach erosion activity and demonstration to help students visualize and understand coastal erosion.



### **Acknowledgments**

Dune profile data are based off of real measurements collected by the VIMS Coastal Geology Lab at the US ACE Field Research Facility in Duck, NC. Dr. Nicholas Cohn aided in field data collection. Support for the lesson plan was provided by Virginia Scientists & Educators Alliance.



## Shifting Sands: Changes in Coastal Dunes Worksheet

Name \_\_\_\_\_

Date \_\_\_\_\_

**Introduction.** Coastal dunes are very valuable to humans and the environment. Coastal dunes provide ecosystem services such as protecting infrastructure and homes, filtering pollutants, providing habitat & a food source, and trap carbon. Scientists track coastal dune changes over time to help predict future changes. If we know what has happened in the past, we might be able to predict what will happen in the future under similar conditions!

Coastal communities want to make sure that their dunes are strong enough to protect infrastructure and continue to provide their excellent ecosystem services. You are now a coastal scientist and have been asked to help monitor dune changes by coastal community Sea Breeze, USA.

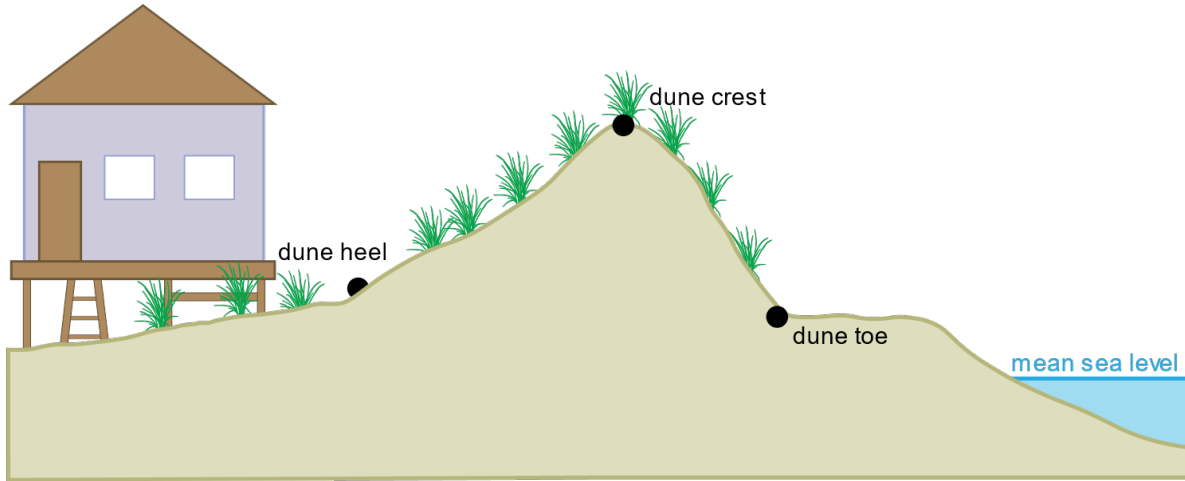
This worksheet contains four before & after coastal dune profiles. For each profile, you will need to identify how the dune has changed. Based on your observations, you will then hypothesize what force(s) caused this change.

Lastly, you will formulate recommendations to the town of Sea Breeze and give them advice on ways that they can prevent dune erosion and/or encourage dune growth.

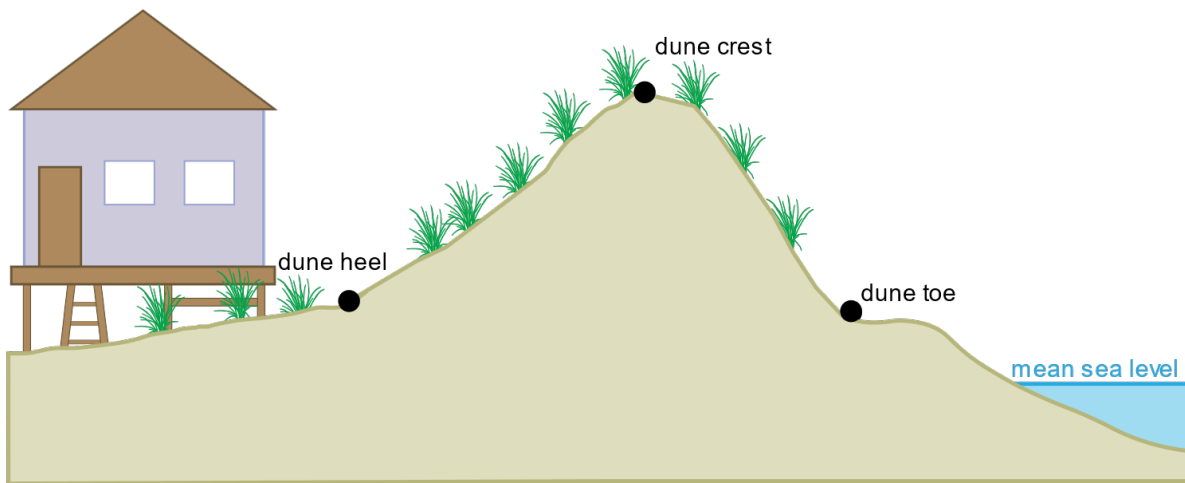
### Instructions

- With your partner, study the before & after graphics of a coastal dune in Sea Breeze, USA.
- Identify areas of dune growth (accretion) and mark them with a star.
- Identify areas of dune erosion and circle them.
- Evaluate the changes and other clues in the graphics to hypothesize the force(s) that contributed to dune change. Be as specific as possible.
  - Defend your hypothesize with reasons why you came to this conclusion.
- Based on your observations, brainstorm 5 recommendations that you would give to the Mayor of Sea Breeze to help them prevent dune erosion and increase dune accretion.

**Part A – Before**



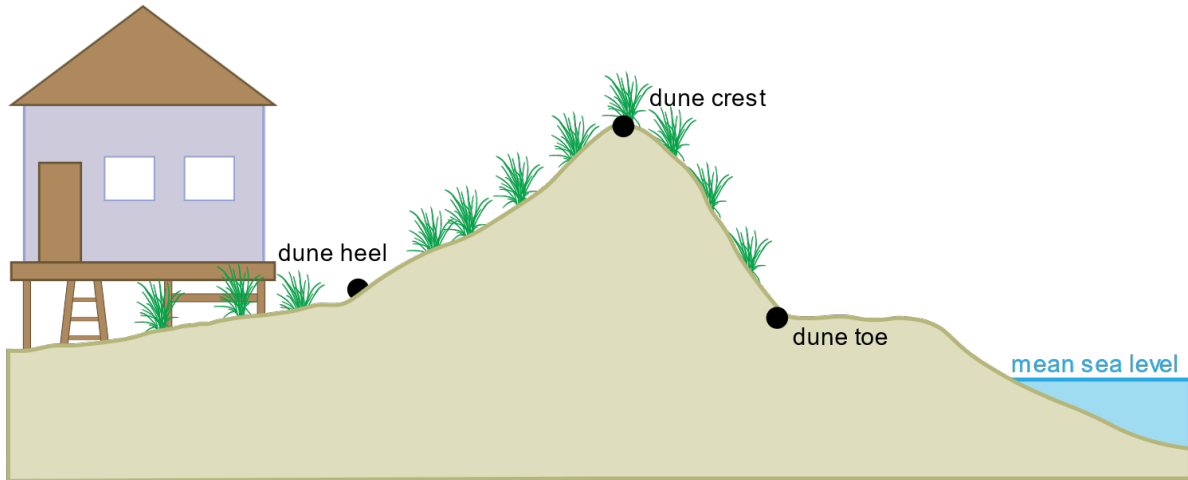
**Part A – After**



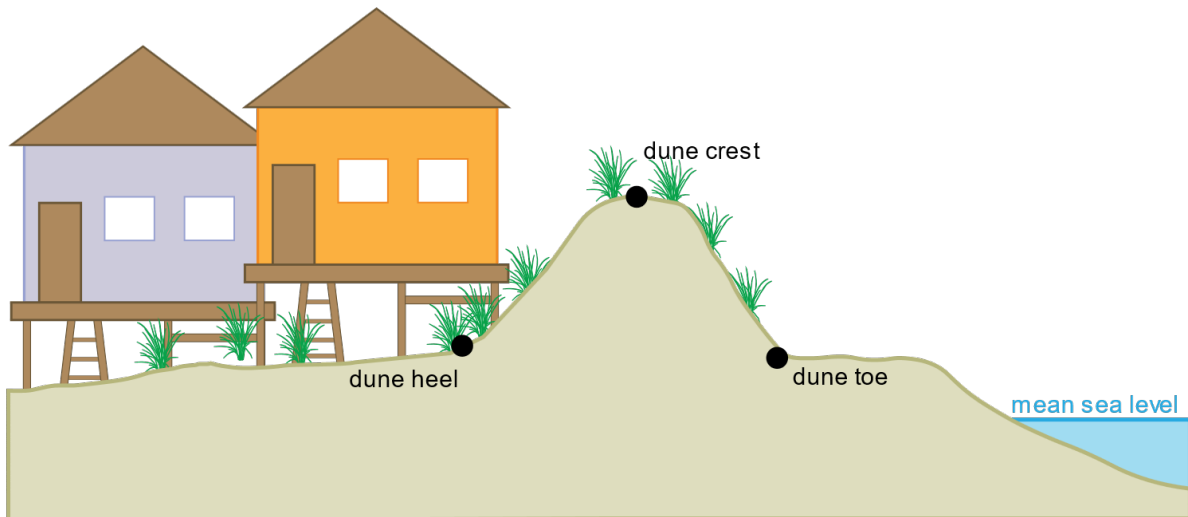
**Questions:**

1. Overall the dune experienced ( erosion / growth ). (Circle answer)
  - a. If the dune grew (accreted), was it vertical, horizontal, or both? (Circle answer)
2. What are some forces that may have contributed to this change? Explain your reasoning.

**Part B – Before**



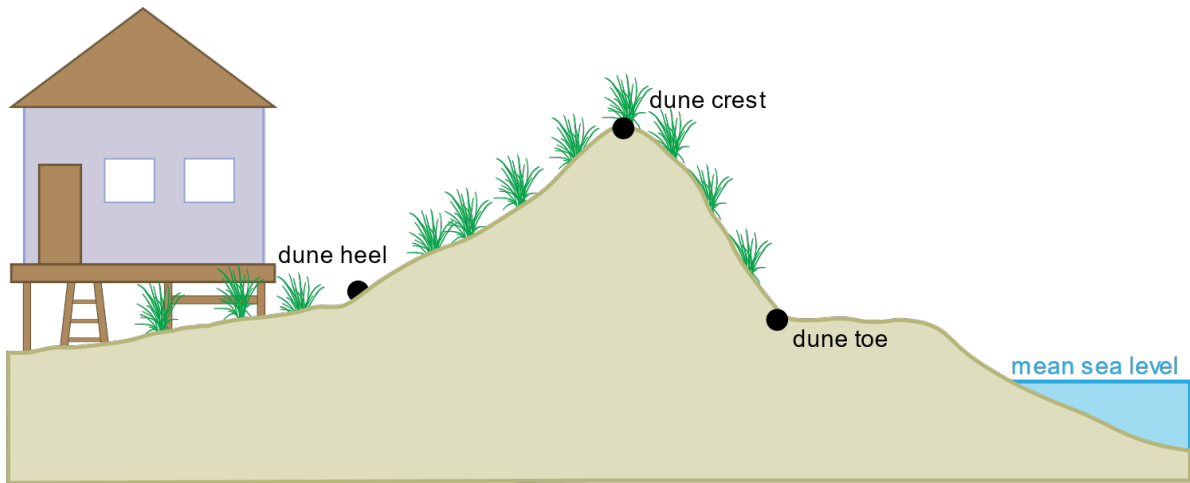
**Part B – After**



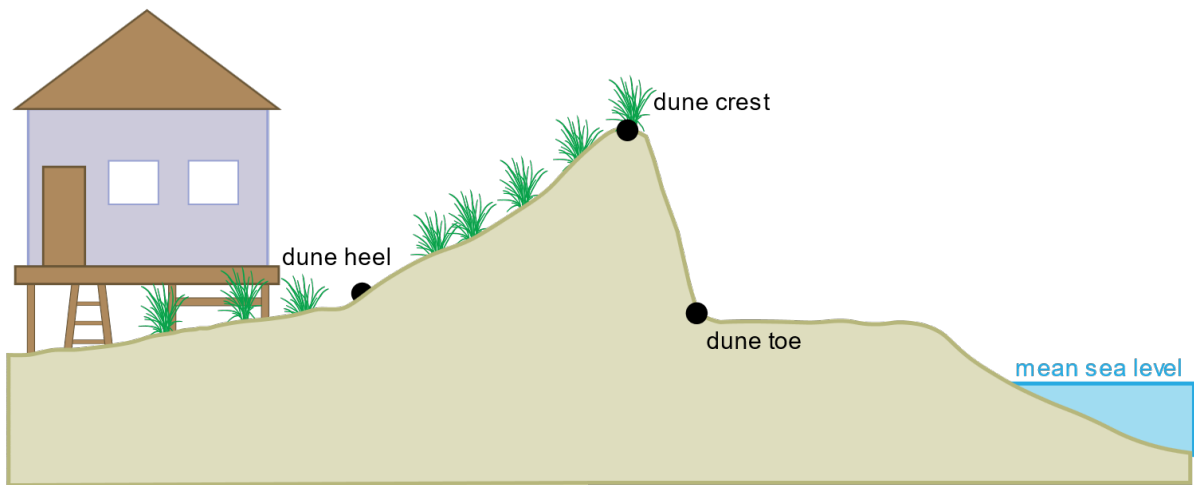
**Questions:**

1. Overall the dune experienced ( erosion / growth ). (Circle answer)
  - a. If the dune grew (accreted), was it vertical, horizontal, or both? (Circle answer)
2. What are some forces that may have contributed to this change? Explain your reasoning.

**Part C – Before**



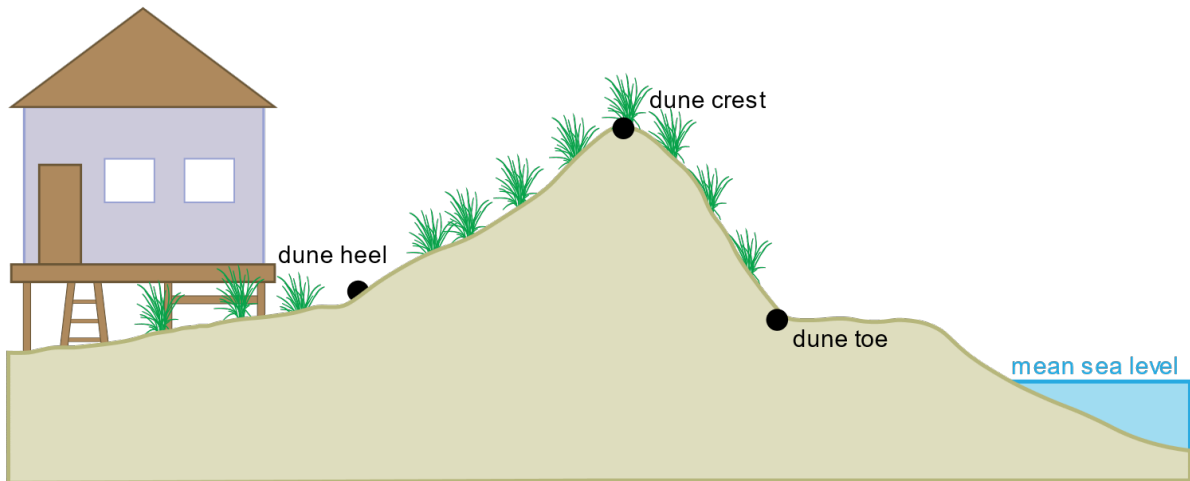
**Part C – After**



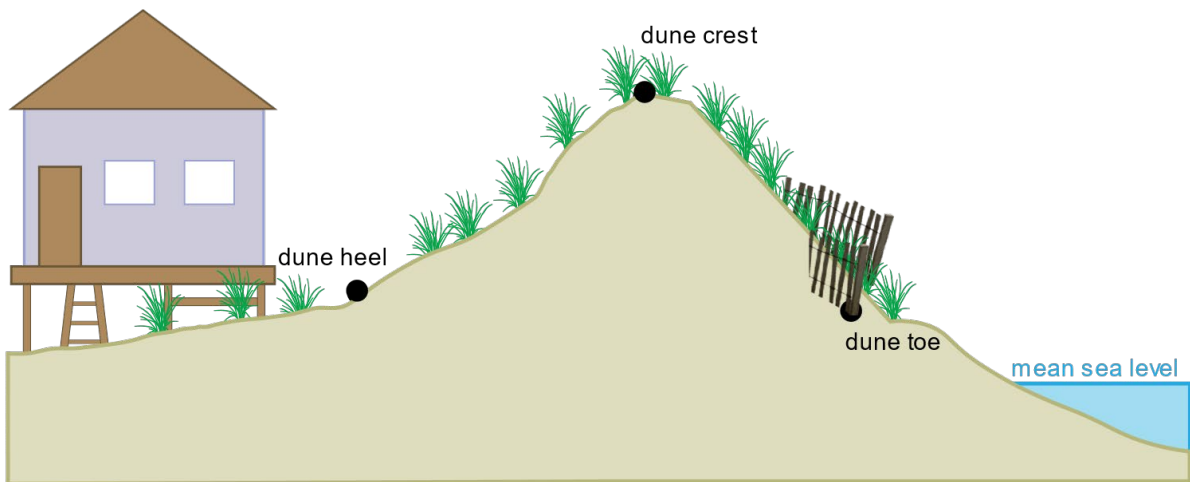
**Questions:**

1. Overall the dune experienced ( erosion / growth ). (Circle answer)
  - a. If the dune grew (accreted), was it vertical, horizontal, or both? (Circle answer)
2. What are some forces that may have contributed to this change? Explain your reasoning.

**Part D – Before**



**Part D – After**



**Questions:**

1. Overall the dune experienced ( erosion / growth ). (Circle answer)
  - a. If the dune grew (accreted), was it vertical, horizontal, or both? (Circle answer)
2. What are some forces that may have contributed to this change? Explain your reasoning.

**Critical Thinking: List 3-5 recommendations to the town of Sea Breeze that would help them prevent dune erosion and/or increase dune accretion.**



## Shifting Sands: Changes in Coastal Dunes

Name\_\_ Instructor Key\_

Date\_\_\_\_\_

**Introduction.** Coastal dunes are very valuable to humans and the environment. Coastal dunes provide ecosystem services such as protecting infrastructure and homes, filtering pollutants, providing habitat & a food source, and trap carbon. Scientists track coastal dune changes over time to help predict future changes. If we know what has happened in the past, we might be able to predict what will happen in the future under similar conditions!

Coastal communities want to make sure that their dunes are strong enough to protect infrastructure and continue to provide their excellent ecosystem services. You are now a coastal scientist and have been asked to help monitor dune changes by coastal community Sea Breeze, USA.

This worksheet contains four before & after coastal dune profiles. For each profile, you will need to identify how the dune has changed. Based on your observations, you will then hypothesize what force(s) caused this change.

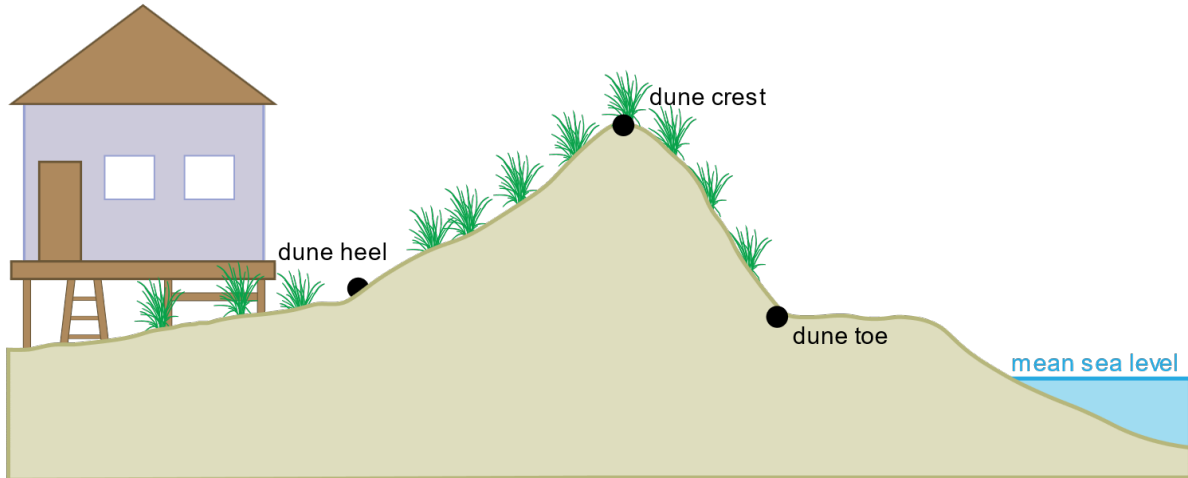
Lastly, you will formulate recommendations to the town of Sea Breeze and give them advice on ways that they can prevent dune erosion and/or encourage dune growth.

### Instructions

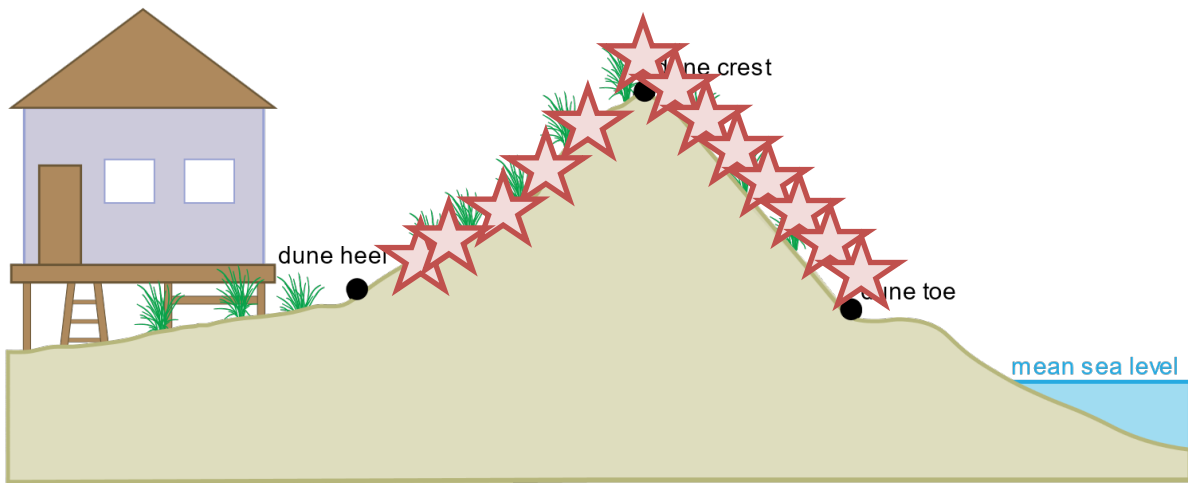
- With your partner, study the before & after graphics of a coastal dune in Sea Breeze, USA.
- Identify areas of dune accretion (growth) and mark them with a star.
- Identify areas of dune erosion and circle them.
- Evaluate the changes and other clues in the graphics to hypothesize the force(s) that contributed to dune change. Be as specific as possible.
  - Defend your hypothesize with reasons why you came to this conclusion.
- Based on your observations, brainstorm 5 recommendations that you would give to the Mayor of Sea Breeze to help them prevent dune erosion and increase dune accretion.



**Part A – Before**



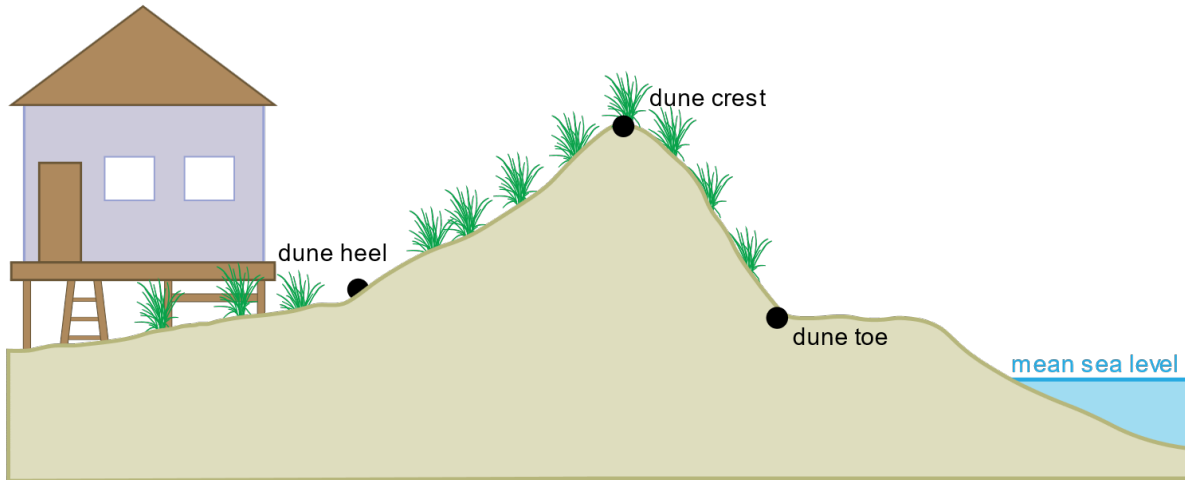
**Part A – After**



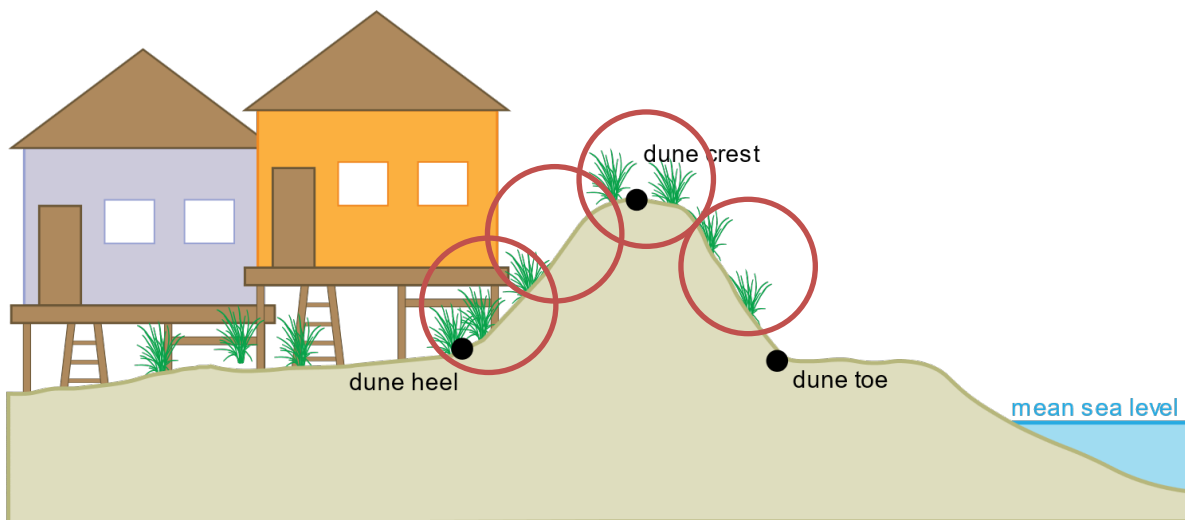
**Questions:**

3. Overall the dune experienced ( erosion / **growth** ). (Circle answer)
  - a. If the dune grew, was it vertical, horizontal, or **both**? (Circle answer)
4. What are some forces that may have contributed to this change? Explain your reasoning.  
*We don't see any evidence of human-induced change, so this dune accretion was most likely a natural occurrence. The vegetation on the oceanside of the dune probably helped to trap wind-blown sand, resulting in horizontal accretion. The vegetation at the dune crest probably helped to trap wind-blown sand as well, leading to vertical accretion.*

**Part B – Before**



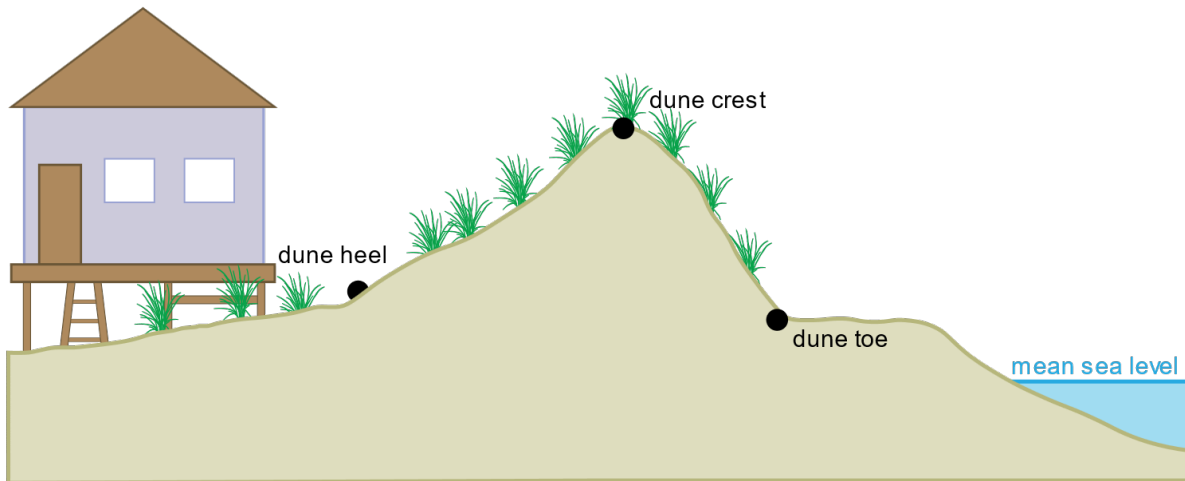
**Part B – After**



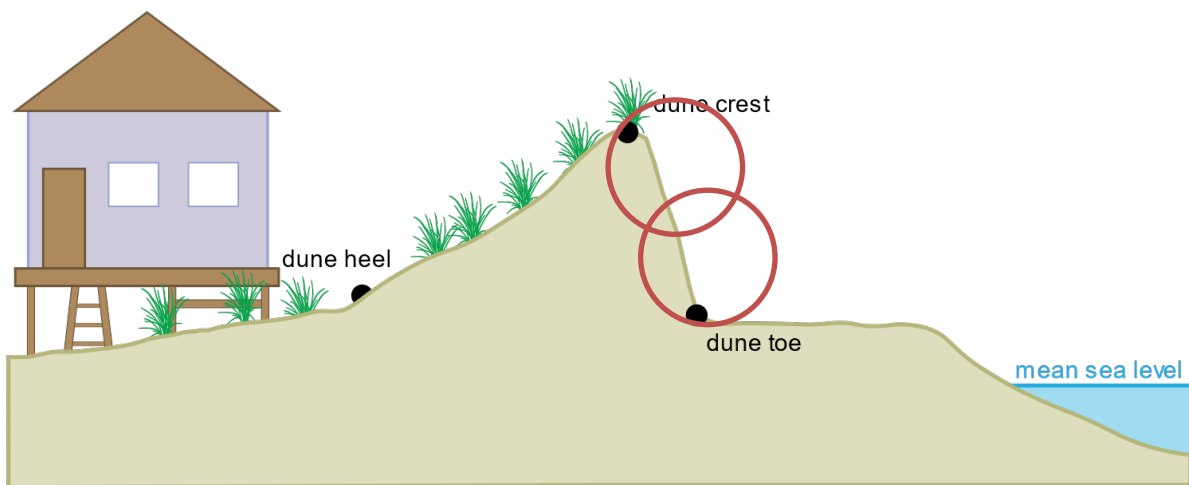
**Questions:**

1. Overall the dune experienced ( **erosion** / growth ). (Circle answer)
  - a. If the dune grew, was it vertical, horizontal, or both? (Circle answer)
2. What are some forces that may have contributed to this change? Explain your reasoning.  
**Forces = anthropogenic construction activities. It appears as if a new house has been built partially on top of the landward side of the dune. The construction activities likely removed part of the dune to create a level area for the house. It also appears as if the dune height has been lowered. This might have occurred to increase the ocean views from the homes.**

**Part C – Before**



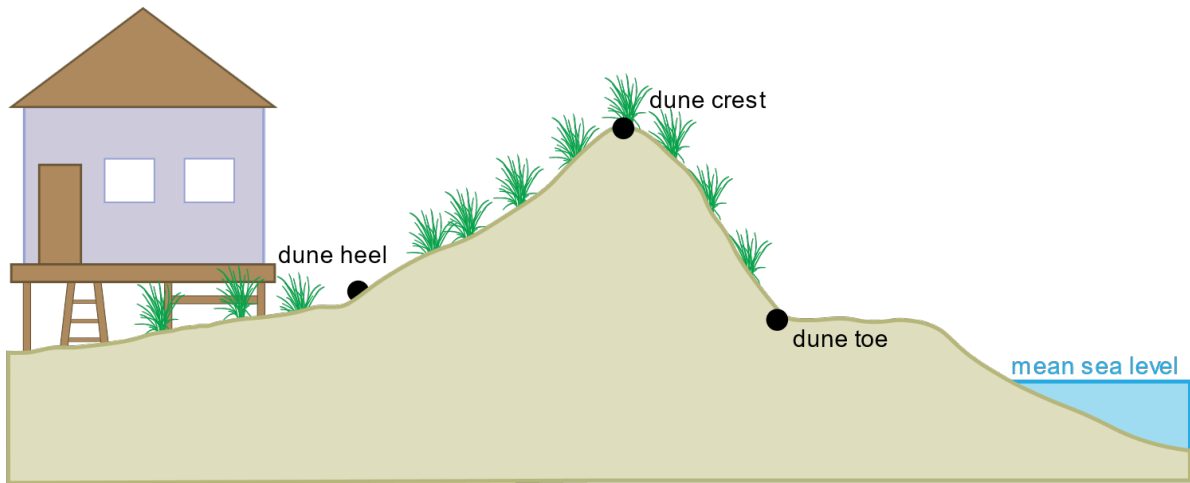
**Part C – After**



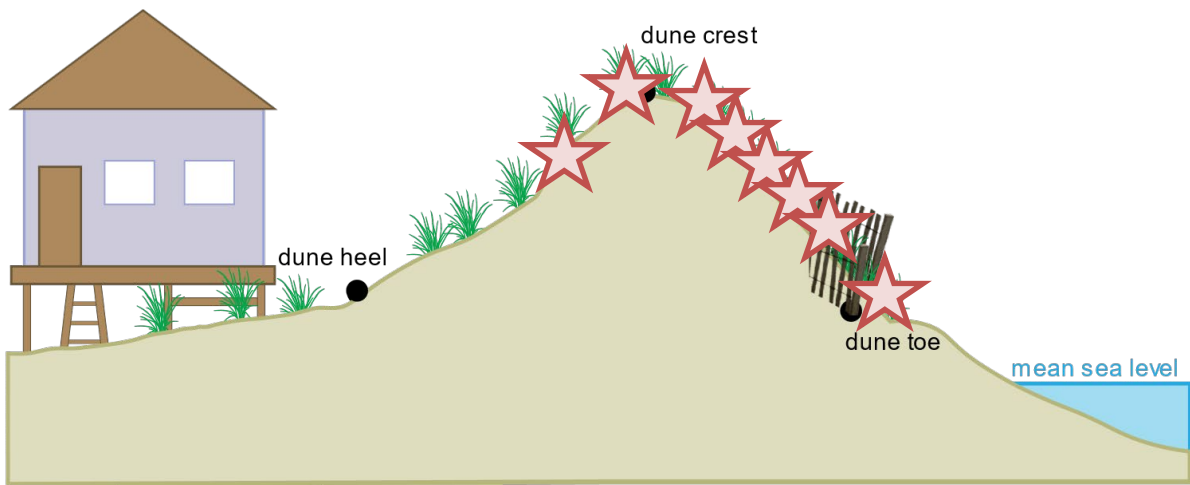
**Questions:**

1. Overall the dune experienced ( **erosion** / growth ). (Circle answer)
  - a. If the dune grew (accreted), was it vertical, horizontal, or both? (Circle answer)
2. What are some forces that may have contributed to this change? Explain your reasoning.  
**We don't see any evidence of human-induced change, so this dune erosion was most likely a natural occurrence. Only the oceanside of the dune has eroded. This leads us to believe that waves might have collided with the dune, causing the erosion. The waves might have been part of a storm. The waves washed away the dune vegetation.**

**Part D – Before**



**Part D – After**



**Questions:**

1. Overall the dune experienced ( erosion / **growth** ). (Circle answer)
  - a. If the dune grew (accreted), was it vertical, horizontal, or **both**? (Circle answer)
2. What are some forces that may have contributed to this change? Explain your reasoning.  
**Forces = anthropogenic. It appears as if sand fences were installed, and additional vegetation was planted on the dune crest and ocean side of the dune. The additional dune vegetation and sand fences are management activities that increase sand trapping on a dune. This caused vertical and horizontal accretion.**



**Critical Thinking: List at least 3 recommendations to the town of Sea Breeze that would help them prevent dune erosion and/or increase dune accretion.** There are a lot of recommendations that students could come up with. Some ideas are: planting dune vegetation, installing sand fences, limiting construction close to dunes, physically add sand to the dunes, don't let humans walk on dunes, preserve existing dunes, etc. If students have a hard time with this, refer back to slides 10-11 & 13-14.



**References and further reading:**

Nordstrom, K.F. (2015). Coastal Dunes. In Coastal Environments and Global Change (eds G. Masselink and R. Gehrels). <https://doi.org/10.1002/9781119117261.ch8>