

Name: _____ Date: _____ Class: _____

Landscapes Changed by Wind - Engage

Learning Target: _____

Do Now:

Video Notes:

Video Questions:

1. Where does the dust come from? Explain what is important about the location of where the dust originates.
2. What location does the dust travel to? Explain what is important about this location.
3. How does the dust travel from one place to the other?
4. What NASA satellite collected the data used in this video?

5. Explain how the geosphere and biosphere are connected in this example.

6. Connect this to your own life: when have you experienced a smoke storm in New York City (**hint:** think about a time when all of the air in NYC was orange colored!)? Where did that smoke originate from? What was it like to breathe that air?

7. How is smoke similar to sand? How is smoke different from sand?

Landscapes Changed by Wind - Explore Day 1

Learning Target: _____

Do Now:

Part 1: Abrasion by Windblown Sand

You will examine the effects of particles carried by wind on rocky material. Your group is going to run a model that examines the effects of windblown sand on rock. Examine a sample of small sandstone or limestone pebbles.

1. In the space below, record the characteristics of the pebbles. Sketch them with as much detail as possible. Pay particular attention to the edges and faces of the pebbles. Write down annotations of key details that you notice on the pebble.

Sketch and Annotations

2. Put the pebbles and 50 g of sand in a small plastic container. Close the container. Seal the container using some tape to make sure the sand does not leak. **Predict what will occur when you shake the container.**
3. Take turns vigorously shaking the container. You should shake the container for 3 minutes total.
4. Open the container and examine the pebbles
 - a. **On the top of page 4**, record any changes to the pebbles that you observe.
 - b. Compare your predictions to your results. Explain any differences.
 - c. State your conclusions.

Observation of Pebble After 3 Minutes Shaking	Comparison of Prediction to Results
Sketch:	
Written Observations:	
Conclusions	

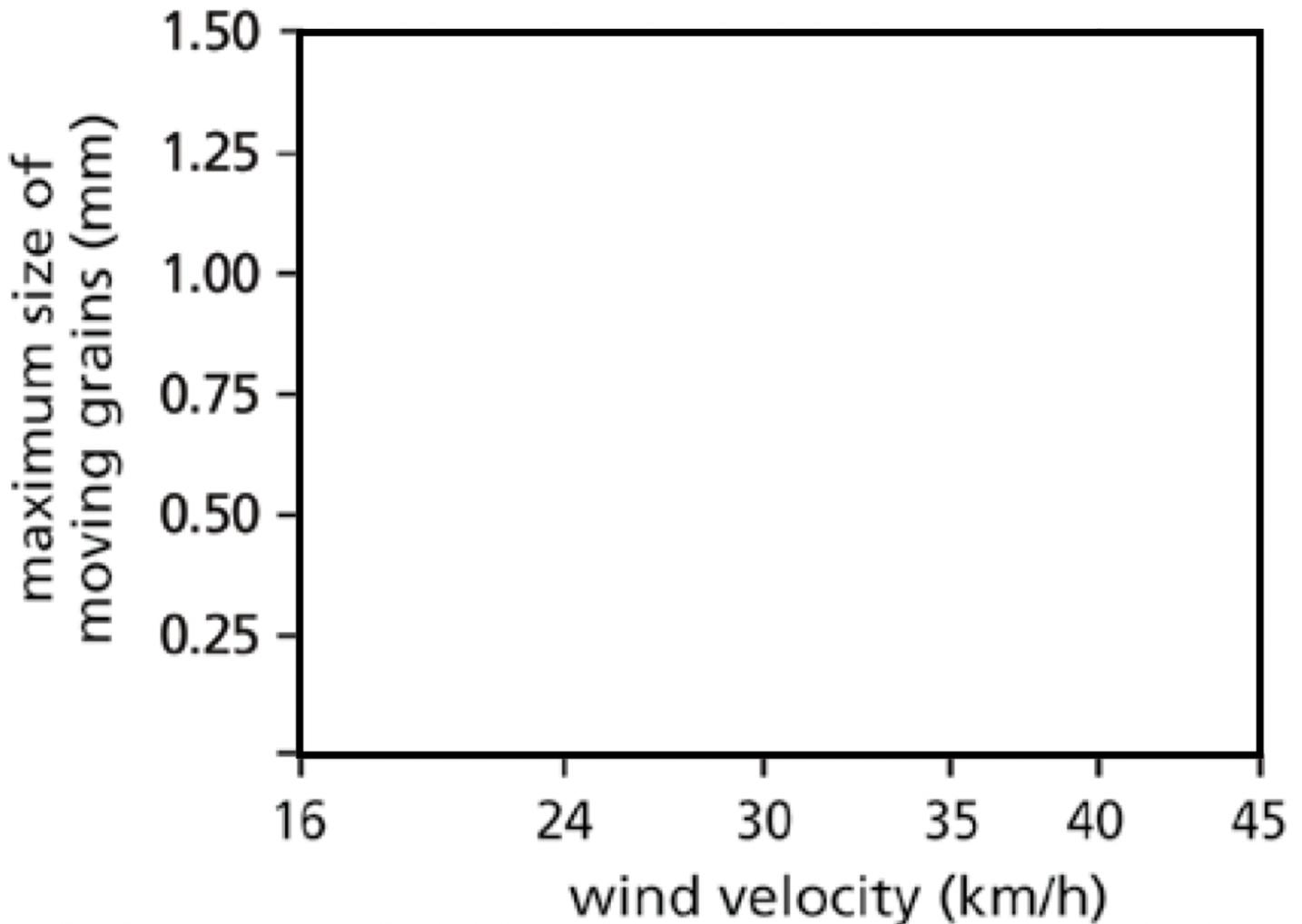
Part 2: Wind Velocity and Moving Sediment

The size of grains moved by wind depends on wind velocity. Table 1 shows the relationship between wind velocity and particle size.

Table 1: Relationship Between Wind Velocity and Particle Size	
Maximum Size of Moving Grains (mm)	Wind Velocity (km/h)
0.25	16–24
0.50	24–30
0.75	30–35
1.0	35–40
1.5	40–45

5. Graph the data from Table 1 (on page 4) in the space below.

Relationship Between Wind Velocity and Particle Size



6. Examine the graph you created. Use a complete sentence to describe the relationship shown by the data.

Landscapes Changed by Wind - Explore Day 2

Learning Target: _____

Do Now:

Part 3: Deposition by Wind

In the Engage and Explore Day 1 activities you observed how wind can modify the landscape. It's important to remember, that irregular surfaces do not erode evenly, and that slopes facing the wind are eroded more than slopes that are sheltered. You are now going to look at how obstacles can affect wind flow and the movement of sand grains.

1. In nature, what might obstruct (block) wind flow? Discuss your ideas with your small group and class.
2. Lay a large sheet of paper flat on a surface. Place a fan so that its air flows over the paper. **Draw arrows on the paper that show the direction and strength of the airflow you would expect.**
3. Arrange five plastic cups on the paper to create a pattern of obstacles to the airflow over the paper. **Using a different colored pencil, draw arrows on the sheet that show the direction and strength of the airflow you would now expect. Compare the two patterns of arrows.**

Similarities	Differences

4. Use tape to attach each cup to the paper. Attach 3-cm-long pieces of yarn to the tops of 10 toothpicks. Use modeling clay to attach each toothpick to the sheet. Space the skewers equally over the sheet.

5. Make a sketch of your model.

Sketch and Annotations	

6. Turn on the fan. Observe what happens to the yarn. Record your observations below.

Observations of the Yarn	
Sketch:	Written Observations:

7. Compare your predictions (your arrows drawn on your large piece of paper) to your results.

Similarities	Differences

8. Try to explain the differences you saw in your model.

9. You are now going to determine how the pattern of airflow around obstacles affects the erosion and deposition of windblown sand. To do this, you will add sand directly to the flow of air from the fan. **Predict what will happen to the sand.**

10. **Mark** areas on the sheet where you would expect deposition and erosion to occur. Include any patterns of deposition you expect.
11. Turn on the fan.
12. Supply a constant stream of sand to the airflow in front of the fan. Observe how the sand moves.

Observations of the Sand	
Sketch:	Written Observations:

13. Once all of the sand has been added and the movement of particles has stopped, mark the observed pattern of deposition on your sheet.
14. Compare your predictions to your results.

Similarities	Differences

15. Explain any differences. Briefly describe the relationship between airflow, obstacles, and the deposition of windblown sand.

Landscapes Changed by Wind - Explain

Learning Target: _____

Do Now:

WIND EROSION

Movement of Sediment by Wind

In the *Investigate*, your investigations and models showed you that wind moves sediment in three different ways. You observed that the finest particles are lifted from the surface and travel in moving air. This type of transport is called **suspension**. Some suspended particles fall back to the surface. Depending on the amount of energy, these particles often bounce off the surface, or off other particles, and back into the air. This kind of transport is called **saltation**. Coarse grains are often too heavy to move by suspension or saltation. Instead, they move forward gradually as a result of the impact of grains bouncing against them. The impact of a high-velocity sand grain can move a particle 6 times its size and 200 times its own weight. This slow type of movement is called **surface creep**. (See *Figure 1*.)

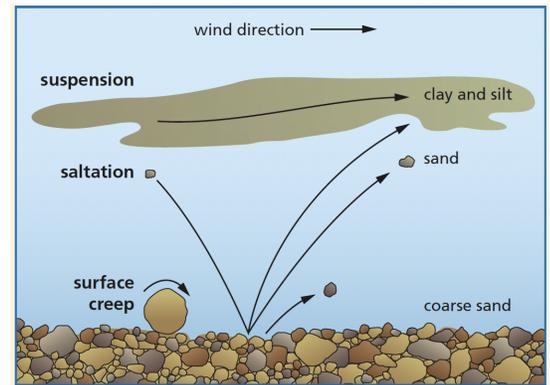


Figure 1 The three main ways that wind transports sediment are by suspension, saltation, and surface creep.

The way particles are captured by wind is quite complex. As wind velocity becomes strong enough to move a particle, it begins to rock back and forth. The wind may overcome the forces holding the particle to the surface. At that point, the particle is suddenly lifted into the air. This occurs because the wind creates a strong upward force under the edge of the particle. As a result, it rises into the airflow at a steep angle. If the wind turbulence is not strong enough to keep the particle in suspension, it crashes to the surface. When a falling particle strikes another particle on the surface, it transfers energy to that particle. This transfer of energy allows the resting particle to lift off. The lift off occurs at a lower wind velocity than would normally be needed. The falling particles bounce back into the air. They stay in the air until they strike the surface and other particles again. These particles may then rise into the airflow. In this way, the velocity of airflow and the movement of particles are important to the capture of new particles from the surface.

Factors Affecting Wind Erosion

Many factors affect wind erosion. First, as wind velocity (kinetic energy) increases, the size of the grain that the wind can move also increases. The graph from your experiment demonstrated this relationship. Also, you may have observed that a patch of clay-sized grains was less likely to move

than a similar-sized patch of sand-sized grains. This may not make sense to you. The clay is finer than sand and has less mass. However, because the surfaces of clay particles are relatively smooth, they do not stick up into moving air as much as those of sand. As a result, it takes a greater velocity to move clay-sized grains than it does sand-sized grains.

Damp (slightly wet) sediments behave in a similar way. They are usually much harder to erode than dry sediments. Water filling the spaces between the loose grains binds them together. Because of this cohesion, it takes a much greater wind velocity to move damp grains than it does for dry grains of the same size.



Figure 2 The wind is deflected by patches of vegetation and affects deposition on the downwind side (White Sands National Monument).

Another factor that affects wind erosion is plant growth. Plants increase surface roughness. This causes a reduction in wind velocity. The decrease in wind velocity causes sediment to become trapped. Removal of vegetation has the opposite effect. It greatly increases the chance of wind erosion.

The shape of a sediment patch also has an effect on erosion. Sediments packed in ridges undergo erosion by grains blowing from the slope that faces into the wind and from the ridge crest. Grains that are deposited behind the ridge and away from its shelter are quickly removed. Sediments that are flat and thinly spread tend to be eroded from the downwind side. That is because there is nothing supporting them from behind.

Wind Erosion and Abrasion

In glaciers and streams, erosion only takes place in channels. In contrast, wind erosion can work over the entire land surface. However, there are very few surface features that are formed just by the action of wind. The simplest form of erosion is the blowing away of loose material (rocks and sediments) by wind. Sometimes this forms a depression called a **deflation hollow**. In arid (very dry) regions where there is little soil and vegetation to protect the surface, finer material is removed.

Bedrock and coarser material are left behind.

These can form a surface of tightly packed angular and rounded grains called a **desert pavement**. (See *Figure 3*.)



Figure 3 The wind-polished surface of a desert pavement in Nevada. Winds and periodic rains remove any loose sediments from the surface.

Moving air that carries sediments has a sandblasting effect. This process is called **abrasion**. Over longer periods, abrasion can produce various small-scale features. These include polishing, pitting, and grooving of rocks. The type of feature that forms by abrasion depends on several factors. The rock type and the direction of the wind are important factors. The hardness, size, and shape of the transported material also affect the type of features that are formed. In the *Investigate*, you observed how larger particles in an airflow change shape. The collision of particles transported by wind wears away sharp edges and projections. This causes particles to become rounder in shape.



Figure 4 Notches on the Great Sphinx in Egypt are the result of windblown sand blasting the sphinx over time.

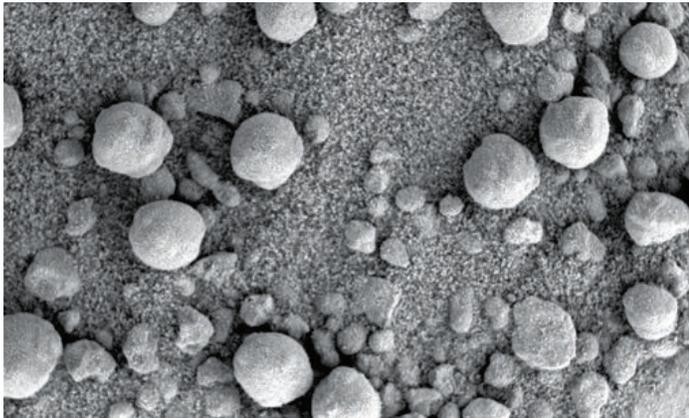


Figure 5 This image from NASA's Mars rover shows windblown particles in a Martian desert. The amount of roundness and angularity depends on how far they have been transported.

Scientists observe the effects of windblown sand. They place rods made of various types of rocks in windy environments. One study was conducted in the Mojave Desert of North America. In this location, scientists recorded how the surfaces of the rods of rock changed over a period of 10 years. They found that 90 percent of windblown particles travel within 65 cm of the ground surface. They also observed the removal of 1 mm of rock from a granite boulder in just 15 years. This might not seem like much, but imagine the effects over millions of years.

Deposition of Moving Particles

In the *Investigate*, you observed how obstacles affect deposition. Deposition of sediment occurs behind obstacles. The airflow behind the obstacle is reduced. Therefore, the ability of air to carry sediment is also reduced. This has been observed in the laboratory. It is also seen in natural, windy regions.

In the *Investigate*, you saw that the rough and irregular surface of a patch of sand is very good at trapping saltating particles. As the patch grows and becomes a mound, it starts to influence the way air and sand moves over it. **Sand dunes** are hills or ridges of windblown sand. (See *Figure 6*.) They grow because the kinetic energy of impacting grains is absorbed by loose sand. A simple sand dune



Figure 6 A dune field in Namibia.

looks like a ramp that is steeper on one side than the other. Sand grains saltate up the shallower side, which faces into the wind. They then fall down the steeper face at the rear of the dune.

Particles remain longer on the slope of the dune that is sheltered by the wind. The rear slope gets steeper and steeper until it becomes unstable. It then avalanches downward. In this way, the crest of the dune moves forward and the dune advances downwind. Over time, the rear face of the dune is buried over and over again.

If you were to cut through a dune, you would see layers where one crest after another had avalanched down, burying the side of the dune that is shielded from the wind.

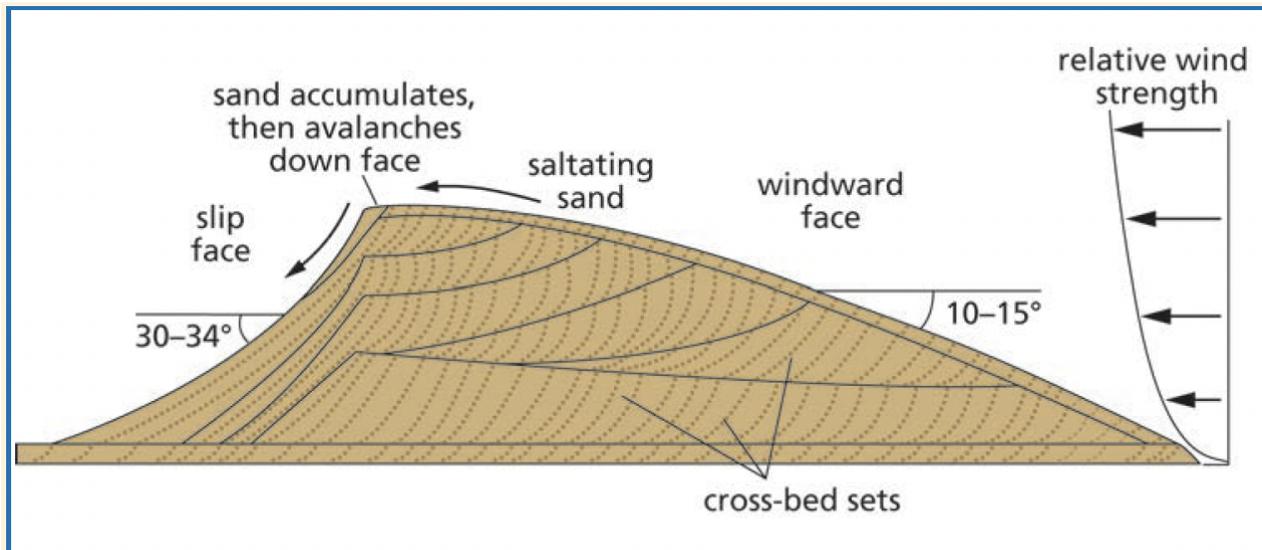


Figure 7 Layers at different angles reflect the buildup and avalanching of sediment.

Sand deposits have many different shapes. Ripples form when there is an irregularity in the sand surface. Various kinds of long, narrow dunes extend for many kilometers. They are usually oriented across the prevailing wind direction. Some dunes are crescent-shaped, with a horn at either end. The horns extend in the downwind direction and taper toward their points. These dunes occur where winds blow in one direction and the supply of sand is limited. Where winds blow in many directions, the shapes of sand dunes reflect this condition. Star-shaped dunes have a central peak and arms that radiate out from them.



Figure 8 Shade highlights the lee side of a dune.



Figure 9 Wind ripples on the surface of much larger dunes.

Environments Where Wind Erosion is Dominant

Wind affects landscapes that have a steady supply of sediment and a lack of plant cover. Such conditions are common in arid (very dry) environments. They can also be found around the cold margins of glaciers and along coasts. The location of Earth's arid environments is controlled by climate. Deserts are common in regions where **evapotranspiration** exceeds precipitation. They often lack soil or have little soil moisture. Here, rocks break down mostly by physical weathering. Also, the surface is usually covered in loose stones, sand, and silt-sized materials. Arid environments cover about 20 percent of the land surface. They include hot deserts and cold deserts of middle and polar latitudes.

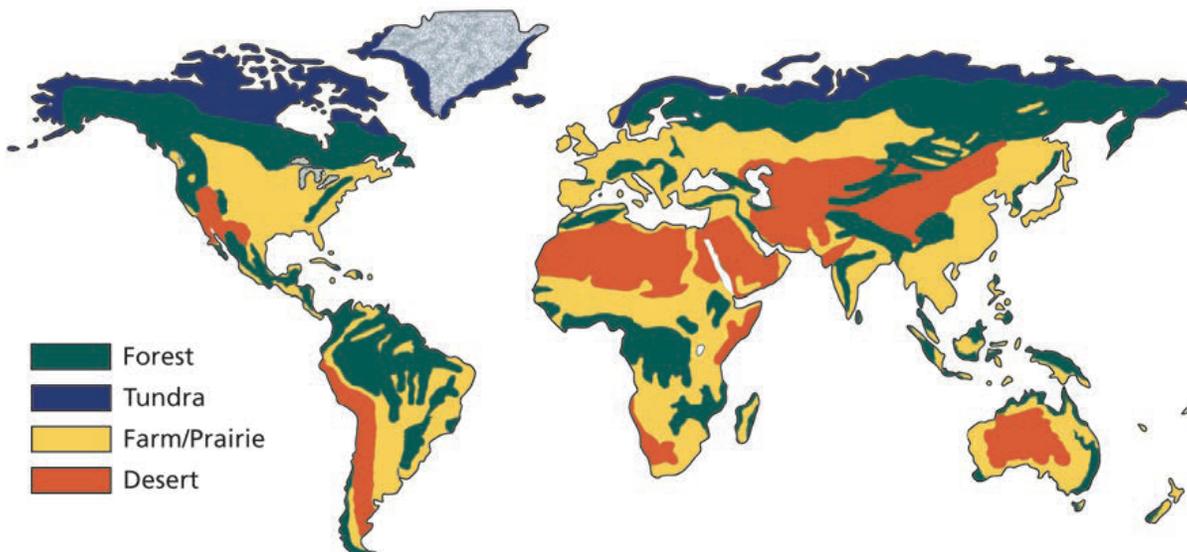


Figure 10 Map showing the location of arid and semi-arid regions on Earth.



Figure 11 Wind-dominated environments are found along coasts and in cold, dry environments.

Earth's Desert Regions

Earth's most active wind-formed landscapes are typically in areas that receive less than 150 mm of rainfall per year. Such areas that receive very little rain are found in the interiors of continents. They can also be found in the shadow of mountains. Here, intense wind erosion and deposition takes place. Erosion removes all but the coarsest rocks and leaves bedrock exposed. It may surprise you to learn that only about 30 percent of most desert areas are covered by sand. Sand is concentrated mostly in lowland areas in great sand seas called **ergs**. Most of Earth's windblown sand fields are greater than 125 km² in area. The largest active sand sea on Earth is the Rub'al Khali or Empty Quarter (560,000 km²), in the southern Arabian Peninsula. Loose sands, up to several hundred meters thick, cover most of the solid rock in this region.

Where does the sediment for Earth's dune fields come from? Scientists believe that the sediments found in deserts originally came from upland areas. The rock was weathered away in these areas. It was carried downhill. Then it was deposited in alluvial fans in lowland areas. In some tropical deserts, the source of the sand is bedrock made up of desert sands. These sands were deposited during older geologic periods in desert environments.

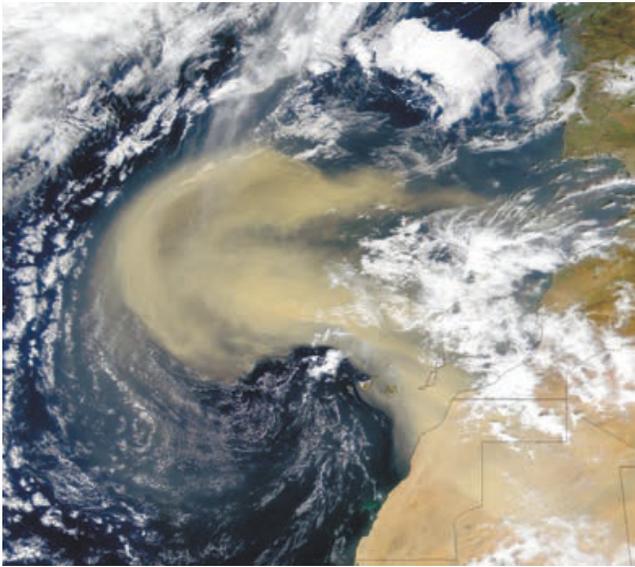


Figure 12 A massive dust storm blows sediment over the ocean from the desert of Northwest Africa.



Figure 13 This image shows about 2500 km² of coastal desert in Namibia. High winds generate dunes reaching 300 m high.

Stabilization of Coastal Dunes

Sand dunes are common in coastal areas and are parts of beach systems. They are always found on the landward side of a beach. The surface of a bare coastal dune migrates in a way similar to what you saw in the model you used in the *Investigate*. However, the development of dunes on the backs of beaches creates microclimates where the wind is less. Here, windblown seeds are deposited and salt tolerant plants, such as Lime and Couch Grasses, grow on the dunes. Their waxy leaves are often rolled, which reduces surface area and decreases transpiration rates. This maximizes available moisture. Once the plants colonize the dunes, their root systems help to bind the sand. The growing plants create a windbreak that reduces wind flow and enables more sand and more seeds to be deposited and helps to build up the dune.



Figure 14 Specialized beach grasses that are tolerant to dry, salty environments help dunes to develop.

Reading Questions

1. How do particles move in the wind?
2. What is a desert pavement?
3. What effect does vegetation have on airflow?
4. Where are Earth's deserts?
5. Identify two land features that can form because of deflation.
6. What areas are most likely to be affected by wind erosion? Give two examples.
7. How do dunes form?
8. Wind can transport particles of many different sizes. What sized particles are probably carried the farthest by the wind? Explain your answer.

Landscapes Changed by Wind - Elaborate Day 1

Learning Target: _____

Do Now:

Today you will use NASA's Earth Observatory and Google Earth to identify one area around the world with active sand dunes and/or wind-blown sediment deposits. You will research that area and identify and record information you research in the table below.

Independent Research	
Area that has sand dunes and/or wind-blown sediment deposits (list the nearest city, state, and what country the dunes are in)	
Why does this area have wind-blown sediment deposits? (Hint: Think about the region's biome)	
How is the wind blowing in the area? Is there a consistent pattern of wind flow? What direction is the wind coming from? What direction is the wind moving toward? How fast does the wind move on average?	
How is the sand deposited in this area? In other words what evidence do you have of wind erosion and deposition of sand?	<input type="checkbox"/> Stable sand dunes <input type="checkbox"/> Moving sand dunes <input type="checkbox"/> Blowing sand <input type="checkbox"/> Other: _____
What are the potential impacts to humans (or other living things) that live in the area?	
What sources did you use?	

Landscapes Changed by Wind - Elaborate Day 2

Learning Target: _____

Do Now:

Question: *What is the scientific question you are investigating?*

Claim: *What claim can you make based on the evidence?*

Evidence <i>What are the science observations or data that address the question?</i>	Science Concepts <i>What concepts connect to the evidence and explain the claim?</i>	Reasoning <i>How do the science concepts relate to the evidence?</i>
<p>The evidence that led to my claim is ...</p>	<p>The scientific concept that relates to the evidence and supports my claim is...</p>	<p>This science concept supports my claim because...</p>

Landscapes Changed by Wind - Evaluate

Peer Reviewer's Name: _____

Rubric				
Expectations	1	2	3	4
<p>NYS Earth Science Standard 4.1.2u</p>	<p>I <u>included two or fewer</u> of the following:</p> <ul style="list-style-type: none"> <input type="checkbox"/> The area that has wind-blown sediments <input type="checkbox"/> The direction the wind comes from <input type="checkbox"/> The type of biome region of area <input type="checkbox"/> How the wind blown sediment affects the area <input type="checkbox"/> What way is the sand deposited <input type="checkbox"/> Potential impacts to the local human population 	<p>I <u>included three to four</u> of the following:</p> <ul style="list-style-type: none"> <input type="checkbox"/> The area that has wind-blown sediments <input type="checkbox"/> The direction the wind comes from <input type="checkbox"/> The type of biome region of area <input type="checkbox"/> How the wind blown sediment affects the area <input type="checkbox"/> What way is the sand deposited <input type="checkbox"/> Potential impacts to the local human population 	<p>I <u>included five to six</u> of the following:</p> <ul style="list-style-type: none"> <input type="checkbox"/> The area that has wind-blown sediments <input type="checkbox"/> The direction the wind comes from <input type="checkbox"/> The type of biome region of area <input type="checkbox"/> How the wind blown sediment affects the area <input type="checkbox"/> What way is the sand deposited <input type="checkbox"/> Potential impacts to the local human population 	<p>I <u>included all</u> of the following:</p> <ul style="list-style-type: none"> <input type="checkbox"/> The area that has wind-blown sediments <input type="checkbox"/> The direction the wind comes from <input type="checkbox"/> The type of biome region of area <input type="checkbox"/> How the wind blown sediment affects the area <input type="checkbox"/> What way is the sand deposited <input type="checkbox"/> Potential impacts to the local human population
<p>NYS Next Generation Learning Standard RST.9-10.2</p>	<p>I <u>did not summarize</u> complex concepts. My writing is not organized, it is difficult to follow, and uses too difficult to understand language.</p>	<p>I <u>attempted to summarize</u> complex concepts and information. My writing is somewhat organized.</p>	<p>I <u>mostly summarized</u> complex concepts and information presented in text by paraphrasing them in simpler terms. My writing is somewhat organized.</p>	<p>I <u>summarized</u> complex concepts and information presented in text by paraphrasing them in simpler, accurate terms. My writing is organized in a clear, concise, and logical manner.</p>
<p>NYS Next Generation Learning Standard WHST.9-10.1</p>	<p>I <u>did not write an argument focused</u> on the content. My argument was not supported and/or contained <u>one</u> of the following:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Scientific Question <input type="checkbox"/> Claim <input type="checkbox"/> Evidence <input type="checkbox"/> Reasoning 	<p>I <u>wrote an argument focused</u> on the content. My argument was not supported and/or contained <u>two</u> of the following:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Scientific Question <input type="checkbox"/> Claim <input type="checkbox"/> Evidence <input type="checkbox"/> Reasoning 	<p>I <u>wrote an argument focused</u> on the content. My argument was somewhat supported and contained <u>three</u> of the following:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Scientific Question <input type="checkbox"/> Claim <input type="checkbox"/> Evidence <input type="checkbox"/> Reasoning 	<p>I <u>wrote an argument focused</u> on the content. My argument was well supported and contained <u>all</u> of the following:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Scientific Question <input type="checkbox"/> Claim <input type="checkbox"/> Evidence <input type="checkbox"/> Reasoning
<p>NYS Next Generation Learning Standard RST.9-10.9</p>	<p>I <u>did not use and/or did not cite</u> any sources for this project.</p>	<p>I <u>used and cited at least 1 source</u> for this project.</p>	<p>I <u>used and cited 2 different sources</u> for this project.</p>	<p>I <u>used and cited at least 3 different sources</u> for this project.</p>

