LandPKS

Land Potential Knowledge System

Three-lesson education module developed by the
Asombro Institute for Science Education

Student Worksheets
Teacher Guides
Task Cards

LandPKS Lesson 1: Pre-Data Collection – Teacher Guide

Program Summary

In this three-lesson module, students become part of the Land Potential Knowledge System (LandPKS) knowledge-sharing team.

- In lesson 1, students learn about the effects of climate, soil, topography, and plant characteristics on land potential. They receive an introduction to soil indicators and how to assess them in the field.
- In lesson 2, students use the LandPKS apps to collect data on a site.
- In lesson 3, students use the LandPKS-generated Land Capability Classifications (LCCs) to learn how scientists, land managers, and city planners use this information. Students then make inferences about their own sites and how they are being utilized. Students use their new knowledge of LCCs to plan a solution to a land management dilemma.

Lesson 1 Summary

Lesson 1 is an introductory lesson. Students receive an introduction to the LandPKS program and goals. They participate in hands-on activities that introduce them to the soil indicators they will be using in the next lesson to collect data with the LandPKS applications. Each activity helps students: (1) understand the importance of the indicators, (2) become familiar with the options for each indicator, and (3) acquaint themselves with the application screens they will interact with in the field.

Student Age

10 - 18

Note: this lesson is designed to align with standards for 5th grade and middle school students (generally age 10 – 14) as specified in the Next Generation Science Standards. However, the concepts and activities are relevant for older students and adults.

Objectives:

- Introduce students to the LandPKS program and how it is being used to help land owners and managers make data-assisted, sustainable, land-management decisions
- Teach students how to document various land features using the indicators in the app
- Familiarize students with the soil and vegetation indicators used to assess the potential of land to generate ecosystem services, resist potential degradation, and recover from degradation

Time

Approximately 60 minutes

Standards

To ensure conformity to the most current research on pedagogical strategies and education standards, these activities are aligned with the Next Generation Science Standards (NGSS), a peer-reviewed, rigorous set of standards that have been adopted by 19 states (representing more than 36% of the students in the United States). This work is applicable internationally and addresses the needs of international partners for student educational materials.

5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
• Obtaining, Evaluating, and Communicating Information • Constructing Explanations and Designing Solutions	• ESS3.C Human Impacts on Earth Systems	• Systems and System Models • Cause and Effect

Background

LandPKS includes mobile apps and data visualization tools to support soil-specific assessment, monitoring, management, and knowledge sharing. LandPKS helps land owners and managers make sustainable management decisions based on the "land potential." Land potential is defined as the inherent potential of the land to sustainably generate ecosystem services. Management of the land determines whether this potential is realized. Land potential elements include the potential for the land to:

1. Generate ecosystem services
2. Resist degradation
1. Recover following degradation (often called resilience)

Different types of land in different climates have distinct potential. LandPKS assists land managers in understanding the climate, soils, topography, and current plant characteristics to help determine this potential. They can then use this information to make sustainable land management decisions.

Materials

Landscape Slope Station (1 set-up per 12 students)

- Stopwatch
- Piece of plywood, a table, or something rigid and at least 1 meter in length
- Ball that can be rolled down the slope (e.g. marbles, bouncy balls, golf balls, soccer balls)
- Task card
- Books or something that can be stacked to create a changing slope

Slope Shape Station (1 set-up per 12 students)

- Small, square baking pan
- Plastic water bottles or cups cut in half
- Water
- Water cup
- Large container to hold water (optional)
- Task card

Land Use and Soil Limitations Demonstration

- Printed copies of landscape photos and enlarged screenshots of app pages (optional)

Soil Texture Activity

- Soil
- Small bottle or cup of water
- Empty bin, bowl, or bucket for used soil
- Spoons
- Towel or paper towels to clean workspace (optional)
- Tablecloth (optional)

Tips for entire class participation

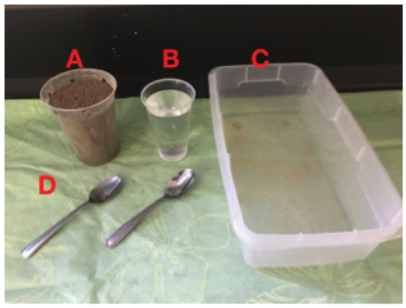
- The lesson is designed for up to 36 students.
- Divide students into groups of up to six students each to rotate through the Landscape Slope and Slope Shape activity stations. In larger classes, prepare two or three sets of each of the two activity stations (for a total of up to six stations).

Preparation

1. Set up computer and projector.
2. Prepare either one, two, or three copies of each activity station. If you have a large number of students (25+ students), prepare three copies of each station.
    - **Station 1: Landscape Slope** – Lay out materials for this station (plywood or table, rolling object, 5 books, stopwatch, and task card). Students will set up the investigation when they get to this station.
    - **Station 2: Slope Shape**
        A) Gather a plastic cup (or 16 oz. water bottle) and a pair of scissors.
        B) Cut the cup in half vertically (see figure). If using a plastic bottle, remove the top and bottom sections before cutting it in half.
        C) Cut off the base of the cup to remove a potential barrier for the water (see figure).
        D) Lay out all other materials for the station: pan, water cup, water, and a large container to hold water, and task card.

Left: Cut the cup in half vertically.
Right: Remove the bottom of the cup as shown.

    - **Soil Texture Activity** – Assemble materials for the demonstration (see figure below), including:
        A) Enough soil for participating students to have 2 tablespoons each.
        B) Water to add to the soil to make a ball and test the texture type.
        C) Bin or bucket to put the soil in when students are done testing the soil.
        D) Spoons to scoop soil and water.
        E) Optional - A tablecloth is to catch any dropped soil. Paper towels or towels can be useful for students to wipe off their hands when they have completed this station.



    - **Demonstration: Land Use, Grazing, and Soil Limitations** – Print copies of the keys and landscape photos (optional) or plan to show the keys and landscape photos with a projector.

Teaching Guide

1. **Introduction** (10 minutes)
    - *(Slide 1)* As global populations increase, sustainable management of natural resources, like soils and vegetation, becomes more important. The Land Potential Knowledge System, or LandPKS, includes mobile apps that allow farmers, ranchers, and other land managers to collect data on the soils and vegetation of their land and make informed management decisions.
    - *(Slide 2)* Show the introductory video.
    - *(Slide 3)* We will play the role of land managers for our school. Today we will participate in hands-on activities designed to help you learn how to use the app and understand why soil is important. In the second lesson, we will use the LandPKS apps to collect data in the schoolyard. Then we will use the data we collect to make possible management decisions.
        - First, we will learn how knowledge of the land use and what the land looks like can guide decision-making. Then, we will learn how knowledge of soil is important for future decision-

making. Finally, we will review today, address any questions, and discuss procedures for Data Collection Day.

2. **Stations Covering LandInfo Module Indicators – Landscape Slope and Shape** (15 minutes)
   Students rotate between two stations to work with models that mimic land/soil indicators. The stations teach students about the importance of each indicator and how to collect data in the app. Students do not work with the actual app during these stations. Students will have 5 minutes at each station.
   - *(Slide 4)* Explain to students why it is important to collect data on the slope and shape of the landscape.
     - Slope and shape are indicators of how water will move over the land after a rain event. Imagine water from a rain event spreading out as a sheet over the landscape. If that sheet is on a sloped landscape, the water will want to move to the lowest point possible due to gravity and it will take the path-of-least-resistance to get there. Over time, the slope and shape cause the water to move in the same pattern repeatedly to get to the lowest point possible after each rain event.
     - *(Click forward)* Eventually, repeated rain events can create rills or gullies. These rills or gullies are created by water erosion, when particles of soil are moved by water and transported somewhere else. An area's climate, the amount of rainfall and the intensity in which it falls in an area, will affect how quickly rills and gullies are formed.
     - Next, give students a brief overview of the two stations they will rotate between to investigate these indicators.
   - **Station 1: Landscape Slope** – *(Slide 5)* In this station, students will learn how the slope of a landscape affects the speed of water runoff. This affects the amount of water that can infiltrate into the soil for crops or other vegetation.
     - Procedure: *(click forward)* Students will test the effect of slope on the speed of a ball (representing water) rolling down a hill. They will use books under the end of a board to increase the slope of the hill. Here are the steps from the task card:
       1. Place one book under one end of the plywood. Line up the edge of the plywood with the spine of the book.
       2. Have one student hold the ball at the raised end of the plywood.
       3. Have another student prepare to start and stop the stopwatch (Figure B). You will start the stopwatch when the ball is released to roll down the plywood. You will stop it when the ball reaches the end of the plywood.
       4. Let go of the ball and let it roll down the plywood.
       5. Record the time it took for the ball to roll down the plywood on the data table in the Landscape Slope Station section on your worksheet.
       6. Repeat steps 2 - 5 with 3 books.
       7. Repeat steps 2 - 5 with 5 books.
       8. Answer questions 2 and 3 on your worksheet.
       9. *Extension for older or mathematically advanced students – calculate the slope of the test area using a ruler or meter stick.

   - **Station 2: Slope Shape** – *(Slide 6)* Students will learn how slope shape is important in hilly landscapes. Slope shape affects how water moves and can be an important factor in deciding where to plant crops or have livestock forage.
     - Procedures: Students work with cups or bottles cut in half to model convex and concave hill shapes. Students place the cup in the pan and pour water over it. When students pour water

over the convex hill model, they should see that it immediately falls off the cup and pools around the base of the cup. The concave hill model should force water into a stream that rushes to the opposite end of the pan away from the cup. Here are the steps from the task card.

1. Place the cup in the pan with one end resting on the edge of the pan to create a convex hill (Figure A).
2. While one student holds the cup in place, another student should fill a cup with water and pour it onto the hill.
3. Watch carefully to see how the water runs down the hill and where the water pools.
4. Using arrows, create a map in the Slope Shape Station section on your worksheet showing where the water ran off the cup and where it gathered in the pan.
5. Pour the water out of the pan.
6. Now place the cup in the pan so that it resembles a concave hill (Figure B).
7. Repeat steps 2-5.
8. Answer question 2 on your worksheet.

- Give students five minutes at each activity station.

3. **Land Use/Soil Limitations Demonstration** (10 minutes)
    - *(Slide 7)* This activity focuses on using the app to describe the current landscape conditions of sites. Students can appraise what the app icons' equivalents would look like in the field by practicing with landscape photos. They will examine both the land use and soil limitations. Land use is what the landscape around your site is predominately covered with or how it is being used, and are there animals grazing it. Soil limitations describe the soil properties of the site that could be responsible for hindering plant growth.
    - There are two options for walking students through this demonstration. Option A is to project the keys and landscape photos. Option B is to give each group all of the keys and landscape photos. Both options are described below.
    - **Option A:** Project the keys and landscape photos onto a screen or wall. If the keys are too small for students to see well, print the keys out and give them to each group.
        - *(Slide 8)* **Land Cover:** As we start to collect data for our landscape it is important to know how the land at our site is currently being used and what it looks like. For this activity we will be practicing describing our site using the app icons so that you are comfortable with the apps when we collect data on our schoolyard. Altering landscapes from one condition to another (i.e. grassland to shrubland) risks disturbing soils and local ecosystems. Landscape structure indicates how well the landscape can resist and recover from disturbances, allowing land managers to make appropriate decisions.
        - Have students look at the Land Cover key. This section of the app asks you to describe the land cover around your plot. For example, a grassland or shrubland would predominately be covered in grass or shrubs, a savanna would be a grassy plain sparsely populated with trees, and barren would mean an absence of plant life. Ask students if they see this reflected in the app icons.
            - Direct students to examine Landscape photo 1, labeled in the upper left-hand corner. Which land cover best describes the landscape around this plot? Briefly discuss with students what the best choice might be. (grassland)
            - Click forward through the next three landscape photos and have students choose the best icon to describe the land cover.
            - 1: grassland; 2: forest; 3: savanna or cropland; 4: barren
        - *(Slide 9)* **Grazing**: It is important to know if the land is being used for grazing and by what

type of animal since different animal species have different impacts on the land. Cattle and sheep are primarily grazers and have a big impact on grass, while goats prefer woody plants like shrubs and young trees. Click forward through the four landscape photos and have students match it to the app icons. More than one app icon can be selected per photo.

    - 1: cattle and wildlife; 2: wildlife or not grazed; 3: wildlife or not grazed; 4: not grazed
    - Note: Many options could be considered correct for this section. Even if animals are not seen in the photo, students may infer that there may be animals using that area to forage at other times.
    - An extension of this activity is to take landscape photos from your area that may have different grazers and have students analyze those photos.

- *(Slide 10)* **Soil Limitations – Salt on Surface:** This section describes characteristics of the soil in your site that could be responsible for hindering plant growth. For this activity, students are only looking at salt on the soil surface and surface stoniness. On Data Collection Day, they also analyze their site for vertical cracks in the soil.

  Soils with high salt content are often low in species diversity because salt can interfere with water intake by plants. Students will know if there is salt on the soil surface because salt forms white, crusty patches, which can inhibit plant growth because most plants do not like salty soil. Ask if they notice any of these white patches in Landscape photo 1.

    - Click forward through the four landscape photos and have students identify whether or not there is salt on the soil surface.
    - 1: no; 2: no; 3: no; 4: yes

- *(Slide 11)* **Soil Limitations – Surface Stoniness:** Stones can be a barrier for plant roots and inhibit growth, but they can also be a barrier for livestock or agriculture equipment, like tractors, to navigate. Ask students what percentage of the surface looks to be covered in stones; use the infographic to determine which category they think best represents this landscape photo. Click forward through the four landscape photos and have students identify the percentage of the surface that is covered in stones.

    - 1: <0.1%; (suggested answers may differ from student answers)
    - 2: <0.1%;
    - 3: <0.1% or 0.1-3%;
    - 4: 0.1-3% or 3-15%

- **Option B:** For Option B, follow the same pattern as Option A but have students use copies of landscape photos and keys (rather than the slides) to assess land cover, grazing, and soil limitations (salt on surface and surface stoniness). Pass out one set of the Land Use and Soil Limitations keys and Landscape photos to each group. Use notes in Option A above to discuss student answers.

4. **Soil Texturing – Whole Class Demonstration** (20 minutes)

- *(Slide 12)* Procedure: Students work with soil to learn how texture affects water availability for use by plants. Hand texturing supplies should already be on the tables.
- Explain that soil is made up of small particles that vary in size (draw the figure at right on the board if projector is unavailable). The largest particles are called sand, the medium sized particles are called silt, and the smallest sized particles are called clay. The combination of these different-sized particles helps us determine the soil texture. Soil texture tells us important information about the soil such as how fast water will move through the soil and how much water the soil holds for plants.
- *(Click forward)* Explain to students that larger gaps between the particles means that water will move through the soil faster and that there will be less stored water. Smaller gaps mean slower water movement through the soil and more storage of water in the soil.

- Ideal soil texture would have a mixture of all three sizes of soil particles. Sand allows the water to move quickly through the soil which can prevent the soil from becoming water-logged, but silt and clay are important for water storage in the soil so water can be available to plant roots.
- Walk through hand texturing with students:
    1. *(Slide 13)* Every student should put two tablespoons of soil in their palm.
    2. Slowly add water one scoop at a time until the soil is moldable. Roll soil into a ball with your hands. Demonstrate to students, have them copy the technique, and answer question 1 on their worksheet.
    3. *(Slide 14)* After making a ball, the next step is to make a ribbon. This tests how well the soil holds together. Soil with larger particles cannot hold together as well as soil with smaller particles. The longer the ribbon, the smaller the soil particles. Place the ball of soil between your thumb and forefinger and show students so they know where to place their ball of soil. **Click forward to play video**. Gently push the soil upwards with your thumb, squeezing it upward into a ribbon. Point out that the ribbon needs to be formed going up and over their hand and not down their palm. The hands on the left in the video are mashing the soil in an effort to make it flat (incorrect technique), while the hands on the right are squeezing the soil together then pushing it upward with the thumb to make a long thin ribbon (correct technique). The ribbon in this video is made by clay soil which is why it is able to make a long ribbon. The more sand or silt in your soil, the shorter the ribbon will be.
    4. Allow the ribbon to extend over your forefinger until it breaks from its own weight and show it to students. Have them make their own ribbon and answer question 2 on their worksheet.
    5. *(Slide 15)* Have students measure the length of their ribbon with the ruler on their worksheet and answer question 3. Based on their answers, they will proceed to question 4, 5, or 6.
    6. *(Slide 16)* Finally, pinch off some wet soil between your thumb and forefinger, dip it into the water, then rub the soil between you thumb and forefinger to determine the soil texture and answer question 4, 5, **OR** 6 about how the soil feels.
    7. After completing these steps, students have identified their soil texture and should write it in the blank for question 7.
    8. *(Slide 17)* Have students wipe off their tables and clean their hands.

5. **Wrap-up/Review/Procedures for Data Collection** (5 minutes)
    - Landscape Slope Station – Ask students what they noticed about the speed of the ball as the slope increased. Ask about question #3 for this station.
        - As the slope of the hill increases, the speed that the ball travels down the hill also increases.
        - Slower moving water infiltrates the soil where plant roots absorb and use the water to grow. Faster moving rain water does not infiltrate the soil as well. Faster moving water is more likely to carry loose soil and debris away, potentially causing rills or gullies to form on a landscape.
    - Slope Shape Station – Ask students about the differences they saw between the convex and concave hill shapes. Then ask about question #2 of this section. Were they able to deduce which hill shape could cause rills or gullies? On the convex hill, water should have pooled at the base of the cup. This will likely cause low water availability on the hill because the shape of the hill directs water to the base of the hill, but can also create water accumulation in some areas that could be beneficial for certain crops or livestock. On the concave hill, water should have run down the hill, like a stream, and pooled away from the hill potentially causing rills or gullies on this landscape.
    - *(Slide 18)* If there is any time left over, start splitting the class into teams to prepare for the next lesson. There will be two large teams per class (1 team per site) and each large team will split into 5

mini-teams:

- Hole digging and soil collecting
- Land cover transect North
- Land cover transect South
- Land cover transect East
- Land cover transect West

Name: _____ Date: _____

Landscape Slope Station

1. Use the stopwatch to collect data and enter it in the table below.

Number of Books	Time it took for the ball to roll down the hill (in seconds)
1	
3	
5	

2. In this model, the ball represents water moving down a hill.

   a. At which slope (number of books) did the water move the slowest? _____

   b. At which slope (number of books) did the water move the fastest? _____

3. Slower moving water has more time to soak into the soil, reducing the amount of water runoff. How might this affect the plants on the hill and soil erosion?

_____

_____

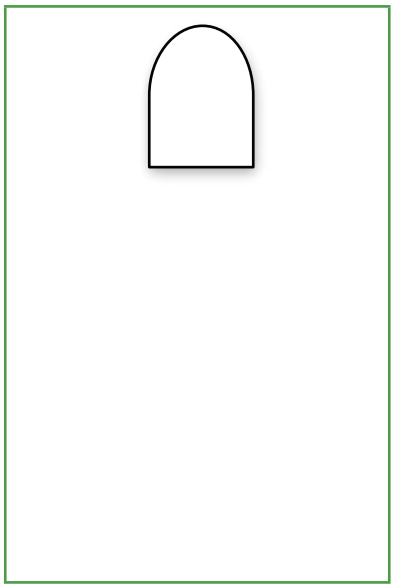
_____

_____

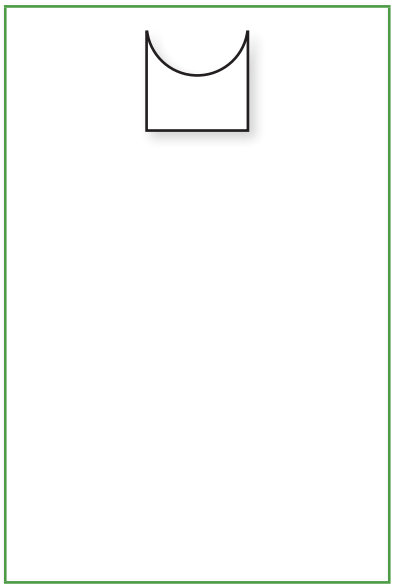
Slope Shape Station

1. Draw arrows tracing the path that water rolls down on the convex and concave hill slope shapes. Map where the water gathered in the pan below.

Convex



Concave



2. Slope shape determines the direction and strength of water flow. Based on your test results, which hill shape might lead to rills or gullies? Explain your reasoning.

_____

_____

_____

_____

_____

Hand Texturing Soil

1. Does the soil form a ball?

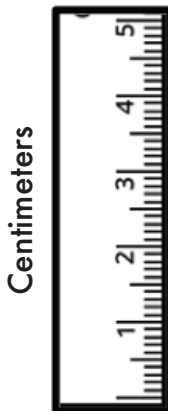
   ☐ Yes (proceed to #2) ☐ No – This is sand.

2. Does the soil form ribbon?

   ☐ Yes (proceed to #3) ☐ No – This is loamy sand.

3. What is the length of the ribbon?

   ☐ <2.5 cm (proceed to #4)
   ☐ 2.5 – 5 cm (proceed to #5)
   ☐ >5 cm (proceed to #6)



4. How does the soil feel?

   ☐ Gritty – This is sandy loam
   ☐ Not gritty or smooth – This is loam
   ☐ Smooth – This is silt loam

5. How does the soil feel?

   ☐ Gritty – This is sandy clay loam
   ☐ Not gritty or smooth – This is clay loam
   ☐ Smooth – This is silty clay loam

6. How does the soil feel?

   ☐ Gritty – This is sandy clay
   ☐ Not gritty or smooth – This is clay
   ☐ Smooth – This is silty clay

7. What is the texture of your soil? (for example, sand, clay loam, etc.) _____

Soil texture affects how much water the soil holds. Sand holds the least water and clay holds the most.

TASK CARD

LANDSCAPE SLOPE

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1. Place one book under one end of the plywood. Line up the edge of the plywood with the spine of the book (Figure A).
2. Have one student hold the ball at the raised end of the plywood.
3. Have another student prepare to start and stop the stopwatch (Figure B). You will start the stopwatch when the ball is released to roll down the plywood. You will stop it when the ball reaches the end of the plywood.
4. Let go of the ball and let it roll down the plywood.
5. Record the time it took for the ball to roll down the plywood on the data table in the Slope Station section on your worksheet.
6. Repeat steps 2 - 5 with 3 books.
7. Repeat steps 2 - 5 with 5 books.
8. Answer questions 2 and 3 on your worksheet.

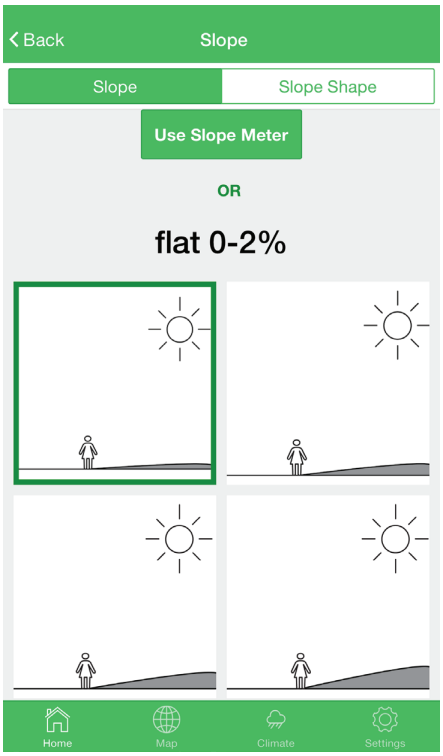

Figure A

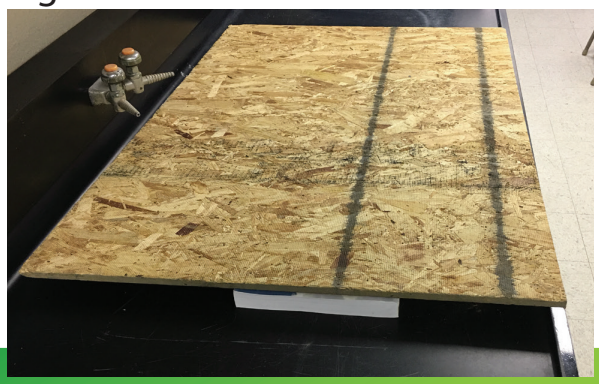

Figure B

TASK CARD

SLOPE SHAPE

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1. Place the cup in the pan with one end resting on the edge of the pan to represent a convex hill (Figure A).
2. While one student holds that cup in place, another student should fill a cup with water and pour it onto the hill.
3. Watch carefully to see how the water runs down the hill and where the water pools.
4. Using arrows, create a map in the Slope Shape Station section on your worksheet showing where the water ran off the cup and where it gathered in the pan.
5. Pour the water out of the pan.
6. Now place the cup in the pan so that it represents a concave hill (Figure B).
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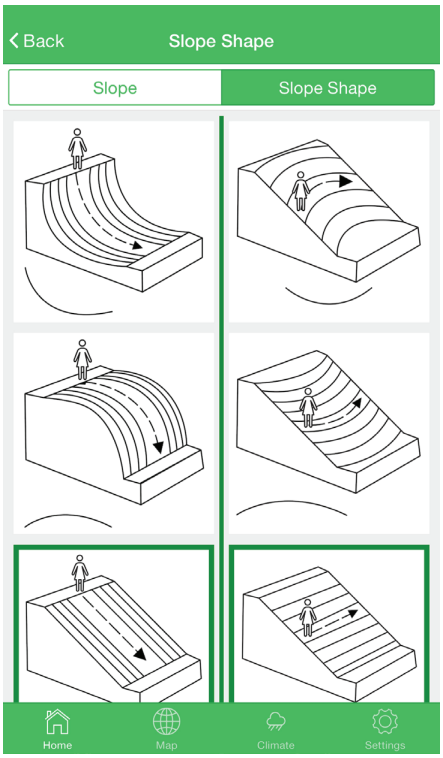

Figure A

Figure B