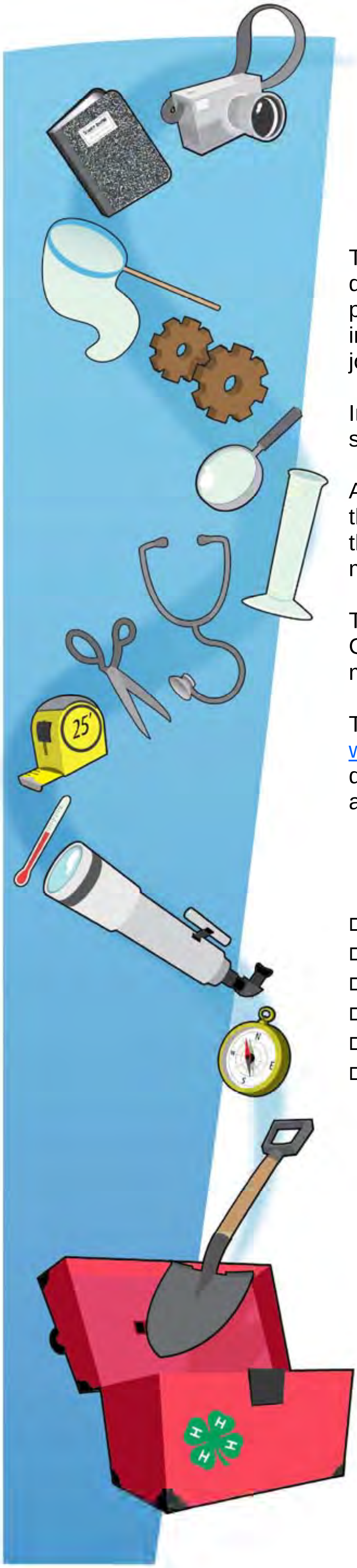
4-H Science Toolkit

Geospatial Science



About the 4-H Science Toolkit Series: Geospatial Science

The ability to think spatially is an increasingly important skill for youth to master in order to succeed in school, careers and as informed citizens. Popular web mapping applications such as GoogleEarth, VirtualEarth and ArcGISExplorer have captured the imagination of youth and adults as they view their world from a new perspective and jobs in geospatial science will increase by 20 percent in the next 10 years!

In this series, activities are designed to move 4-H youth and adults from casual observers to “power users” of geospatial tools.

All of these adventures call on students to predict what will happen, test their theories, then share their results. They’ll be introduced to geospatial science vocabulary, learn the basics of using hand-held gps units and maps and gain an understanding of how maps are made.

The lessons in this unit were developed by the 4-H Geospatial Science team based at Cornell University in the Institute for Resource Information Sciences in the Department of Crop and Soil Science.

To find out more about the 4-H Geospatial Science Programs, visit www.nys4h.cce.cornell.edu. To find numerous resources related to the inserts, outdoor exploration and the environment, check out the national 4-H Resource Directory at http://www.4-hdirectory.org.

Geospatial Science Table of Contents

4-H Science Toolkit

Geospatial Science:
What Is GPS?

Activity Series: Geospatial Science
Grade: 3-6
Time: 60 min

Main Idea

The Global Positioning System is a system of satellites, ground control units and receivers. A GPS can pinpoint a user's location to within just a few feet.

Motivator

Global positioning systems are everywhere, whether you know it or not. Everyone from farmers to fighter jet pilots use the technology. If you've ever looked at someone's home address on an internet map, you've used it too!

Pre-Activity Questions

Before you start the activity, ask the students:

- ❑ Who do you think originated the concept of a GPS? (U.S. Army)
- ❑ Did you know that a pizza delivery driver inspired the first GPS for use in cars?
- ❑ When someone asks you where you live in relation to school, have you ever answered with a time — about 20 minutes away?

Activity 1
You Measure Distance with a Clock?

Supplies

- ❑ Five volunteers (a "satellite", a "signal", two "hikers" and a "timer")
- ❑ Stopwatch (watch, clock with a second hand, cell phone with a timer, etc)

1. The "satellite" should close his/her eyes while one of the "hikers" stands some distance away. The "signal" will stand by the "satellite".
2. When everyone is ready, the "signal" leaves the "satellite" and walks (do not run) to the "hiker." When the signal reaches the "hiker," the "signal will yell out "stop!" Have the "timer" time how long it takes for the signal to reach the hiker from the satellite.
3. Have the "satellite" keep their eyes closed and repeat this process with the other "hiker. This time, the "hiker" should be a different distance (twice as far or half as far is good) from the "satellite."
4. Can the satellite tell which of the two "hikers" is further away? How?(By noting how long it is until the signal says "stop.")

Science Checkup - Questions to ask to evaluate what was learned

- ❑ What is the formula for speed? (Distance divided by time, i.e. miles/hour or meters/second)
- ❑ It is important for the signal to be traveling at the same speed at all times. What would happen if the signal were to speed up or slow down? (Errors in the distance between the satellite and the hiker.)

Objectives

- Learn what global positioning systems are used for and how they work

Learning Standards

(See Matrix)

Common SET Abilities 4-H projects address:

Predict
Hypothesize
Evaluate
State a Problem
Research Problem
Test
Problem Solve
Design Solutions
Develop Solutions
Measure
Collect Data
Draw/Design
Build/Construct
Use tools
Observe
Communicate
Organize
Infer
Question
Plan Investigation
Summarize
Invent
Interpret
Categorize
Model/Graph
Troubleshoot
Redesign
Optimize
Collaborate
Compare

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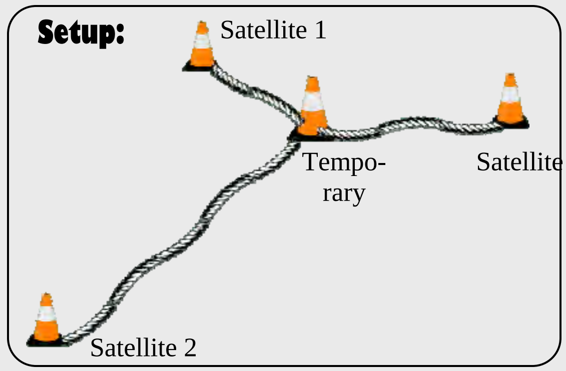
4-H Science Toolkit

Geospatial Science:
What Is GPS?

Activity 2
What is trilateration?

Supplies

- Three pieces of rope of different lengths (Between 10 - 25 feet long)
- Sidewalk chalk
- Four temporary place markers (pieces of tape, cones, etc)
- Six volunteers (three “satellites” and three “signals”)
- Large open area where you can draw with chalk on the floor or ground

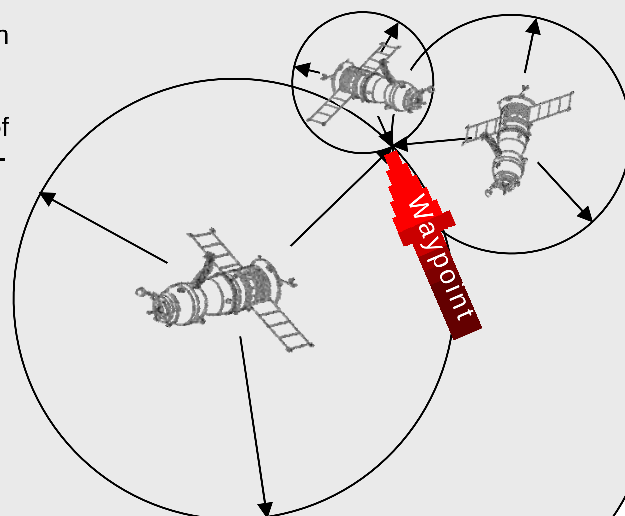


Do this before the students arrive:

1. Use a temporary place marker in the center of a large open area.
2. Lay each of the three ropes on the floor, starting from the original place marker and radiating out in different directions.
3. At the end of each rope, put another place marker. Then, pick up the ropes and lay each rope in a pile, near its far end place marker. Pick up the center place marker.

With the students:

1. Each of the three “satellites” should stand on one of the three place markers and pick up one end of the rope.
2. Each “signal” should pick up the other end of the rope, and walk in a circle around the satellite, drawing this path on the ground with the chalk.
3. Each of these circles represents the area where a hiker could be.
4. After the first circle is drawn, the ***waypoint*** could be anywhere on that circle.
5. After the second circle is drawn, the hiker could only be in the area where the two circles intersect.
6. The point where all three circles cross is the location of the waypoint and should be the same as your original center place marker.



Science Checkup- Questions to ask to evaluate what was learned

- Why is it important to u se three satellites when trying to find your location? (The points where two signals cross could be thousands of miles apart in real life. If you only had one signal, your hiker could be anywhere along the arc.)
- Would it make a difference if your GPS receiver was able to pick up signals from more than three satellites?
- Using the distance from three different points in order to determine your exact location is called what? (Trilateration! It is how GPS receivers figure out where you are! “Tri” come from the Latin ***tres*** word for three, while “lateral” comes from the Latin ***latus***, meaning sides).

Geospatial Science:

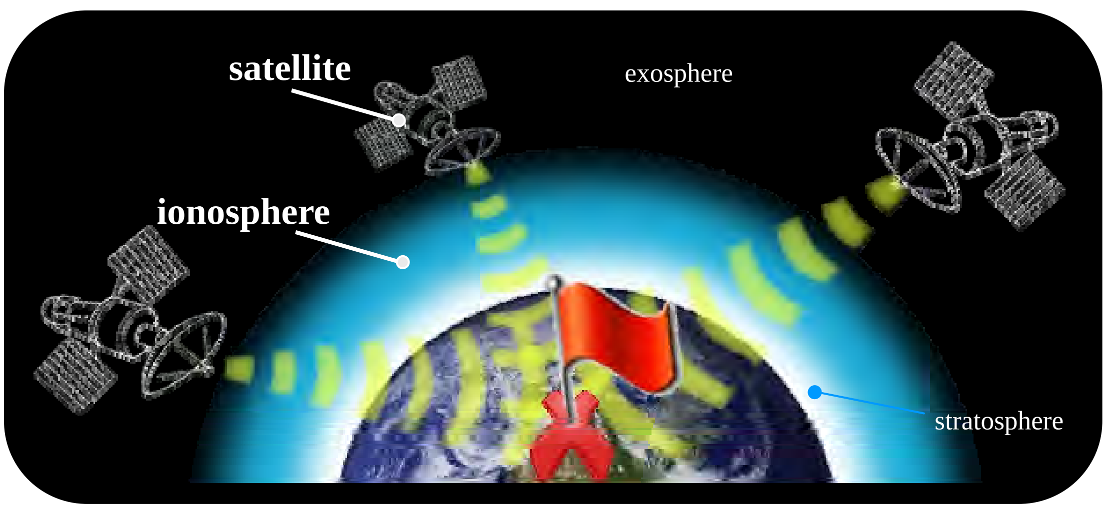
What Is GPS?

Extensions

- Sometimes, obstacles interfere with the path of the satellite signal. Have another student represent a skyscraper or a canyon wall, by standing in the field somewhere near the "satellite" but not directly between the "satellite" and the "hiker." When the signal is sent from the "satellite," the signal should bounce (gently!) off of the obstacle before going out to its normal arc. Would this affect the accuracy of the GPS? How?
- There are some layers of the earth's atmosphere (specifically, the ionosphere) that affect the speed of a satellite signal. To illustrate this, have the "signal" crab-walk a portion of the distance. What effect does that have? In the real GPS system, accurately surveyed ground stations determine correction factors to take this into account and provide accurate readings.

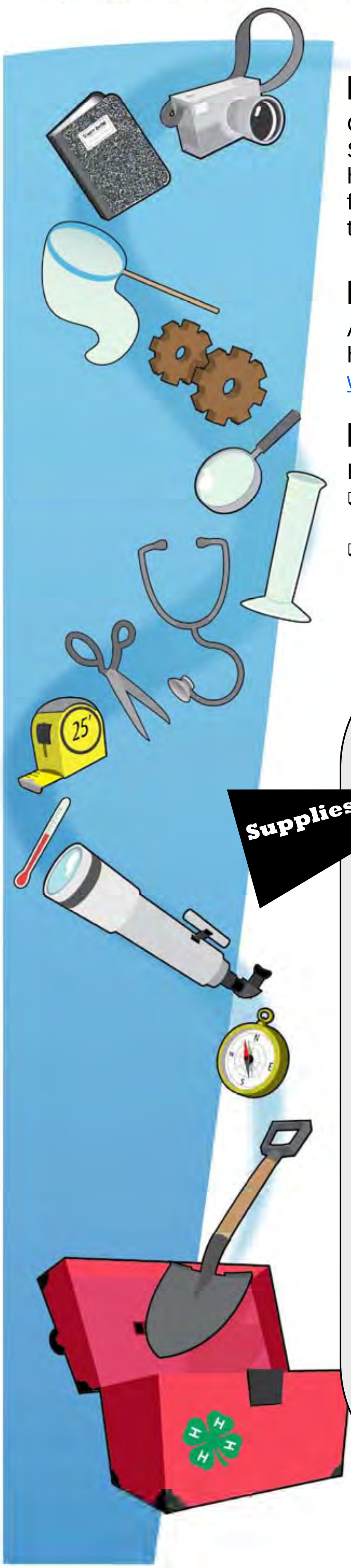
Vocabulary

- **Ionosphere:** The region of the earth's atmosphere between the stratosphere and the exosphere, consisting of several ionized layers and extending from about 50 to 250 miles (80 to 400 km) above the surface of the earth.
- **Satellite:** A device designed to be launched into orbit around the earth.
- **Trilateration:** The measurement of three unique distances between points for the purpose of establishing relative positions of the points. Illustrated by the yellow beams, below.



Background Resources

- Hinch, Steven. "*Outdoor Navigation with GPS*." Wilderness Press.
- Latham, Lawrence and Alex Lathem. "*GPS Made Easy: Using Global Positioning Systems in the Outdoors*." Mountaineers Books.



Geospatial Science:
Geocaching

Activity Series: Geospatial Science
Grade: 3-6
Time: 60 min.

Main Idea

Geocaching is a fun and exciting activity using the Global Positioning System (GPS) to explore the great outdoors. Imagine a giant treasure hunt with thousands of treasure boxes hidden all over the world! It's fun for everyone and it's a great way to get exercise and make new friends in the geocaching community!

Motivator

As of the writing of this Toolkit, there are more than 1 million geocaches hidden all over the world, and more than 65,000 geocachers registered at www.geocaching.com. Those numbers are growing every day!

Pre-Activity Questions

Before you start the activity, ask the students:

- When you head out on the trail, what should you bring with you? (first aid kit, water bottle, snacks, GPS receiver, map, compass, etc.)
- What kind of clothing do you think would be appropriate for an outing? (Long pants, long sleeves, boots and clothes that can get dirty)

Activity 1

Supplies

- A GPS receiver (GPSr), ideally one unit for every two to three students
- A variety of weatherproof containers of different shapes and sizes
- An outdoor natural area, ideally a blend of natural areas including forest and field, but any outdoor area will do.

There are many kinds of geocaches but the simplest type is known as a "traditional" geocache.

1. Dig through your recycling bin at home to find a few different plastic containers that have good, sturdy lids. Butter tubs, whipped cream containers, or other similar containers make fine temporary geocaches. (Later, if you decide to hide a permanent geocache, you will want something much sturdier and weather-resistant.) Be sure to include a log book, or at least a strip of paper in a plastic bag, in your geocache.
2. Make a visit to a large outdoor space such as a local park, or a friend's big backyard.
3. Using a GPSr, take a walk and find a good place to hide your container. You will want to put it in a spot where it will blend in to the environment. You might want to paint it a dark color, or cover it with camouflage tape.
4. Once you have hidden the container, mark its location on your GPSr. It's a good idea to allow your GPSr to rest at the cache

Objectives

- To practice more with GPS units by learning about geo-caching

Learning Standards

(See Matrix)

Common SET Abilities 4-H projects address:

Predict
Hypothesize
Evaluate
State a Problem
Research Problem
Test
Problem Solve
Design Solutions
Develop Solutions
Measure
Collect Data
Draw/Design
Build/Construct
Use tools
Observe
Communicate
Organize
Infer
Question
Plan Investigation
Summarize
Invent
Interpret
Categorize
Model/Graph
Troubleshoot
Redesign
Optimize
Collaborate
Compare

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Geospatial Science:
Geocaching

location for a few minutes before you actually mark the location, so you can get the most accurate coordinates possible.

4. Share the coordinates of your geocache with your friends. Next time they are in the area, they can try to find the geocache that you have hidden! When you find a geocache, sign your nickname in the log book to prove that you found it.
5. If you plan to leave your cache in place for more than a few days, it's a good idea to use something sturdier than a recycled butter tub. Lock-n-Lock containers and surplus military ammunitions cans make good sturdy geocaches for more durable hides. Take a look at "Rules For Hiding A Geocache" for suggestions on hiding any long-term cache.

Science Checkup - Questions to ask to evaluate what was learned

- Would you consider geocaching a healthy form of exercise? Why or why not? (Yes! It's a good way to get outside, enjoy the fresh air, and stretch your legs.)
- Do you think geocaching has an impact on the environment? If so, is it a positive or a negative impact? Can you think of at least one positive and one negative? (Geocaching can have both positive and negative impacts. One benefit is that it can raise our awareness for the environment, the negative impact can come when geocachers trample vegetation creating new trails where there were none. It is important to take care of our environment.)

Activity 2

Supplies

- A GPS receiver (GPSr), ideally one unit for every two to three students
- Computer with internet connection

With more than 1 million caches hidden all over the globe, the world is your playground with geocaching! Plan a geocaching trip with some friends or family members at a local park.

1. First, you need to find the coordinates of official geocaches. There are a few different Web sites that list geocaches, but the largest one is **www.geocaching.com**. You will need to create a free user account to get started.
2. Once you have logged into the Web site, enter your zip code in the "Hide and Seek a Geocache" box. You will see a list of geocaches near you. Browse through the list, clicking on geocaches that sound interesting and take a look at the detailed cache description. Look for these things:
   - Difficulty and terrain ratings. Rated from one to five stars, these will give you a feel for how difficult the cache will be to find. Start simple and work your way up to more complex caches.
   - What kind of cache is it? Traditional caches are the most common, but there are many different variations, so you will want to know what you are looking for. Check out the site, http://www.geocaching.com/about/cache_types.aspx, for a detailed description of the cache types that geocaching.com recognizes.
   - What size is the cache? Caches range from very small to very large.
   - Read the description. Sometimes the cache hider will give hints about the cache in the

description.
    - Look at the logs posted by the last people to find the cache. If the last four or five people to look for a cache couldn't find it, it could be missing. You can often learn a lot from other people's logs.
3. Take a family trip to the local park. Park the car, and hit the trail!
4. Once you get near a geocache, you may find that your receiver is giving you mixed signals. Check out "loose bearings" in the vocabulary section.
5. When you finally find a cache, there are a couple of basic guidelines:
    - Sign the log book. Use a nickname rather than your real name.
    - Take something. Some caches will have trade items. These are there for other cachers to take. Feel free to take one.
    - Leave something. If you chose to take anything from the cache, you are also expected to leave something behind. Some folks choose to leave trade items even when they don't take one. The rule of thumb is to trade equal or trade up! For example, if you take a baseball, you should leave something of similar or greater value, like a small first aid kit.
    - Re-hide the cache in exactly the same spot you found it.
    - When you return home, go back to the geocaching Web site and log your find. This helps the owner and other geocachers to know that the cache is still in good shape.

Science Checkup - Questions to ask to evaluate what was learned

- ❑ Sometimes when you find a geocache, your GPSr can still say that you are well over 30 feet away. How is this possible? (GPS receivers are not perfect, and every unit has a small amount of error. The unit used by the person who hid the geocache has a small unit or error, and your unit had error when you found it, compounding to up to 50 feet of error at times!)
- ❑ After you have found a few geocaches, write down a list of the different ways that caches have been camouflaged. How has camouflage helped these caches survive? Can you think of any animals in nature that use camouflage to survive? (Squirrels are gray to hide in the trees. Stick bugs are designed to look like branches)

Vocabulary

CITO: An acronym standing for Cache In, Trash Out. This ethic encourages geocachers to pick up litter and trash and leave the environment cleaner than they found it.
Geocache: A weather-resistant container hidden in a public, outdoor place, with its coordinates recorded on a GPSr and shared with others.
GZ (Ground zero): The area in which a geocache is expected to be found. Typically GZ is an area of approximately 30 feet around the actual cache.
Loose bearings: The point at which the direction on your GPSr no longer points in the correct direction, mostly because you've slowed down to a point that it doesn't know in which direction you're moving.
Muggle: A person who isn't familiar with the game of geocaching (as in "There were a few muggles around, so I decided to wait for them to leave before looking for the 'cache.' ")

Background Information

- Geocache Listing Sites: www.earthcaching.com, www.geocaching.com, www.navicache.com
- Geocache Hiding Guidelines: http://www.geocaching.com/about/guidelines.aspx

Geospatial Science: Geocaching

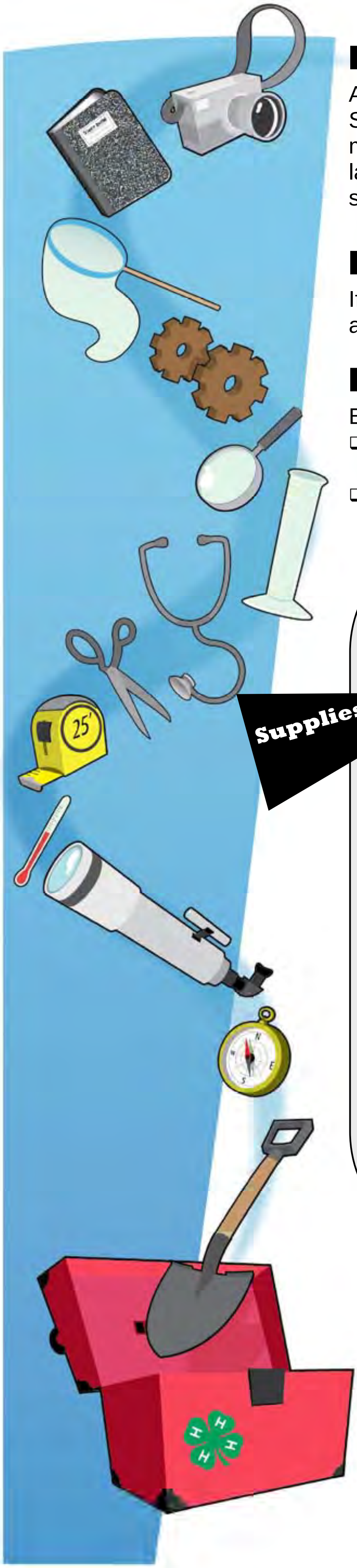
Rules for Hiding a Geocache

1. Be Respectful of the Environment: When you hide a cache, you may soon find a new trail of foot-prints from other geocachers, straight to your hide. Visitors to your cache could end up doing a lot of damage if you place your cache next to a new bird's nest, or some species of rare plant!
2. Be Respectful of Private Property: If you are hiding a cache on land that is not your own, be sure to place it on public land. If you place a cache on private land, be sure to get permission first!
3. Never Bury a Geocache: You don't want people digging up 30 feet of grass and leaves to find your cache. See #1.
4. Don't Hide A Cache Anywhere That it Could Cause Unnecessary Harm: If non-cachers were to see someone poking around at the cache site, would they be panicked? You wouldn't want to hide a cache near a railroad track or under a bridge.

4-H Science Toolkit

Geospatial Science: Using a GPS receiver

Activity Series: Geospatial Science
Grade: 3-6
Time: 60 min.



Main Idea

A GPS Receiver (GPSr) is just one piece of the Global Positioning System, but it's the piece that most people are familiar with. There are many kinds of GPS receivers available, from simple handheld models to larger models with touch-screens for use in cars. This lesson helps students use the handheld models for geocaching and basic mapping.

Motivator

If you know how to use a GPS receiver, you can find all sorts of things and find your way around the earth!

Pre-Activity Questions

Before you start the activity, ask the students:

- What are some things a GPS could help you to do? (determine direction, plan a route, find a specific location, measure distance)
- What kinds of things would you like to learn about using a GPS?

Activity 1

Supplies

- A GPS receiver, one unit for every two to three students
- The user's manual for the GPS receiver
- A handful of temporary place markers (cones, Frisbees®, anything that won't blow away in the wind)
- A large outdoor natural area
- Note pad and pencil

Since GPS receivers have varied settings and appearances, spend a few minutes setting up the receivers to make them consistent so everyone is looking at the same information.

1. Look through your instruction manual for the section on setting the ***map datum***, the set of reference points your receiver will use as its data. Be sure that all of your receivers are set to the WGS84 Datum. (See "Map datum" under vocabulary.)
2. Now, look in your manual for information on setting the ***coordinate format***. Different formats allow you to express your location in different ways, such as hemisphere (North, South, East or West), followed by latitude and/or longitude (degrees, minutes and/or seconds). Set your format to hddd mm.mmm, which stands for **h**emisphere, **d**egree, **m**inutes and **d**ecimal minutes.

Science Checkup - Questions to ask to evaluate what was learned

- What would happen if you used a different datum than someone else in your group? (Your unit may be referenced from a different starting point, so your waypoints could be significantly different.)

Objectives

- To learn to use a GPS receiver to find a location or object

Learning Standards

(See Matrix)

Common SET Abilities 4-H projects address:

Predict
Hypothesize
Evaluate
State a Problem
Research Problem
Test
Problem Solve
Design Solutions
Develop Solutions
Measure
Collect Data
Draw/Design
Build/Construct
Use tools
Observe
Communicate
Organize
Infer
Question
Plan Investigation
Summarize
Invent
Interpret
Categorize
Model/Graph
Troubleshoot
Redesign
Optimize
Collaborate
Compare

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- What is the difference between formats? Why are there so many? (It's kind of like fractions or decimals, just different ways of saying the same thing. It's typically a regional choice.)

Activity 2:
Where am I? Where are you?

The most basic functions of the receiver are to record your current location and to mark a different location. Do you know where you are right now? Your receiver may not… YET!

1. Turn on your receiver and let it find the satellites overhead. Make sure there is nothing above you (like a dense tree canopy), otherwise, the receiver may not connect to the satellites.
2. In your manual, find the section about how to record a ***waypoint***.
3. Standing outside in a clear, open space, record your current location. Name this first waypoint, "*test*." You can delete this later, but for now, you're just practicing. While you are marking this location, take a look at the ***coordinates*** of the waypoint displayed on your GPS unit. This will include a direction and degrees of longitude and latitude. On your note pad, write down your coordinates.
4. Got the hang of it? Try it again! Move 50 steps away and try marking another waypoint. Name this one "*test 2*." On your note pad, write down the coordinates of this second waypoint. Take a look at the coordinates of "test 2." How do they compare to "*test*"? Are they the same? If not, are they similar?
5. How accurate is a GPS receiver? Try this experiment to find out. Pick out a nearby landmark (a water fountain, a light pole, etc.) or simply place a place-marker on the ground.
6. Have each member of the group take turns marking the location of the land marker and saving it in their receiver as "*test 3*."
7. Compare your coordinates with the others in your group. How similar are they? It is likely that they will be very similar, but not identical. Why do you think this might be? Remember that your receiver is communicating with satellites 12,000 miles away!
8. Another way to record a waypoint is to type in the coordinates. Remember that scrap where you wrote wrote the coordinates to your original waypoints? Use your instruction manual and create a new waypoint by typing in those original coordinates.

Science Checkup - Questions to ask to evaluate what was learned

- Do you think your receiver is accurate enough for you? Why might someone need theirs to be more accurate? (You are using your unit for recreation. Firemen might need to find the gas shut-off valve to your house in the case of emergency. The purpose for which you are using the GPSr will determine the level of accuracy that is needed.)
- Would your receiver be good for recording the locations of telephones in your home? Why or why not? (GPSr's don't work well indoors because they need an unobstructed view of the satellites overhead.)

Activity 3:
How can I get there from here?

Once you enter a waypoint into your unit, the receiver stores the coordinates for that waypoint in its internal memory. The first step in getting from here to there is finding that waypoint in your receiver.

(Continued on page 3)

4-H Science Toolkit

Using a GPS receiver

1. In your manual, look up how to find a waypoint and then look on your receiver for the waypoint called "*test 2*."
2. Once you find the waypoint, check your manual for help in how to "*goto*" or navigate to that waypoint.
3. Take a walk with your receiver and see how it works to help you go back to the place that you marked as "*test 2*."

Science Checkup - Questions to ask to evaluate what was learned

- How is your receiver like a compass? How is it different? (It can tell direction, but most receivers require that you are moving in order to tell direction.)
- Does your receiver consider obstacles that might be between you and your final destination? How do you know? (No, the receiver only knows the direction and the distance to the final destination. It always draws a straight line path.)

Activity 4
Putting it all together

Note: You will need two groups for this activity.

1. Give each group a place marker of some sort (a cone or a bandana).
2. Each group should take a short walk (no more than 300 feet) in different directions and put their place marker on the ground.
3. Each member of the group should mark the location of their place marker on their GPS receiver
4. Once the waypoints are marked, gather back at the starting place.
5. Share coordinates with the other group and enter the other group's coordinates into the receivers.
6. As a group, see if you can find the other group's place marker!

Science Checkup - Questions to ask to evaluate what was learned

- What factors might affect the accuracy of your receiver?

Extensions

- If people in your group have different models of GPS receivers, try Activity 4 with various receivers and see how accurate they are and how well they locate the placemarkers. Take your coordinates and enter them into Google Earth or mapquest.com to see your location from above or a street map of your location. These programs show you two of the myriad ways you can use coordinates to find a location or find your way around.

Vocabulary

Coordinate: Any of a set of two or more numbers used to determine the position of a point, line, curve, or plane.
Map Datum: A set of reference points on the earth's surface against which position measurements are made.
Coordinate Format: Any of a number of methods for displaying the coordinates of a given location on earth. Typical examples would include HDDDDDDDD, HDDD MM.MMM or HDDD MM SSS, where H is the Hemisphere (North, East, South or West), D is degrees of latitude or longitude, M is minutes (1 degree = 60 minutes) and S is seconds (1 minute = 60 seconds).
Waypoint: Waypoints are named coordinates representing points on the surface of the Earth.

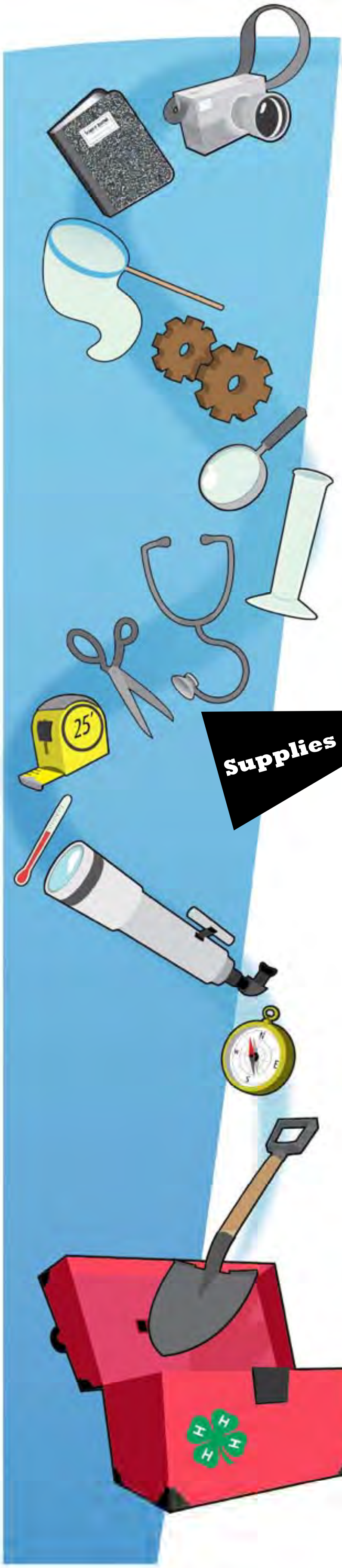
Geospatial Science:
Using a GPS receiver

Background Resources

- Download a manual for your GPS receiver at:
  Garmin: http://www8.garmin.com/support/userManual.jsp
  Magellan: http://www.magellangps.com/support/index.asp
  DeLorme: http://www.delorme.com/support/search.aspx
  Lowrance: http://www.lowrance.com/en/Downloads/Manuals/
- Check out geocaching.com for more information about GPS units and the sport of geocaching.

4-H Science Toolkit

Geospatial Science: Making Sense of Maps



Main Idea

There are a variety of kinds of maps that can be used for many different purposes. The map creator or cartographer must choose the correct medium and information to display depending on the purpose of the map.

Motivator

Did you know that maps can show you much more than just how to find your way around? Maps can show who people voted for in a presidential election, they can show what mountains are the tallest and they can even tell you how many ice cream shops there are in your town.

Pre-Activity Questions

Before you start the activity, ask the students:

- What are some ways that you use a map?
- What kinds of information do you typically find on a map?
- What kind of symbols do map makers use on their maps?

Activity 1: Make your own map

Supplies

- A map that contains a legend, scale, orienting arrow, date of production and name of producer
- A topographic map of your city or town, in color
- A thematic map from the Internet – good examples include how your town or city voted in the last presidential election or maps from the www.census.gov site from your state
- A photographic or image map – an aerial photo of your town from Google Earth is a good option
- Pencils, paper and markers or crayons for each student
- Rulers

1. Show students the first map, explaining that the legend, scale, orienting arrow, date and name are important features in any map. Explain what they are used for.
2. Pass around the other three maps and briefly explain the difference between them.
3. Ask students to create a topographic map of their own. They could choose to map their backyard, their neighborhood or the area of their school or meeting place. Have them use the correct colors for water, buildings, roads and trees and vegetation. Have them try drawing to scale, even though the measurements will be guesses.
4. Make sure their maps include legends, scales, orienting arrows, date and their names.

Objectives

- Learn about map forms and content and how they've changed over time

Learning Standards

(See Matrix)

Common SET Abilities 4-H projects address:

Predict
Hypothesize
Evaluate
State a Problem
Research Problem
Test
Problem Solve
Design Solutions
Develop Solutions
Measure
Collect Data
Draw/Design
Build/Construct
Use tools
Observe
Communicate
Organize
Infer
Question
Plan Investigation
Summarize
Invent
Interpret
Categorize
Model/Graph
Troubleshoot
Redesign
Optimize
Collaborate
Compare

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Department of Crop and Soil Science

Geospatial Science: Making Sense of Maps

Science Checkup—Questions you might ask to evaluate what was learned

- ❑ Name at least three types of maps.
- ❑ What does the color blue represent on a topographic map?
- ❑ List two things that all maps must possess to be considered a map.
- ❑ Can aerial photos be used in the creation of maps?
- ❑ What is one of the most commonly known use of thematic maps in the United States?

Extensions

- Visit your town library to compare older maps of your area with present-day ones. How are they different? How are they the same? What features/symbols/names are included on older maps that aren't included today? How has your town changed?
- Read about early cartographers to find out how they created maps with the limited tools they had.
- Try taking some measurements and creating a scale map of your meeting area.
- Visit www.census.gov to see detailed thematic maps of your area and explore the various demographic characteristics that are mapped by the Census Bureau. How is this information useful? Why is it more useful in map form?

Vocabulary

Cartographer: A person who creates maps.
Topography: The physical features of a landscape, both natural and manmade, such as rivers, trees, mountains and buildings.
Legend: A key that explains the meaning of various characters or symbols on a map.
Orienting Arrow: An arrow that shows which direction is north on a map.

Background Resources

Minimum Requirements for a Map:

All maps must have the following features to be considered a map:

- Legend - An explanation of characters or symbols used on that map.
- Scale - The scale can be verbally expressed or expressed mathematically. In a ratio scale such as 1:63,630, one inch equals 63,360 inches in the real world, or about one mile. Both sides of the ratio must represent the same measurement.
- Orienting arrow - Generally these arrows point north, but the arrow may point in other directions depending on the time of production and the group who produced the map.
- Date of production
- Name of producer

Types of Maps (adapted from Rand McNally Goode's World Atlas 1982):

Topographic maps: Show the physical features of the landscape, both natural and significant man-made structures. These include BLUE water bodies (ponds, lakes, rivers, streams), terrain (hills, mountains, depressions, etc), BLACK buildings (solid black shapes for inhabited and hollow black outlines for seasonal or uninhabited), RED for highways and BLACK for roadways (which are also expressed in frequency of use by color or by solidity of the line) and GREEN for vegetation cover.

Thematic maps: Theme maps can be used by a wide variety of fields (medicine, politics, conservation, world aid, retail) to display a specific piece of information over a large area. The results are often based on limited specific data but extrapolated onto the map. The most common example of this type of map is the presidential election maps. While not everyone in a state may vote Democrat or Republican, if the largest number of cast votes are of a specific party, then the state is shaded to the color that corresponds to that party.

4-H Science Toolkit

Geospatial Science:

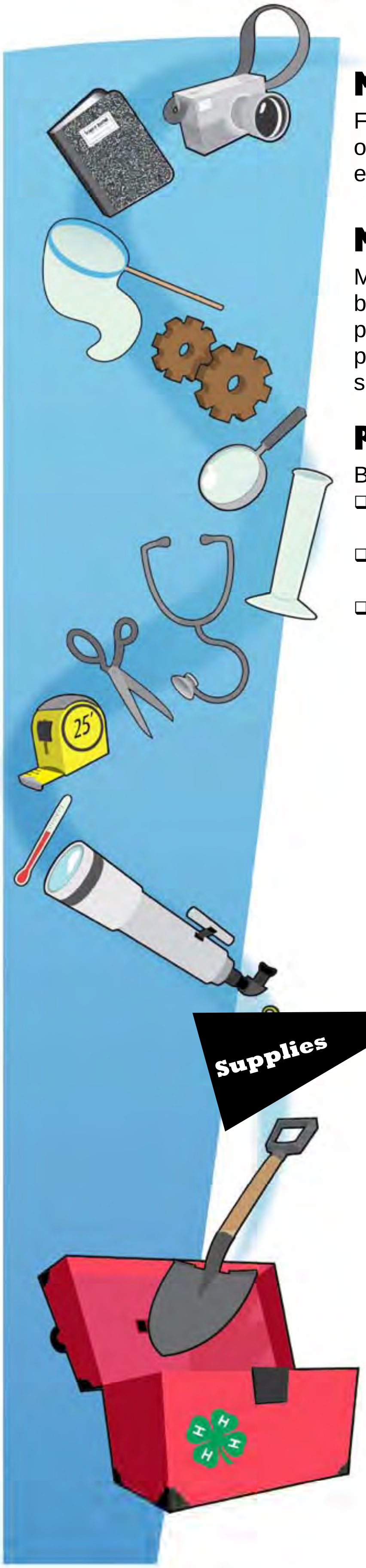
Making Sense of Maps

Photographic/Image Maps – An actual photo (usually a satellite image or aerial color photo) is used as the foundation for the map. Informational materials are then displayed on the photo itself. The photo tends to display more natural colors than the topographic map, but in some cases different areas may blend together along the edges because of the altitude the photo was taken from. The information that can be displayed on a photographic map includes social, political, and biological data.

Other interesting map facts:

- Definition of a map: Maps have been described as " . . . diagrams of an area and the location of features or places . . . " (Webster's Student Dictionary 1999) or " . . . visual representations of objects, regions, and themes . . . " (Wikipedia 2009) and the spatial characteristics that separate these objects.
- The map has evolved as human discoveries and technology have evolved. At one time, maps were the "illustrations" of a cartographer (a person who creates/makes maps) done by extensive and careful hand drawing, but today most maps are created by people working with powerful software that can place layer upon layer onto the base map.
- The use of aerial photos or satellite imagery in the creation of maps has now become common place, but has yet to replace traditional maps in some uses because the forms illustrate certain features differently.
- Maps can be two-dimensional, like an aerial photo, or three-dimensional like a globe. Google Earth and Pictometry have found a niche somewhere between two-dimensional and three-dimensional and both are very interactive.

Geospatial Science:
Precision Farming



Main Idea

Farming is no longer what it used to be. Today's farmers are depending on geospatial science technology to make their farm businesses more economic, efficient and environmentally safe.

Motivator

Most everybody knows that farmers have to use tractors, plows, combines and other crop equipment. But did you know that today farmers depend on technical equipment and systems that use space satellites, computers and special electronic receiving devices (called GPS – Global Positioning System receivers) in order to plant and manage crops?

Pre-Activity Questions

Before you start the activity, ask the students:

- ❑ In what ways can farmers change their planting methods that will protect the environment?
- ❑ How can farmers save money by applying just the right amounts of fertilizers and pesticides, in exactly the right places?
- ❑ What new kinds of technical equipment do farmers use today that will help them know exactly where and how to manage their crops?

Activity 1: Making a model of a GPS satellite and receiver system

Supplies

- ❑ Toy/model farm equipment (tractor and implement)
- ❑ Large piece of cardboard or heavy weight paper
- ❑ Marker(s)
- ❑ 50-foot measuring tape
- ❑ Farm implement promotional material – photos of GPS enabled equipment (obtain from local farm implement dealer).
- ❑ 4 or 5 scale models of GPS satellites (create out of balsa wood, paper or foam from egg cartons)
- ❑ Twine or string (approximately 50 feet)

(Note: This activity relates closely with the concepts covered in these other Geospatial Science activities, "You Measure Distance with a Clock?" and "Trilater-WHAT?! Trilateration!")

1. The object is to set up a visual layout that depicts an arrangement of satellites in the sky in relation to farm implements.
2. Prior to the activity:
   - Mark a large piece of cardboard or heavy paper (about 4' X 4') with a grid system using numbers and letters making up a simple latitude /longitude diagram.

Activity Series: Geospatial Science
Grade: 4-6
Time: 60 min

Objectives

- Understand how GPS satellites work with receivers to calculate location.
- Learn how precision farming helps farmers manage crops.

Learning Standards

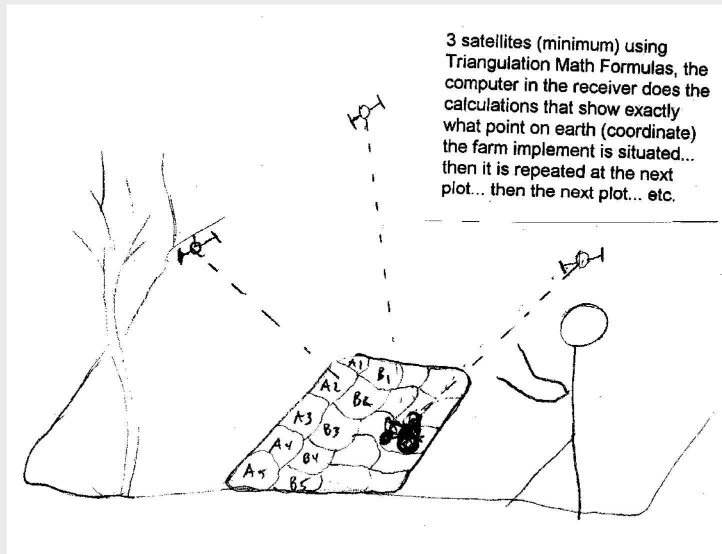
(See Matrix)

Common SET Abilities 4-H projects address:

Predict
Hypothesize
Evaluate
State a Problem
Research Problem
Test
Problem Solve
Design Solutions
Develop Solutions
Measure
Collect Data
Draw/Design
Build/Construct
Use tools
Observe
Communicate
Organize
Infer
Question
Plan Investigation
Summarize
Invent
Interpret
Categorize
Model/Graph
Troubleshoot
Redesign
Optimize
Collaborate
Compare

Contributed By

NYS
4-H Geospatial Science Team
IRIS
Department of Crop and Soil Science



- West (longitude) markings should be along the top and North (latitude) marks should be along the left (see illustration).
- Create 5 or 6 simple models of GPS satellites about 2” to 3” in length using Popsicle sticks, foam, empty plastic film canisters or other art supplies. Label them A, B, C, D, etc.
- Place the model GPS satellites in high locations (hang from trees, ceiling tile grates, etc.) approximately 10’ – 15’ from the model farm implement.
- Place a model farm implement somewhere on the cardboard below the GPS model satellites.
- Cut lengths of twine or string slightly longer than the distances from each GPS satellite model to the model farm implement.

Sample Field Marked in Grid Sections

	W1	W2	W3	W4	W5	W6	W7	W8
N1								
N2								
N3								
N4								
N5								
N6								
N7								
N8								

3. The cardboard grid system represents a crop in a field. The coordinates formed at the intersections of each of the lines on the grid are like the latitude/longitude coordinate system used in GPS receivers. When the farm implements travel through a field, the GPS can record the specific location. By knowing these locations, farmers are able to make maps of crop yields, soil profiles, field boundaries and other information. They are then able to use the information to analyze crops and manage them better. This science is called GIS (Geographic Information System). It can be used for:
   - Documenting harvests and crop performance
   - Managing crop planning operations
   - Managing applications of fertilizer and pesticides on crops.
4. Place the Farm implement on the field in any location. Use the string/twine to measure distances from each of 3 or more satellites to the farm implement. Measure the string/twine and record the distances. Record the information in a simple chart (shown on next page.) Move the farm implement to another location and measure the same way. Record the distances of each string/twine again.
5. Tell the students that computers, calculators, precise clocks and other technical equipment

help farmers manage farming operations in a very precise manner.

6. Use obtained farm implement dealer brochures and catalogues to see the various farm implements that utilize GPS and GIS science for Precision Farming management.

Tractor Location	Length of string from Satellite A	Length of string from Satellite B	Length of string from Satellite C	Length of string from Satellite D
Sample 1: **N1 W3**	12’ 2”	9’6”	5’ 11”	12’ 1”

Science Checkup - Questions you might ask to evaluate what was learned

- What do you think is used to calculate the distance from the real GPS satellites to the farm equipment GPS receivers? (*Answer* – Distance is determined by time, which is calculated by very precise atomic clocks in the satellites and quartz clocks in the receivers. We know how fast radio signals travel, therefore if we know the precise time it takes for a signal to get from a satellite to and receiver and back, we can determine the exact distance from each satellite.)
- What farm management (jobs) could this ***precision farming*** technology benefit? (Answer(s) – Smarter application of pesticides only where needed; more economical applications of expensive fertilizer; better management by recording harvest information specific to field location)

Activity 2: The Space & Farm Connection

Supplies

- 10-15 mini clear plastic cups (1-2 oz.) or small paper cups
- Marker
- Colored water (representing applied fertilizer)
- 1/4 cup measuring device
- GIS cornfield map (pages 6-8 included here), printed in color and assembled
- Clear plastic garbage bag to cover map

1. Before students arrive, print out the three pages of the GIS field map, cut apart and tape together, making sure pages are in order and North directional arrows are pointing in the same direction. You should have one long rectangular map, about 8.5 by 30 inches.
2. The cornfield is a layer of information indicating yields in a certain field last year. Based on that information obtained from GPS and GIS, assume the farm manager wants to apply fertilizer/nitrogen to “boost” crops in areas of poor yield and not apply as much nitrogen in areas where soil seems to be sufficient in nutrients, (where there were excellent crop yields). Set up the following demonstration to compare traditional methods of applying fertilizer to methods of applying fertilizer using GPS and GIS technology.
3. Mark a set of 9 or more small 1 – 2 oz. sampler cups with a line about 1/8 of an inch from the rim.
4. Arrange the cups on the printed image of the corn field in areas of differing yield (indicted by different colors). Each cup represents a part of a field. When the cup is filled with colored

Geospatial Science: Precision Farming

water (representing fertilizer), the line near the rim represents the optimum level of fertilizer in the soil. The goal is to fertilize the field with enough colored water (fertilizer) to bring the level up to the line, but NO MORE, as that will be waste.

5. Fill the cups with varying amounts of water to represent the current conditions in the field indicated by the color of the grid. For example, in green areas where the yield is high, fill the cup to the line near the rim, representing the optimum amount of fertilizer already in the soil. Fill the cups in the medium yield locations (orange) half full, and put only a few drops of colored water in the cups over locations of poor yield (yellow).
6. The demonstration set-up illustrates that different parts of the field have different nutrient requirements. While some parts of the field lack nutrients, other sections of the field contain well-enriched soil with sufficient amounts of nutrients.
7. Ask a participant to "drive" the farm implement (model tractor or imaginary) through the field, dispensing an equal amount of colored water (somewhat less than half a cup) to each cup. Remind everyone that the conventional method of applying materials (like fertilizer) to a farm field is to spread it evenly and at the same rate over the entire field. Areas that may not need as much of an application may receive a wasteful quantity, while other areas don't get enough. This is pointed out visually with this demonstration.
8. Results: Let the group observe and be ready to share what results they find. Some cups will overflow and cause runoff. Explain the environmental concerns of runoff. Some cups will be filled to a level between the line and the top of the cup, which is more than optimum and thus inefficient and expensive. Explain economic concerns of farmers. Some may be right at the line, which is optimal. Some may be filled to a level below the line, which is less than optimal and will result in a lower yield of crops.

Science Checkup – Questions you might ask to evaluate what was learned

- Why wouldn't a farmer want to apply the same amount of inputs to all parts of the field? (Due to variations in the land or environment, there may be different needs for fertilizer use or pesticides in different parts of the field.)
- How could a farmer learn about the crop or soil needs in each part of the field? (Divide the field into small, manageable plots and sample each plot. Keep track of the plots with the use of the GPS system.)
- What happens if plants get too much or too little fertilizer or pesticides? (Very costly; possibly destructive to the environment; could be harmful to the crop]
- Where do the excess materials go? (Into the groundwater; may pollute streams, rivers, lakes and wells.)
- What if you get everything just right? (Good crop yields; low impact on the environment; farmers get better profit.)

Extensions?

- Discuss how GPS systems could be used in animal agriculture or wildlife tracking.

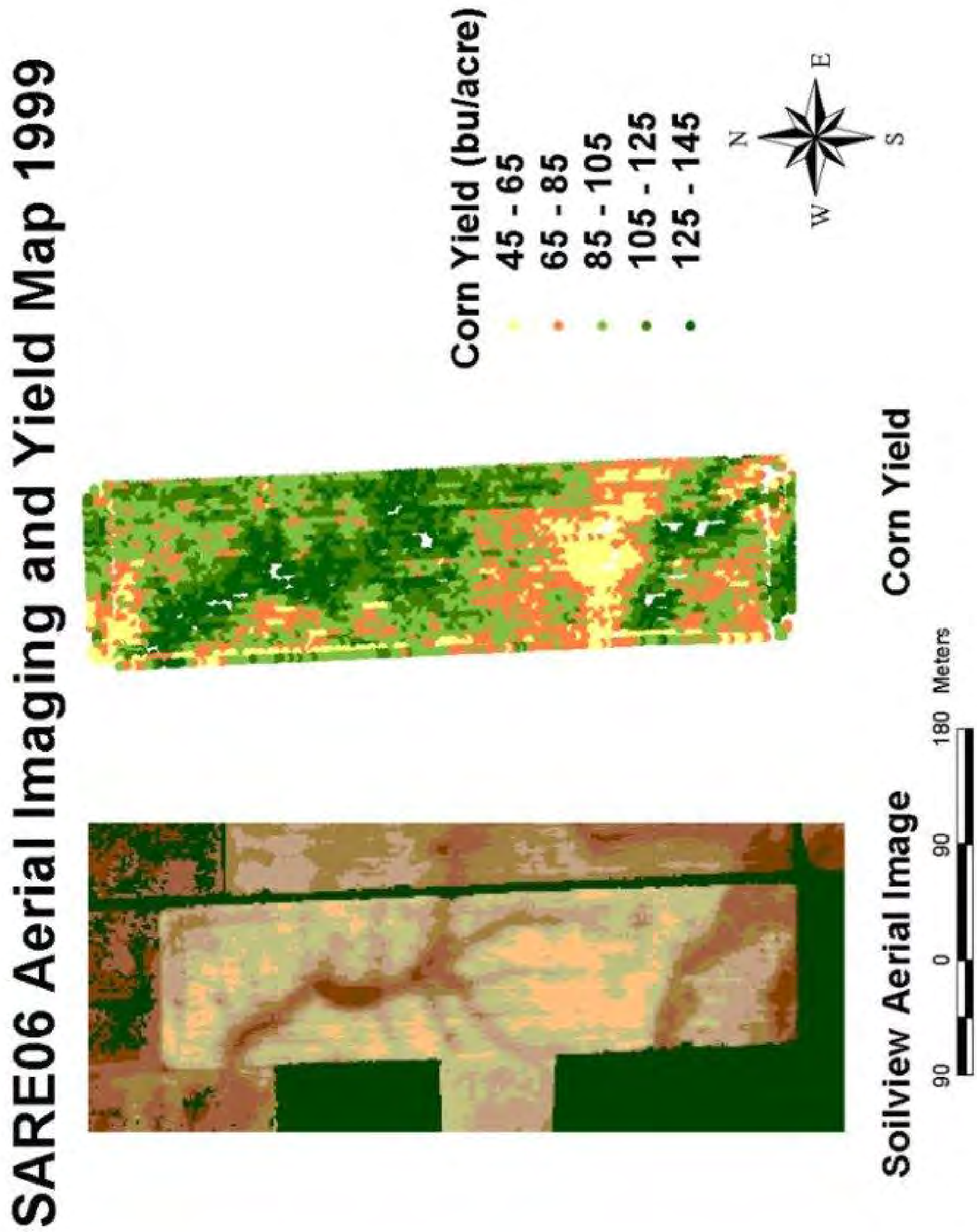
Vocabulary

Precision farming: Farming practices that use very specific information on very specific plots to reduce waste and maximize efficiency.
Efficiency: Maximum amount of benefit with the least overall cost or input.
Runoff: When inputs (like fertilizer and pesticides) are applied in excess and some of the excess flows off the field into streams.
Input: Refers to the resources like fertilizers, herbicides, insecticides and even the labor time that are applied to a field in order to grow a crop.

Background Resources

- GPS is used for "precision farming" to increase efficiency of use of field inputs (such as seed, fertilizer and pesticides) and for economic and environmental reasons. It can also be used to map crop yields and other information. Many other agricultural uses of GPS technology may be developed in the future.

Geospatial Science:
Precision Farming



Find this activity and more at: http://nys4h.cce.cornell.edu

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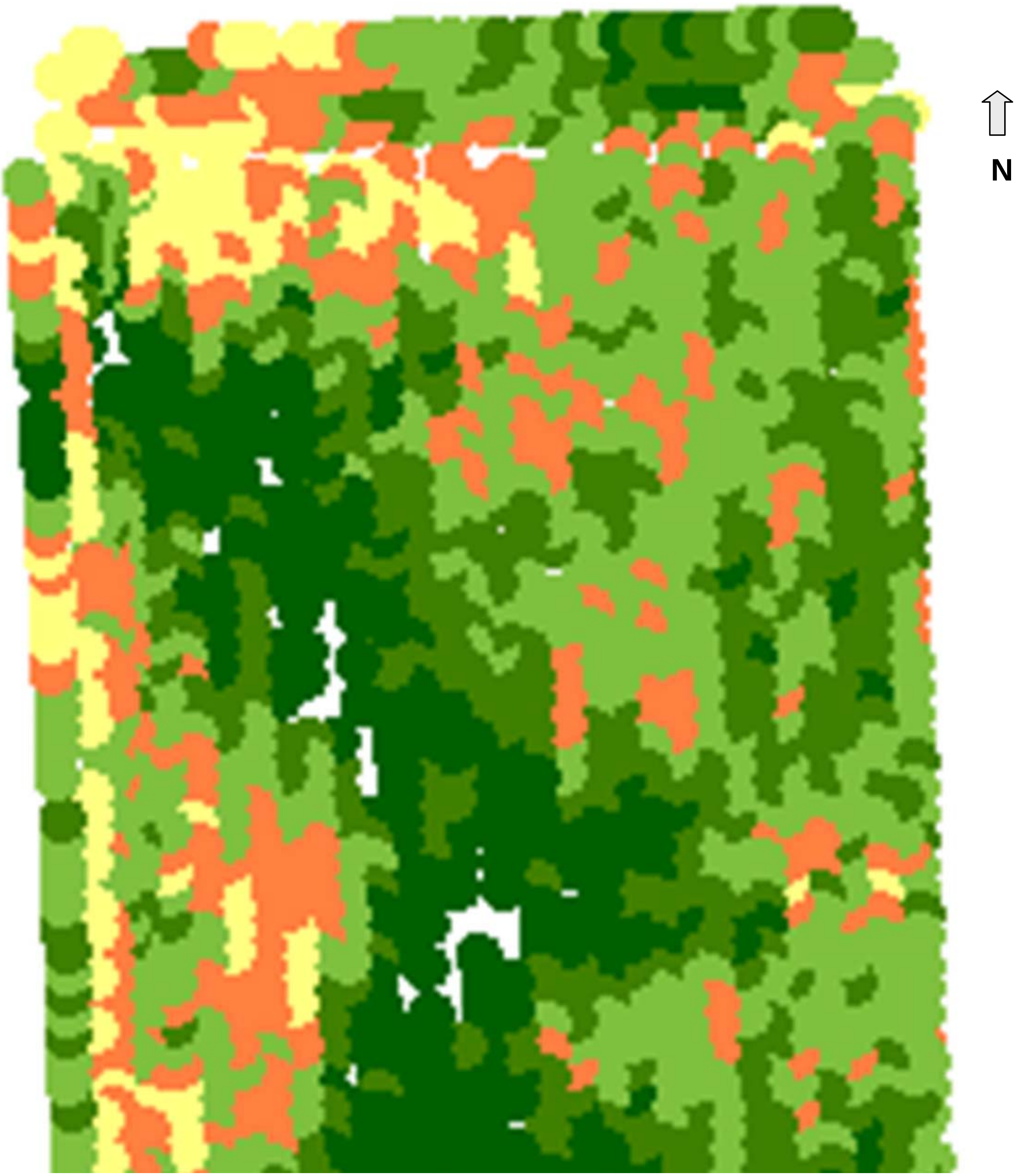
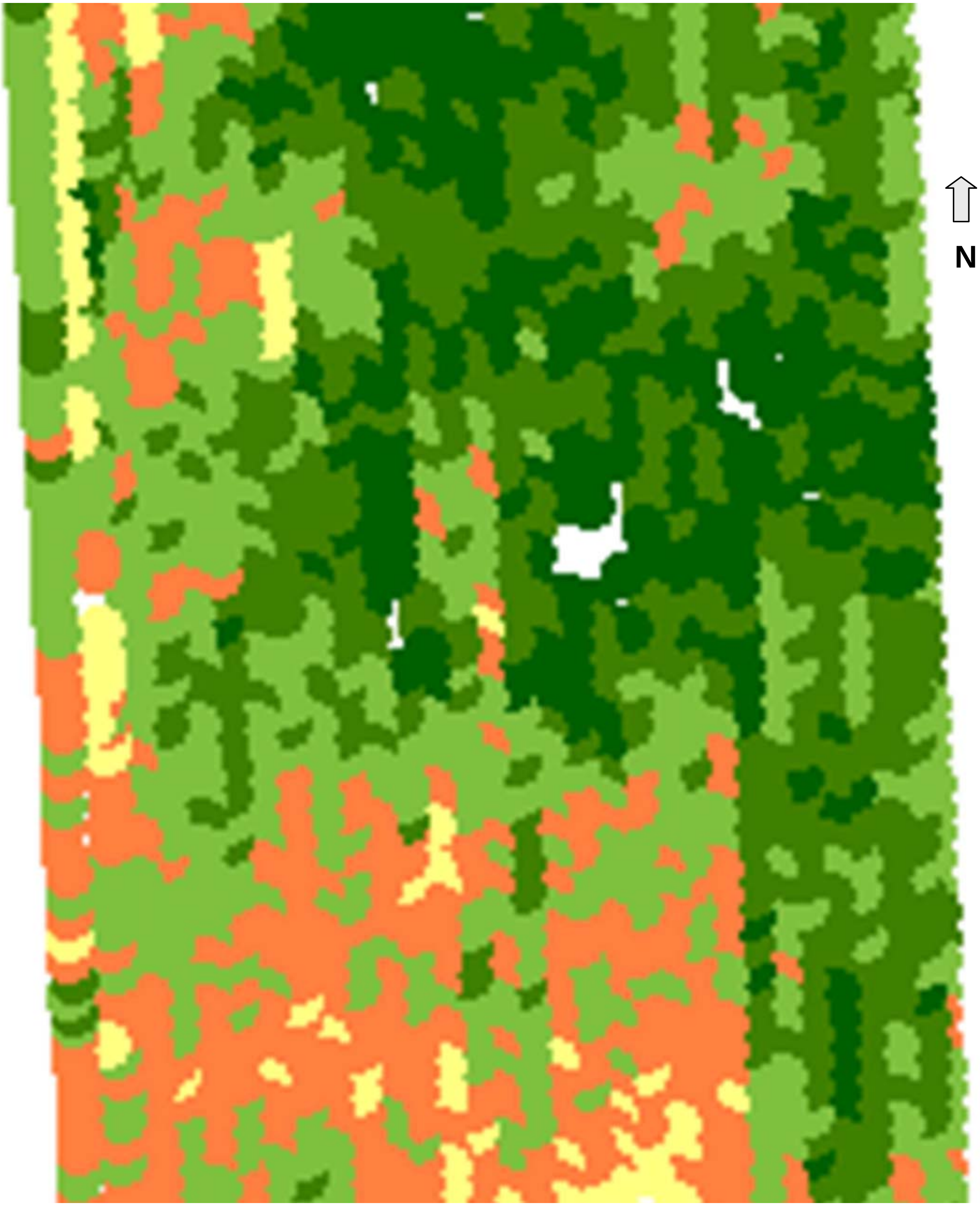
Geospatial Science:

Precision Farming

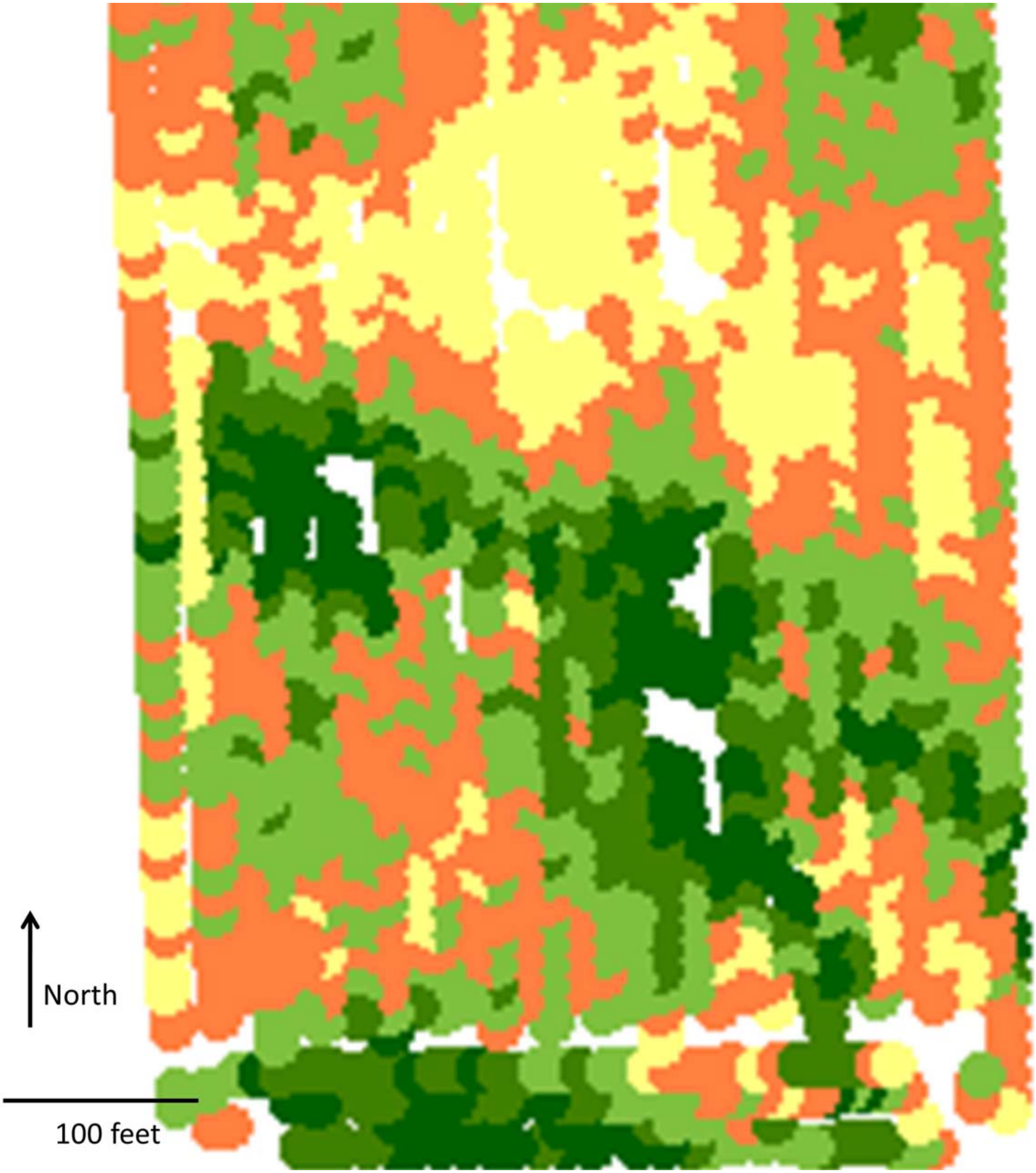


Geospatial Science:
Precision Farming



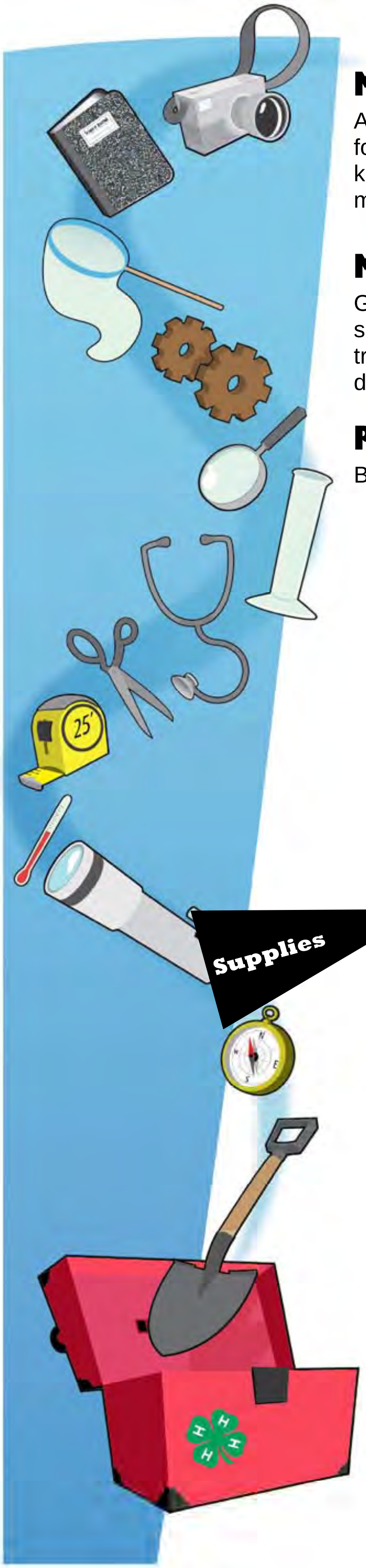
Geospatial Science:

Precision Farming



Geospatial Science:

Layers and Layers of Data



Main Idea

A Geographic Information System (GIS) is a computerized mapping tool for managing spatial data. This activity explores some of the background knowledge needed before using a GIS and demonstrates two of the primary capabilities of a GIS using maps.

Motivator

Geographic Information System tools are the driving force behind many services. The system is used for emergency response or 9-1-1 systems, tracking health crises such as flu outbreaks and organizing pickup and delivery routes, like those for school buses.

Pre-Activity Questions

Before you start the activity, ask the students:

- What kind of maps are you familiar with? (highway maps, trail maps, state and world maps, topographic maps)
- How do these map differ? (content, detail, scale)
- If you had two different maps of the same area, how would you put them together (or copy the data from one to the other)? (Possible answers: place one on top of another and trace the information if they are at the same scale; "eyeball" transfer information from one to the other if map scales are different.)

Activity 1: GIS controls orientation and scale of mapped data.

Supplies

- Danger Island Harbors map
- Trails map
- Markers
- 12" piece of string

Graybeard the Pirate has hidden his treasure on Danger Island. Two pirates have stolen copies of his maps and plan to steal the treasure. They arrive at Danger Island the same time from opposite directions (east and west) and are racing to the treasure chest.

On the Harbor Map:

1. Graybeard the Pirate never trusted anyone and devised ways to keep his treasure safe. One of these methods involved separating information about Danger Island into thematic maps. One thematic map is named "Trails" and shows only the trails for Danger Island. Both pirates have a copy of the trails map.
2. Another trick that Graybeard used was to change the orientation of his thematic maps. The "Trails" map has been rotated.

Activity Series: Geospatial Science
Grade: 3-6
Time: 60 min

Objectives

- Explore how geographic information systems allow map makers to combine data.

Learning Standards

(See Matrix)

Common SET Abilities 4-H projects address:

Predict
Hypothesize
Evaluate
State a Problem
Research Problem
Test
Problem Solve
Design Solutions
Develop Solutions
Measure
Collect Data
Draw/Design
Build/Construct
Use tools
Observe
Communicate
Organize
Infer
Question
Plan Investigation
Summarize
Invent
Interpret
Categorize
Model/Graph
Troubleshoot
Redesign
Optimize
Collaborate
Compare

Contributed By
NYS
4-H Geospatial Science Team
IRIS
Department of Crop and Soil Science

Geospatial Science:
Layers and Layers of Data

You must align the "Trails" map to the "Harbor" map and trace the trails onto the Harbor map.

3. Where do you think the treasure chest is? What are the map coordinates for the point? (east coordinates are J or K, north are 13 and 14)

   East: ____________
   North: ____________

4. Select the shortest route to the treasure chest for each pirate. The shortest route can be determined by using your string. Start at the harbor and lay the string out as you go along the path. Mark the string when you reach the location of the treasure. Using the same end to start, measure the trail from the other harbor the same way. Do you use more or less string? Another estimate of distance can be made by counting the number of grid cells (squares) that each trail touches. (Note: The "Danger Island Revealed" map shows trail distances. If you're counting cells, the answers should be A=26; B=23; C=15; D=18; E=30 and F=29.)
5. Which pirate do you think will reach the treasure first? (The pirate coming from the west has the shortest route, Trail C.)

Science Checkup - Questions you might ask to evaluate what was learned

- Where is "north" on the map? (Left when the map is oriented for reading)
- If you are facing north, in what directions are south, east, and west? (Behind you, to your right and to your left respectively.)
- Which pirate should get to the treasure chest first? Why? (The pirate coming from the west because the trail is shorter.)
- Which direction are they traveling? (East)
- Is it possible that the pirate traveling farther can get to the chest first? (Yes, if they are traveling faster.) What might make that possible? (This map does not include topography, which is elevation information. Topography information would show hills, valleys, ravines and other landforms that could hinder movement.)

Maps cannot show everything. The map maker has to decide what to show and what to ignore. That decision is influenced by the purpose of the map.

To make a good map you must be accurate with your orientation (north/south, east/west, left/right, up/down) and your scale (distance/size).

Activity 2: Scale and Overlay

A Geographic Information System can help when you're trying to combine maps — it helps when you need to change the size of a map (scale) or show one map on top of another (overlay).

Supplies

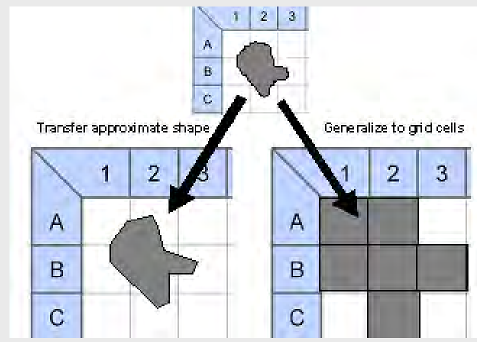
- Danger Island Harbors map
- Land Dangers map
- Markers

Geospatial Science:

Layers and Layers of Data

With the Land Dangers map:

1. As you now know, Graybeard the Pirate never trusted anyone, so he devised many ways to keep his treasure safe. In addition to the thematic map idea and rotating the map, Graybeard also made some of his thematic maps at different scales.
2. The pirate coming from the east has one of the danger maps called "Land Dangers," but it is at a different scale than the Harbor map. Note that the Harbor map has a grid of square cells printed on it. The "Land Dangers" map also has a grid on it of smaller cells. The cells on each map represent the same area on the island. This is the way Graybeard (and you) are able to "scale" one map to the other.
3. Rotate the "Land Dangers" map so that the island is orientated in the same direction as the Harbor map. Transfer the information from the dangers map to the Harbor map. You can use one of the two methods shown at right: 1) by coloring the cells on the Harbor map that match the Land Dangers map; or 2) by approximating the shape. Use different symbols for different dangers. This is similar to what a GIS does when it "overlays" data.
4. Now which route should the east pirate use to reach the treasure safely? (B or F)
5. Is the shortest route for the west pirate still a safe route? (No)



Science Checkup – Questions you might ask to evaluate what was learned

- ❑ Did the transfer method that you used make a difference in your results? (You should get the same results using either method.)
- ❑ When do you think it would make a difference how the transfer was done? (When the trails and danger areas only touched the same cell at locations far from each other.)
- ❑ Approximately how far is it across one grid cell on the "Land Dangers" map? (1 kilometer)
- ❑ Approximately how far is it across one grid cell on the "Danger Island Harbors" map? (1 kilometer)
- ❑ How much **area** is represented by one grid cell on both maps? (1 square kilometer)
- ❑ Do you know the accuracy of the representations of the danger areas? (No, there is no information about whether these areas are correctly drawn or located.

Activity 3: Alignment and Orientation

For a GIS to work correctly, all data must be aligned or oriented correctly.

Supplies

- ❑ Danger Island Harbors map with trails and dangers drawn in from Activities 1 & 2.
- ❑ Animal Dangers map (all grid labels). An *additional version of the Animal Dangers map (minimal grid labels) is included if you'd like to challenge your students.*
- ❑ Markers

4-H Science Toolkit

Geospatial Science:

Layers and Layers of Data

With the Animal Dangers map:

1. The west pirate also has another of Graybeard's maps called "Animal Dangers. It also has a grid of small cells on it that represent the same areas as on the Danger Island map.
2. Rotate the Animal Dangers map until you think it is oriented the same way as the larger grid of the Harbor map. Transfer the information from the Animal Dangers map to the Harbor map. Label the grid cells along each side with the appropriate number or letter. Use the same method as you did earlier: color the cells on the Harbor map to match the Animal Dangers map. Use different symbols (colors) for different dangers.
3. Is the east pirate following a safe route? (Only Trail F is safe.)
4. Now which route should each pirate use to reach the treasure safely? (The pirate from the east should use trail F and the pirate from the west should use trail E.)
5. The bad news for both pirates is that Graybeard did not make maps of all the dangers on the island. Only one of the routes is safe. What other dangers might exist on the island that could be put on thematic maps? (Poisonous plants or waterways could be other dangers.)

Science Checkup – Questions you might ask to evaluate what was learned

- Was it easier or harder to make this transfer? (The change of orientation and not having the islands shown make it harder.)
- How did you figure out what the correct orientation was? (One way would be to take an extreme location - for example, the crocodiles in the lower right, and see where that location would need to be on the Harbor map to occur on land.)
- Did you figure out how to label the grid cells? (Count the cells along the grid sides to determine the direction to label the cells.)

Vocabulary

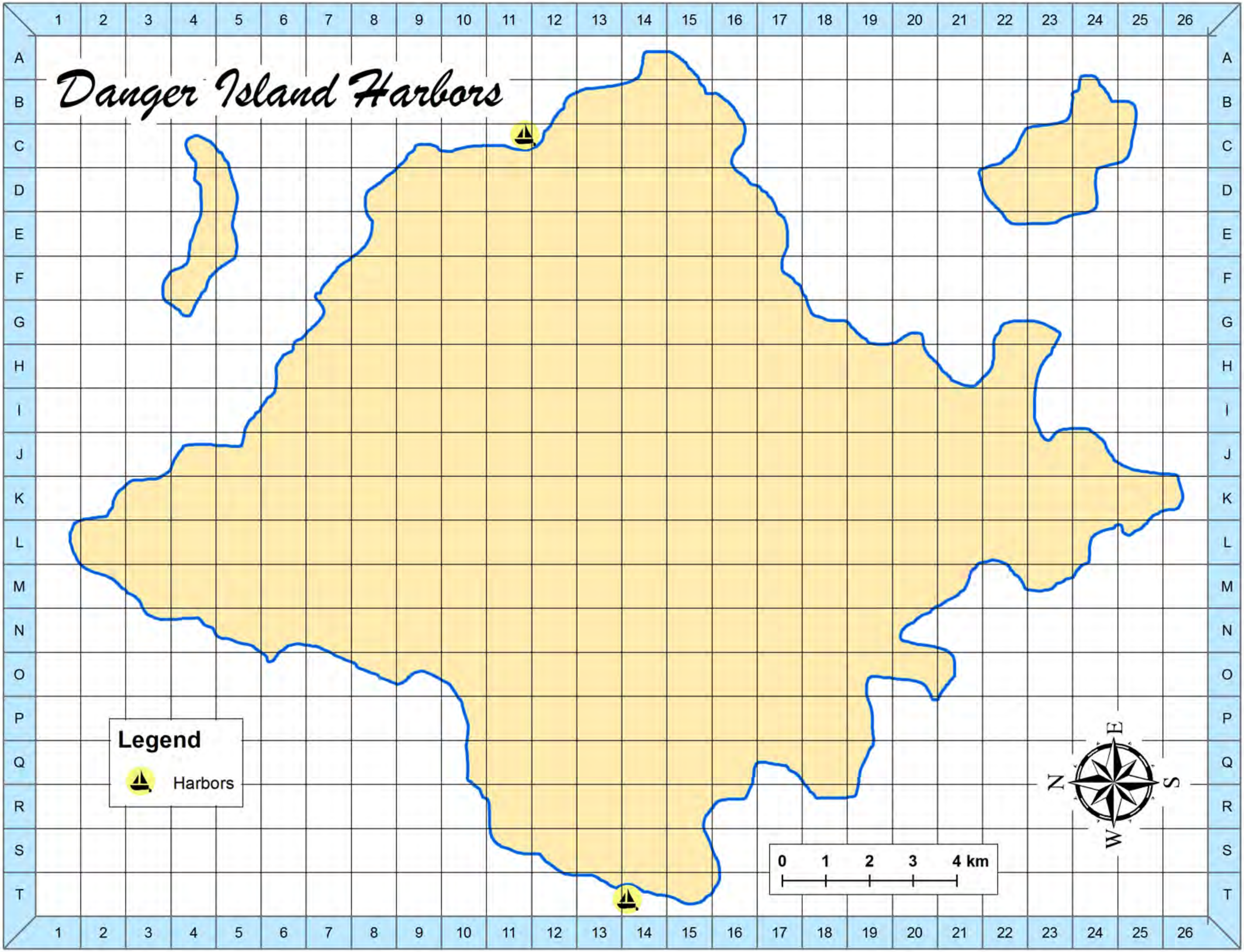
Coordinate system: A reference framework of points or lines used to define the location in space. The geographic coordinate system (latitude / longitude) used on the earth's surface is a common examples of a coordinate system.
Grid cell: The smallest unit of information in raster data or the area identified by intersecting coordinate lines. Each cell represents a portion of the earth, such as a square meter or square mile and usually has an attribute value associated with it, such as soil type or vegetation class.
Orientation: A map's orientation or north/south direction, should be shown. It is also important that if a coordinate system is available that it be identified. A north arrow does not give the reader any idea what part of the world is depicted in the map. Using and displaying a known coordinate system enables the reader to "fit" the map into its proper place in the world.
Overlay: The process of superimposing one map upon another, either digitally or on a transparent material, for the purpose of showing the relationships between features that occupy the same geographic space.
Scale: All maps are estimates of the real world. We try to make them as accurate as possible by drawing them to "scale" which means that a specific distance on the map consistently equals a specific real world distance.(e.g. 1 inch = 1 mile).
Scale change: The process of changing the scale of one map or data set to match another.
Thematic map: A thematic map shows pieces of information that share something in common For example: a thematic map of roads may contain many types of roads (e.g. divided highways, local streets, trails) but not contain streams or lakes. Thematic maps are often referred to as "layers" in a GIS.

Geospatial Science:
Layers and Layers of Data

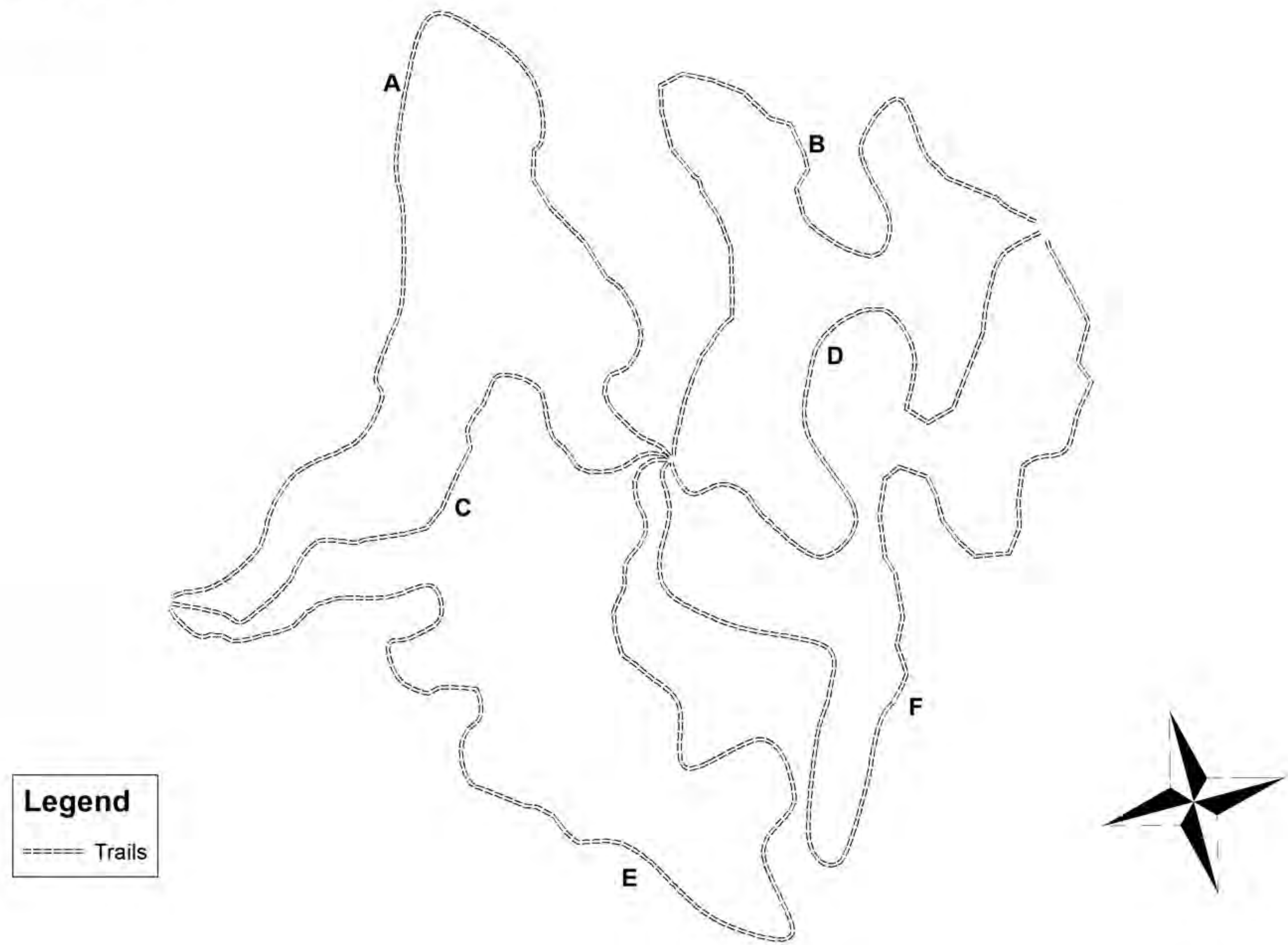
Background Resources

- ESRI, Inc.: http://www.gis.com
- GIS Lounge: http://www.GISlounge.com
- Thinking Spatially Using GIS, Napolean, E.J. and E.A. Brook, Our World GIS Education, Level 1, ESRI Press, 2008
- Mapping Our World: GIS Lessons for Educators, Malone, L. et. al., ESRI Press, 2005.

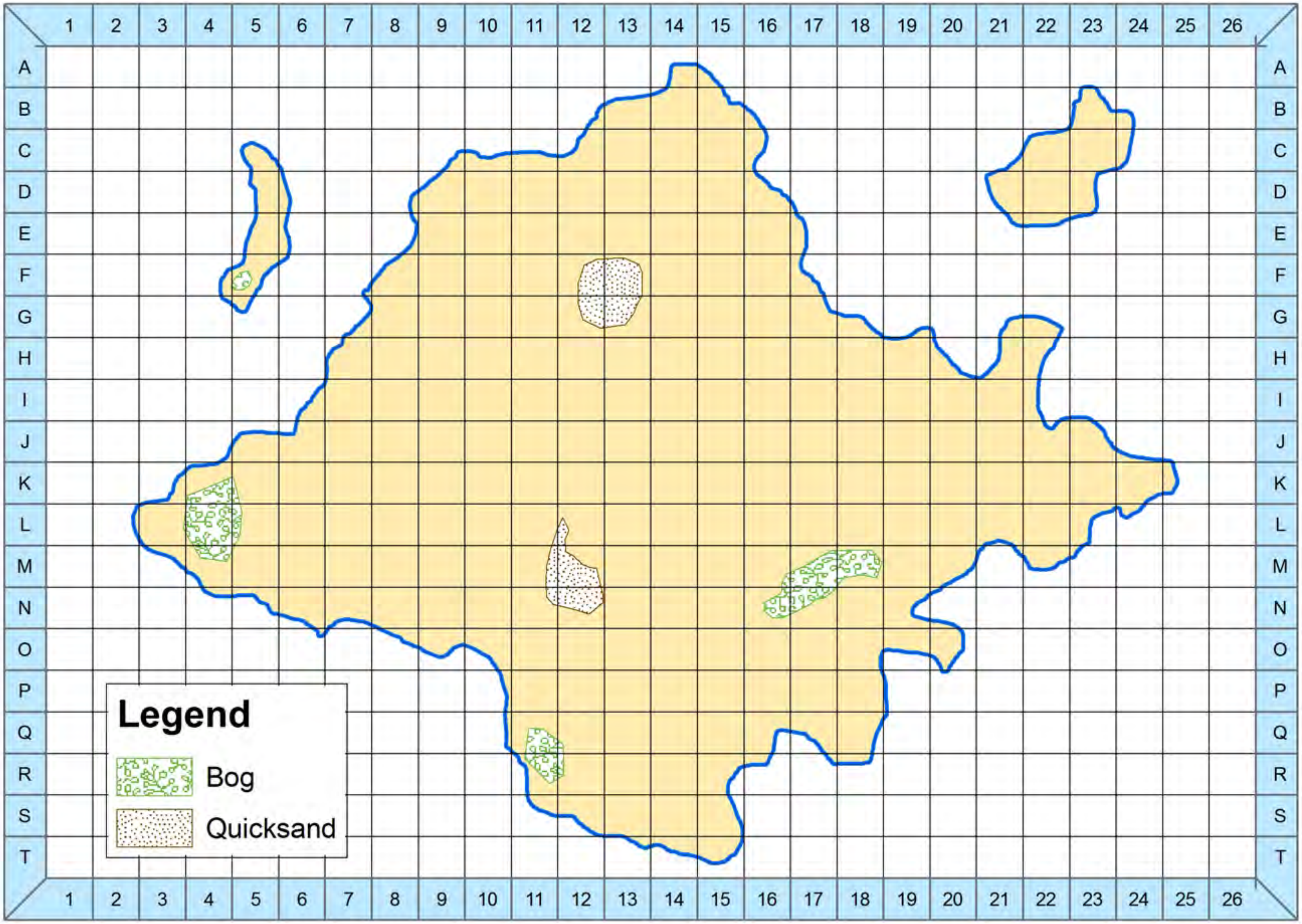
Guide to PDF pages


Danger Island Harbors
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
A B C D E F G H I J K L M N O P Q R S T
Legend
Harbors
0 1 2 3 4 km
N E S W

Trails

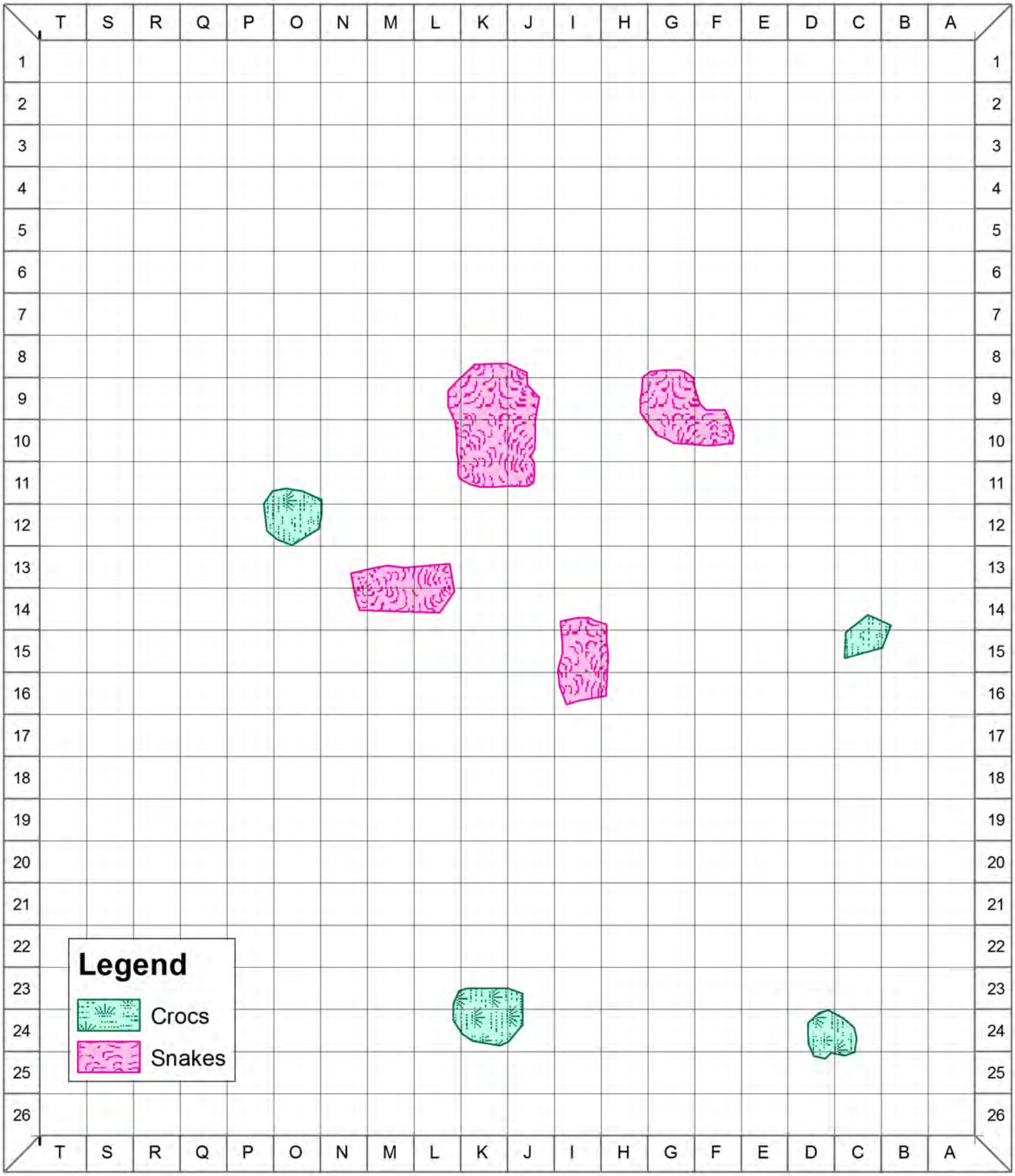


Land Dangers



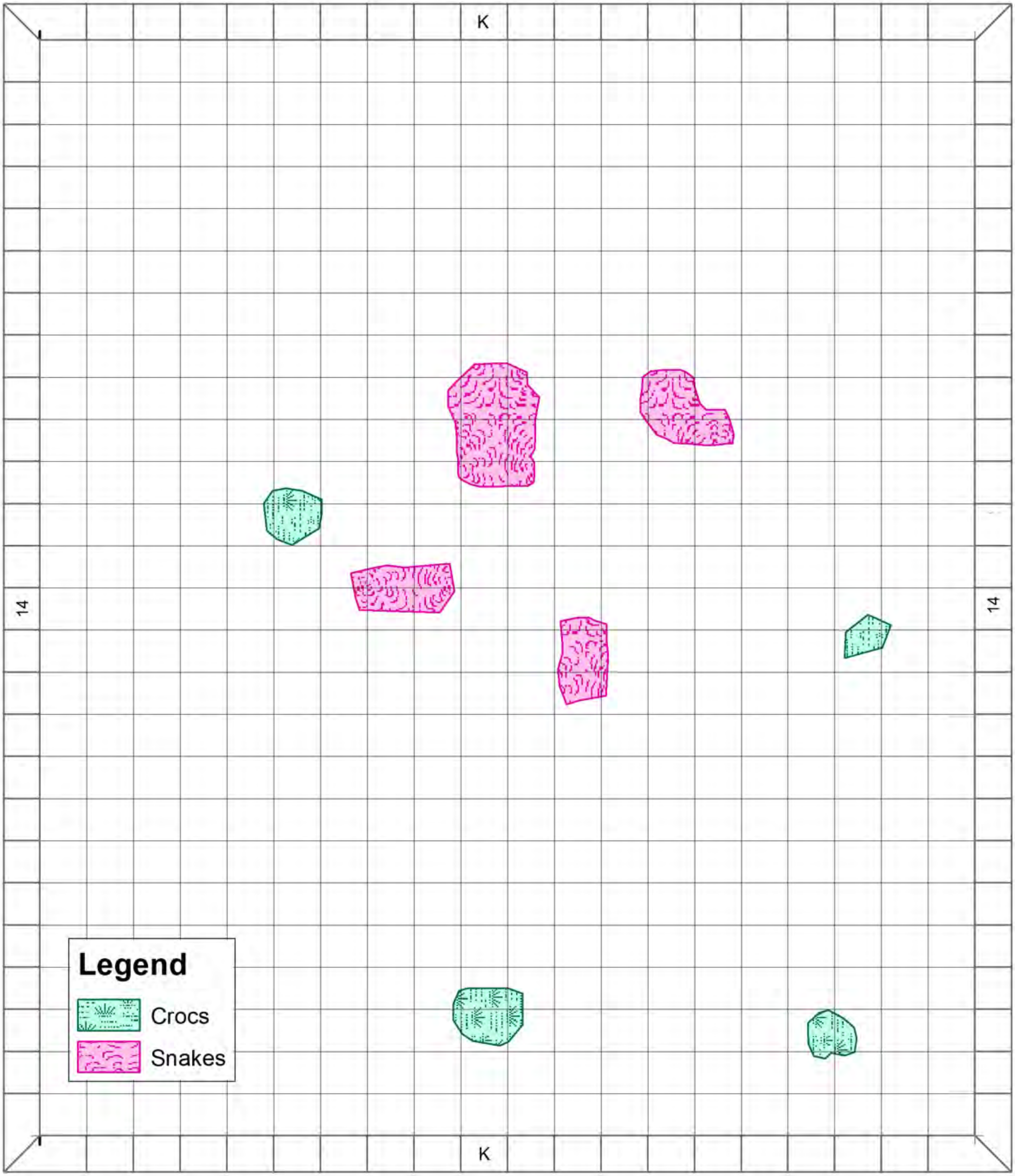
Step lightly me lads!

Animal Dangers

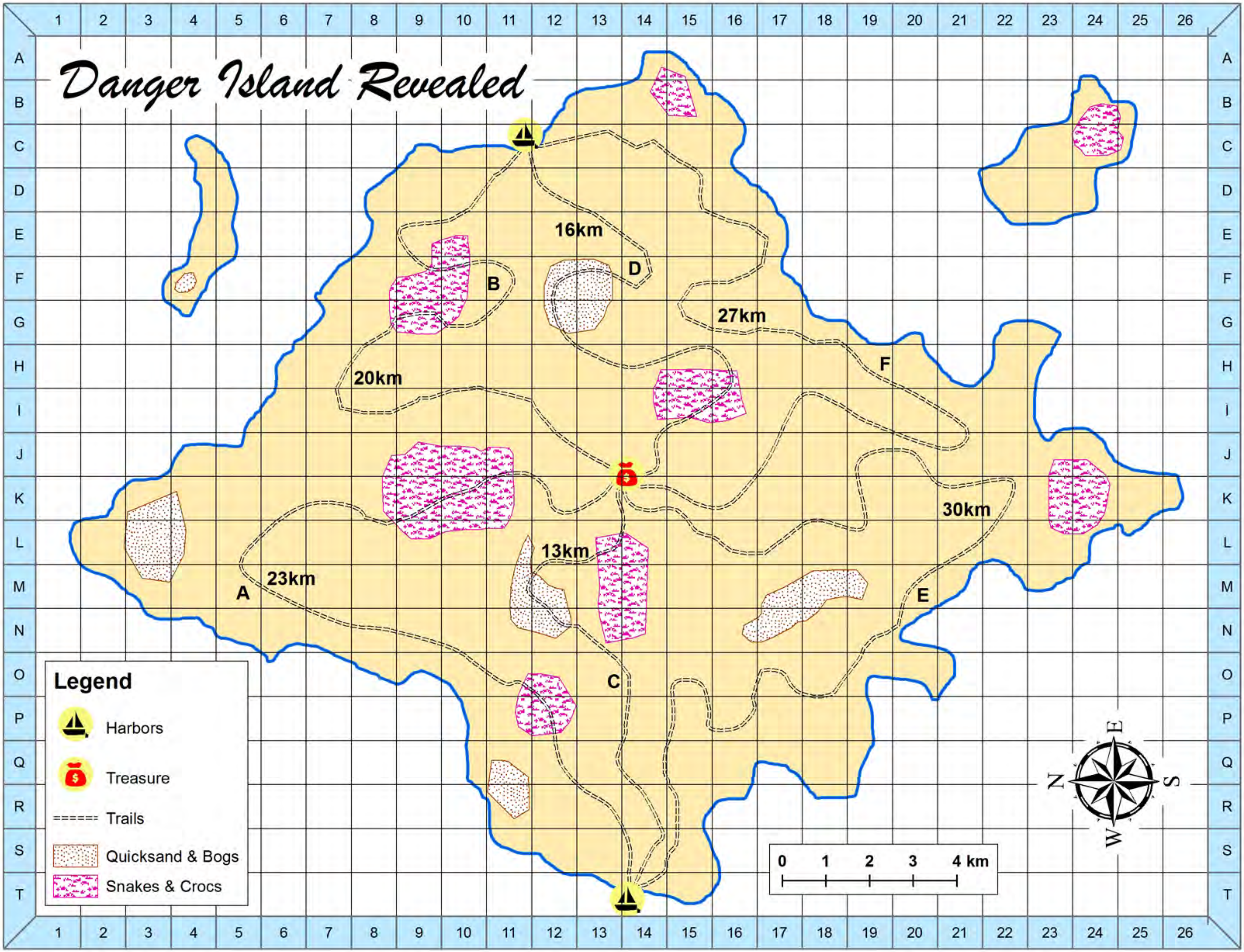


Only your eyes and ears can save you!

Animal Dangers



Only your eyes and ears can save you!



Danger Island Revealed
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
A B C D E F G H I J K L M N O P Q R S T
16km
20km
27km
13km
23km
30km
A
B
C
D
E
F
Legend
Harbors
Treasure
Trails
Quicksand & Bogs
Snakes & Crocs
0 1 2 3 4 km
N
E
S
W