Module 4, Investigation 3: Log 1
Gaining different perspectives

You will need
• colored pencils,
• lined paper (or graph paper), and
• a three-dimensional object (supplied by your teacher).

1. Place an object on the floor. Look at it from directly overhead. Sketch it.

This is an aerial view. Airplanes, satellites, the Space Shuttle, and the International Space Station can take aerial views of objects on Earth.

2. Place an object on a flat desk or table top. Stand to the side of the object. You should see both the top and one or two sides of the object. Sketch it. Add perspective to capture the shape more correctly.

This is an oblique view. Airplanes, satellites, the Space Shuttle, and the International Space Station can also take oblique views of objects on Earth.

3. Kneel or sit down so you are looking directly at the side of the object. You should not see the top of the object. Sketch it.

This is a ground-level view. Airplanes, satellites, the Space Shuttle, and the International Space Station do not take this type of view of Earth. It is what is typically seen by human eyes.
The Petén, Guatemala

The Petén, northern Guatemala, was once inhabited by a population of several million Maya before the population collapsed in the 9th century A.D. The 7th and 8th centuries were the height of the Mayan civilization; by 930 A.D. only a few scattered houses remained. Scientists think that at the time the population collapsed, the Maya had deforested much of their region. Now after centuries of regrowth, the Petén is the largest tropical forest in Central America, but once again, it is experiencing rapid deforestation as new settlers invade the area. The old sustainable techniques used by the native population are being abandoned in favor of more destructive monoculture and cattle raising. These new methods also contribute to the destruction and looting of unrecorded archeological sites.

Today remote sensing and geographic information system (GIS) analysis are used to address issues in Maya archeology as well as to monitor the effects of deforestation. The ancient Maya successfully adapted their agricultural methods to their environment, but even so, they finally overused their resources. Current inhabitants are threatening to do the same thing in less time with a smaller population. Scientists are using remote sensing and GIS to learn from the past to protect the resources of the future, but they cannot rely only on remotely sensed data. By studying remote sensing images of the Petén, scientists can see

- different types of vegetation,
- the pattern of deforestation,
- Mayan roads that lead to unrecorded sites, and sometimes
- archeological sites themselves.

Sometimes it is necessary to go to the jungle to verify what they see in the remote sensing images. This is called ground truthing.

Ground Truthing in the Petén

Ground-truth information, often referred to as “reference data,” involves the collection of measurements or observations about objects, areas, or phenomena that were remotely sensed. This ground-truth information can be used by social scientists in two ways: first, the data can aid in the interpretation, analysis, and validation of the remotely sensed data; second, it helps in understanding the socioeconomic forces behind human-produced, land-cover modifications.

Ground truthing is expensive and time consuming. In recent years, even though the cost of computer hardware and software for remote sensing has dropped, the costs of ground-truth activities have increased because airfare, lodging, vehicle rental, food, labor, and other costs have risen. Recent advances in GPS receivers and digital data field recorders have helped keep costs down because they make researchers much more efficient while they are in the field.

In order to create an accurate reference data set, scientists have to visit as many sites as possible in remote and rugged Petén. Typically, they change locations each day. They do not remain at a site or village to excavate archeological features—they simply map and verify their existence. Some of the challenges encountered by the field workers included logistical and communication problems,
equipment failure, poor map quality, physical
stress, and unfriendly local inhabitants. Once a
research team was captured and held at gunpoint
for several hours before being released.

Logistics are probably the biggest fieldwork prob-
lem. Often team members are the first profession-
als to visit an archeological site. A logistics coordi-
nator schedules, in advance, the jeeps, boats,
aircraft, mules, horses, and workers that will help
the team get to its destination. Since many areas
of the Petén do not have telephones, a Guatema-
lan team member must make arrangements for the
rentals with local people weeks or months in
advance. The more inaccessible the location, the
more difficult the arrangements. Once the logistics
have been coordinated, the field missions last two
to three weeks. As the mode of travel switches
from jeeps to boats to horses and mules, it is
critical that the dates, times, and locations be
arranged in advance so that the vehicles, guides,
and animals are there to help the team get to its
destination. Sometimes the team encounters road
and pathway hazards such as downed trees and
extremely muddy conditions.

Occasionally, teams are met with suspicion regard-
ing their true purpose. Teams have successfully
combated this situation by showing the local
residents a large number of satellite images,
explaining how the imagery is used, and by leaving
a copy with the local residents. Only through years
of exposure and word of mouth do teams gain
acceptance and support for their activities from the
local inhabitants. Many local people have become
so educated about satellite imagery and GPS units
that they can help teams interpret some of the
features and anomalies on the images. Having a
Guatemalan on the research team is a real benefit.

GPS measurements are very helpful to the field
researchers. In 1988, when there were fewer
satellites in orbit, and the receivers were not as
good, teams often found themselves climbing a
temple at midnight to determine their position
because the satellites were in position only be-
tween 1 and 4 a.m. In addition, the dense rain
forest vegetation sometimes interfered with the
satellites’ signals. Today readings can be taken at
any time. More satellites and better GPS receivers
allow field workers to collect more data with greater
accuracy, but even with all the latest technology,
there are still hazards.

One problem is the inaccuracy of available maps.
Often lakes, rivers, archeological sites, and cultural
features are not located where the map indicates.
If information from these inaccurate maps is
incorporated into a GIS, it will lead to faulty predic-
tions. This problem is solved by constantly com-
paring GPS measurements, imagery, and maps to
eliminate any errors. But even this doesn’t help
when the names on the maps are not the same as
those used by local inhabitants.

Protecting the Petén
As teams studied deforestation in the Petén, they
tried to distinguish between new forest clearings
and regrowth. They are now expanding their
activities to include information about the decisions
that lead to land-use change and land conversion.
Teams are in the process of interviewing local
farmers and ranchers to address the scientific
issues of deforestation rates and trends in land-use
conversion. Through the interviews, the scientists
hope to learn how farmers decide the amount of
land they convert to pasture or shifting to agricul-
ture, how they decide the amount of land they
cultivate and the amount they leave fallow, how
forest fragmentation affects the environment, what
are the spatial characteristics of cleared land, and
what are the socioeconomic characteristics of the
farmers. These data will be correlated to provide
better analytical information for future land-man-
agement decisions—and to help save archaeologi-
cal sites, known and unknown.
Module 4, Investigation 3: Log 2
Ground truthing in the Petén

Read Briefing 1. Check your understanding by answering these questions.

1. The Petén is a __________.
   a. city in Guatemala
   b. a tropical rain forest in Central America
   c. the name of a national park
   d. a temple

2. The Petén, today mostly uninhabited, was the home to __________ during 7th–9th centuries.
   a. Spanish conquistadors who conquered the native population
   b. many endangered animal species of the tropical rain forest
   c. the Aztec Indians
   d. several million Maya

3. Sites of this ancient culture are difficult to locate today because __________.
   a. the buildings were burned and left as rubble
   b. the buildings were made of wood and have long since decayed into the rain forest floor
   c. the tropical rain forest has grown over the buildings and paths and cannot be easily seen either on the ground (forest is too thick) nor from aerial photographs (vegetation covers it)
   d. new cities have been built over the old sites, and agricultural and industrial areas cover the ancient remains

4. Ground truthing means to __________.
   a. collect measurements, data, and objects in locations that were remotely sensed
   b. ask native populations in the region to tell the truth as they relate stories about the ancient culture
   c. look at maps and pictures of an area
   d. use many remotely sensed images of different types to gather information

5. Ground truthing is expensive and time consuming because__________.
   a. computers, used to record the data, are very expensive and difficult to carry
   b. costs of travel, lodging, guides, and food are expensive, and arrangements are not always easy to make
   c. geoarchaeologists must stop to excavate the site before continuing
   d. the remotely sensed images are expensive, and it takes years to learn how to interpret the image before you can ground truth it

Indicate whether the following statements are true or false.

_____ 6. Ground truthing aids in interpretation, analysis, and validation of the remotely sensed data.

_____ 7. Global positioning systems (GPS) provide flexibility and accuracy in pinpointing exact locations.

_____ 8. Following the ancient footpaths is an easy task since modern-day inhabitants have kept them clear for the tourists.

_____ 9. All native people welcome geoarchaeologists who ground truth because they bring new knowledge about the ancient inhabitants and their ancestors.

_____ 10. One problem with ground truthing is that local maps may be inaccurate.
Module 4, Investigation 3: Briefing 2
Ground truthing and the geography of sites

Objectives
In this part of the investigation you learn how and why a geoarchaeologist ground truths features detected on remotely sensed images. You match geographical information to archaeological sites and photographs of archaeological sites to aerial views.

Part I
Ground Truthing
A geoarchaeologist’s job is to discover and explain historical sites. After using remote sensing, the geoarchaeologist travels to the site to discover what is on the ground and to excavate (dig) for more information to assemble the pieces of history, geography, and culture. This process is called ground truthing. The geoarchaeologist matches remotely sensed data with exact features on the ground.

With global positioning systems, the objects and features can be accurately mapped. Photographs are taken to study geographical and cultural features.

By comparing locations and features on the ground with those in the image, geoarchaeologists are better able to interpret the remotely sensed images.

If an unknown feature appears on a remotely sensed image—say a rectangular red object—ground truthing may determine what it represents. If it is a temple, then other rectangular red objects on the same image are interpreted as temples.

The Geography of a Site
When traveling to a country to ground truth an image, geoarchaeologists need to know what conditions to expect. Climate influences how well sites may be preserved. A dry region preserves artifacts. A wet climate could encourage deterioration and vegetation that covers the features. On one ground-truthing expedition to Guatemala, geoarchaeologists reported accidentally finding ruins about three meters from the road. The vegetation was so thick they could not see the temple ruins from the road. Vegetation had also grown over the site so it was hidden from any airplane search. The temple was difficult to pinpoint on the remotely sensed image due to the scale and inaccuracy of the local maps. Researchers wondered how many other ruins they may have missed.

Knowing the terrain is also important when ground truthing. Geoarchaeologists need to know elevation and ruggedness to plan for special equipment or vegetation.
Part II

Types of Images

There are three types of images:

- **Ground-level views**—used to show how an object in an aerial view looks on the ground.
- **Oblique views**—may be taken from an angle (usually above), giving a partial side view of a site. The oblique view provides a sense of shape and features of buildings.
- **Aerial views**—taken from directly above allowing objects to be seen from the top down. The advantage of an aerial view is that you can see patterns not visible in a ground view.

Examples of Images

Below are three images taken of the Petén, a rain forest in Guatemala. The ground-level view provides a sense of the shapes and heights of the trees. The oblique view reveals a larger space with buildings. You see some features of the buildings (like steps), their sizes, the distances between them, and their relationship to one another. The aerial view shows a much larger region. No small features are clear, but there is a pattern showing the edge of the rain forest (the straight line between the light area and the darker green area).

A Ground-Level View    An Oblique View    An Aerial View

[Images of ground-level, oblique, and aerial views of the Petén]

http://www.ghcc.msfc.nasa.gov/archeology/peten.html
Module 4, Investigation 3: Log 3
Checking it out on the ground

Preparing to Visit a Site
Archaeological sites are located in these countries:
- Cambodia
- Oman
- Costa Rica
- Turkey
- Guatemala

Use an atlas to locate the five countries and complete the chart using information in the atlas to understand the physical geography of each country. For example, a climate map helps you identify the precipitation and temperature.

After completing the chart, analyze the photographs and remotely sensed images found in Log 4. Match each photo and image to a country below.

Using the information obtained from these data, complete the last column by listing supporting visual evidence. What information from the images did you use to ground truth?

<table>
<thead>
<tr>
<th></th>
<th>Climate/ Precipitation</th>
<th>Climate/ Temperature</th>
<th>Types and Quantity of Vegetation</th>
<th>Elevation/ Terrain</th>
<th>Ground-Truth Evidence</th>
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<tbody>
<tr>
<td>Cambodia</td>
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</table>
Module 4, Investigation 3: Log 4
Ground truthing

Matching Ground Photos with Historic Sites
Below are site photos taken at ground level or oblique angles. These are followed by aerial images and descriptions of the sites. Under the site description write the letter of the photo(s) that shows what feature is found at this site. You may want to consult an atlas to identify climatic conditions and vegetation in different regions to help you interpret which photos match which sites.

Photo A

Photo B

Photo C

Photo D

Photo E
Module 4, Investigation 3: Log 4
Ground truthing

Arenal Region, Costa Rica
TIMS image of footpaths

The people in this area appeared to live in small groups that adjusted to shifting living locations because of frequent volcanic eruptions. Footpaths wound through the hilly terrain.

The description of the Arenal Region matches Photo_________.

http://www.ghcc.msfc.nasa.gov/archeology/arenal.html

The Petén, Guatemala

This region is rich in Mayan history. Old buildings were found covered by dense rain forest. Several sites have been cleared and the structures rebuilt for tourists. Connected by footpaths, the cities have step pyramid temples with broad courts for games.

The description of the Petén matches Photo_________.

Deforestation in the Petén
http://www.ghcc.msfc.nasa.gov/archeology/peten_groundtruth.html

Ubar, Oman
SIR-C radar image

Ubar was an ancient city along the frankincense trade route. Although this area is very dry today, more water was available in ancient times. Water was stored in deep caverns, indicating periods when water supplies fluctuated.

The description of the Ubar matches Photo_________.

http://www.jpl.nasa.gov/radar/sircxsar/sc-ubar1.gif
Module 4, Investigation 3: Log 4

Ground truthing

This region is covered today by thick rain forest. Only radar penetrates the tree cover to reveal evidence of human occupation. This was once a city and religious center for at least one million Khmer people. They built temples that reflected both Hindu and Buddhist influence. There is evidence of an extensive irrigation system.

The description of the Angkor matches Photo_________.

This region was part of the ancient Greek and Roman Empires. At one time it was the best way to cross the Euphrates River. As transportation routes shifted farther south, this area lost its importance. The reservoir created behind the dam is expected to cover fields of pistachio trees and evidence of various empires.

The description of Zeugma matches Photo_________.

1. What do these sites have in common (besides being ancient)?

_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________

2. How does remote sensing help archaeologists find features common to all ancient sites?

_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________

http://www.csulb.edu/~kkeo/angkor/P024.html

Module 4, Investigation 3: Log 5
Writing your own ground-truthing log

Objective
In this part of the investigation you research an archaeological site and create a ground-truthing log to explain what is discovered at the site.

The regions listed below are well documented by remote sensing and ground-truthing photos. With a little research on Internet sites, your group will be able to create a ground-truthing trip and write a field log.

Imagine that your group has been sent on a one-week trip to ground truth the images of your selected site. Prepare a log, which includes the remotely sensed data, a map, and a description of your trip: where you went and what you found day by day. Describe the physical and human characteristics of the region and the evidence found of prior human occupation. Include photos, sketches, and descriptions of interviews and encounters with the local population. Be accurate.

Below is a sample field log model to get you started.

Sites to choose from:
• Chaco Canyon in New Mexico
• Arenal Region in Costa Rica
• Ubar in Oman
• Angkor in Cambodia
• Mirador in Guatemala
• Zeugma Project in Turkey

Our group was sent to ____________________________.

It is located at ____________________________________. (latitude/longitude)

Some objects/colors in the remotely sensed images we studied are:

Module 4, Investigation 3: Log 5
Writing your own ground-truthing log

Things we need to know before our trip:

Climate during this time of the year: ____________________________________________________
______________________________________________________________________________

Expected terrain: ___________________________________________________________________
______________________________________________________________________________

Vegetation: _______________________________________________________________________
______________________________________________________________________________

Native population, language, special cultural features: _________________________________
______________________________________________________________________________
______________________________________________________________________________

Our team member: ___________________________________________________________________
(include photos if you like)

Daily log (for one week from landing at the airport to leaving)
Include: what you did on each day
        what you looked for
        who you met
        who you interviewed
        what you discovered

Our trip was a success! We discovered _______________________________________________

References
Angkor, Cambodia
Photos: http://www.csulb.edu/~kkeo/angkor/P024.html

Arenal Region, Costa Rica
http://www.ghcc.msfc.nasa.gov/archeology/arenal.html
Photo: http://www.ghcc.msfc.nasa.gov/archeology/arenal.html

Chaco Canyon, New Mexico
http://www.ghcc.msfc.nasa.gov/archeology/chaco_compare.html

Baker Aerial Archaeology’s Chaco Project

Chaco Canyon endangered
http://members.aol.com/mjhinton/chaco/chaconews.htm

Chaco Culture National Historical Park
http://www.cr.nps.gov/worldheritage/chaco.htm
http://www.nps.gov/chcu/roads.htm

The Petén, Guatemala
http://www.ghcc.msfc.nasa.gov/archeology/peten.html
http://www.ghcc.msfc.nasa.gov/archeology/peten_deforest.html
Photos: http://www.ghcc.msfc.nasa.gov/archeology/peten_groundtruth.html

Ubar, Oman
Photos: http://observe.ivv.nasa.gov/nasa/exhibits/ubar/ubar_4.html

Zeugma, Turkey
http://www.ist.lu/zeugma
http://www.bbc.co.uk/science/horizon/Zeugma_info.shtml
Remote sensing is used to help geoarchaeologists locate sites of past human occupations. Scientists continue to improve ways of enhancing images to better detect human and physical features.

Write answers to the following questions in the spaces below. If you have completed one or more of the investigations, include information from them to help you answer the question.

1. How does remote sensing help the search for archaeological sites?

_______________________________________________________________________________
_______________________________________________________________________________
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2. How and why is geography important to understanding remotely sensed images and archaeological sites?

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