Manual Land Cover Mapping Learning Activity

Purpose

To produce a land cover type map of the 15 km x 15 km GLOBE Study Site from hard copies of Landsat satellite images

Overview

Students place clear transparencies over the Landsat images and use markers to outline and classify areas of different land cover using the MUC System. Students use their local expertise of their GLOBE Study Site and their Sample Site measurements to create and assess the accuracy of their maps.

Student Outcomes

Students learn how to interpret Landsat images and learn about the different types of land cover in their GLOBE Study Site. Students gain a spatial or landscape perspective of their local area.

Science Concepts

Geography

> The characteristics and spatial distribution of ecosystems
> Show how humans modify the environment

Scientific Inquiry Abilities

> Classify land cover and create a land cover type map.
> Evaluate the accuracy of land cover maps.
> Identify answerable questions.
> Design and conduct scientific investigations.
> Use appropriate mathematics to analyze data.
> Develop descriptions and predictions using evidence.
> Recognize and analyze alternative explanations.
> Communicate procedures, descriptions, and predictions.

Level

All

Time

Several class periods

Frequency

One time, but may be an iterative process as you progressively investigate more areas within your GLOBE Study Site

Materials and Tools

> True-color, printed Landsat image of the 15 x 15 km GLOBE Study Site
> False-color, infrared printed Landsat TM image of the 15 km x 15 km GLOBE Study Site
> Topographic maps of your area (if available)
> Aerial photos of your area (if available)
> *MUC Field Guide* or *MUC System Table* and *MUC Glossary of Terms*
> Color photocopier (if available)
> Clear plastic sheets or blank transparencies
> Tape
> Fine-point felt-tipped or transparency permanent markers
> *Manual Mapping: A Tutorial for the Beverly, MA Image*
> *Getting to Know Your Difference/Error Matrix Field Guide*

Preparation

Make color copies of the satellite images, if possible.

Make transparencies of a topographic map or other maps of the GLOBE Study Site (if possible, they should be the same scale as the satellite image.)

Review the MUC System.

Accuracy Assessment Tutorial

Manual Land Cover Mapping Learning Activity – Introduction

Look at the true color satellite image that your teacher has of your GLOBE Study Site. What different colors do you see? What do you think these colors mean? Compare the false color infrared image to the true color. Are the areas that are only one color in the true color image the same size and shape in the false color? What kind of land cover do you think the blue and black colors are? What kind of land cover do you think white or grays are? What is green in the true color image? Find a green area on the true color image; what color is that area in the false color image? What do the different shades of green in the true-color image represent? How is this land cover type represented in the false-color image? Repeat this with the other colors. Try to find your school in the image…it should look like a white or gray set of squares in the center of the image. Are there major roads in the image? What do they look like? Try to make a table (like the one below) that matches each of the different colors and their land cover types.

Work on your own or with a partner. Come up with a list of questions that you would like to answer about the satellite image of your area. From this list, or one that you generate as a class, pick one question that you will try to answer when you create a map from the satellite image. The question can have one or many parts.

The procedure GLOBE students use mimics what scientists do. Scientists ask questions about their images then use a computer version of manual mapping to answer them. This process is called *image interpretation*. *Image interpretation* is translating what you see on a printed image. The computer version of land cover mapping in GLOBE is the *Computer-aided Land Cover Mapping Learning Activity*. Scientists also use information that they have gathered in the field to label areas on the image. In GLOBE, this part of the data collection is known as the *Land Cover Sample Site Protocol*. Once you have collected many Land Cover Sample Sites, you can perform an accuracy assessment on your map to see how well you classified the land cover in your GLOBE Study Site. There is an *Accuracy Assessment Tutorial* in the *Appendix*, which will walk you through the steps.

The land cover maps made by GLOBE students can be used to help scientists' with their mapping efforts. Some GLOBE student maps can be used to help assess new satellite products (e.g., NASA's EOS satellites).

True-Color Image Color	False-Color Image Color	Type of Land Cover (I think)
Example: White	Example: White	Example: My School - Buildings

Teacher Support

The Measurement

Land cover type mapping is a subjective process where you and your students will have to use your knowledge of your GLOBE Study Site to interpret its image. Although this can be a daunting prospect at first, you will find that once you start looking at an image and identifying areas you know, it does become easier. You will be left to identify smaller and smaller areas as you continue the process. Just as scientists collect land cover data in the field in order to label their maps, you and your students should plan to visit sites that cannot be identified using your own knowledge, topographic maps and aerial photos. In those areas, you should carry out the *Land Cover Sample Site Protocol* and report the data to GLOBE. When you have completed your land cover map, feel free to share it with collaborating schools, local government officials and with the GLOBE community via your schools page on the GLOBE website.

The next step is to see how well your students classified the image by carrying out an accuracy assessment using additional *Land Cover Sample Site* data and the *Accuracy Assessment Tutorial*. From here, you can either work on improving the accuracy of your map or see how much change has occurred in your GLOBE Study Site by comparing your older image to a newer image. This comparison can be done using the *Change Detection Protocol*.

Teacher Follow-Up: Once all the areas on the image are identified, transfer the MUC identifications onto a master (paper) copy. Scan the completed map and save it on your school's computer to create a digital copy available for sharing with others.

Supporting Measurements

It may be necessary to carry out the *Land Cover Sample Site Protocol* at some sites where the MUC class is unknown. Some of the *Biometry Protocol* measurements may be necessary at these sites.

Student Preparation

Students should spend time discussing what they see in the Landsat images. They should relate their observations to maps, aerial photos, and their own knowledge of the area.

Students must be familiar with the MUC system, and should discuss the type of land covers that are commonly found in their area.

Helpful Hints:

- Discuss and identify local examples of land cover types, review topographic maps, and discuss mapping and classification before beginning.
- You and your students do not have to label the entire GLOBE Study Site at once. Label areas as you become familiar with them. This may be carried out by other classes in subsequent years as well.
- This method is less accurate than others are because it is more subjective. Students must be careful and specific when outlining areas and assigning MUC classes.
- Have students begin by identifying the most obvious features - usually bodies of water and urban areas - and then progress to more difficult types, such as different types of natural vegetative cover.
- Sometimes cloud shadows resemble lakes and ponds. (See the Beverly, MA image for practice identifying clouds.)
- Use both the true color and false-color images since some types of land cover will be easier to distinguish in the false color and others will be easier to distinguish in the true-color.
- You will need to field-check areas where you cannot identify the type of land cover. Use the *Land Cover Sample Site Protocol*.
- You can also enlarge different parts of the printed image using a color photocopier or have it done at a local copy center. Have groups of students work on a small part of the image. Piece the image back together for final analysis. Once each group has mapped their section, combine

the sections and compare results (especially along the edges) to identify problem areas. If groups of students differ in their labeling of a specific area, they must work out a method of reaching consensus.

- The Landsat image you use may be a few years old. Land cover may have changed since the image was acquired. What you identify on the Landsat image may be different than what you see in your ground assessments. In this case, students should work to determine what was on the ground at the time the satellite recorded the image data.
- If students cannot identify a specific area, have a class discussion to decide its MUC class.

In addition to the color of pixels in a Landsat image, there are a number of keys to help you interpret the land cover types in your image. These keys include shape, size, location, association, and texture. What keys you use depend on the features in your image. Below are some examples of how the keys can be used.

Shape: Agricultural areas tend to have abrupt linear edges and geometric shapes like rectangles and squares. Streams are linear features that can have many bends and curves. Roads frequently have fewer curves than streams.

Size: Major highways and rivers can be distinguished from smaller roads and tributaries.

Topographic or geographic location: If you are in a location with mountains and valleys, forested areas will tend to be on the mountainous areas with steeper slopes, while grassland and agricultural areas will be within the valleys. Since Landsat images are acquired in the morning, hillsides opposite the Sun may be in shadow.

Association: A vegetated area within an urban setting may be a park or cemetery. Wetlands may be located next to rivers, lakes or estuaries. Commercial centers will be located next to major roads, railroads, or waterways.

Texture: In a false-color image, commercial areas often will be consistently light blue or white. Residential areas, however, may have a speckled appearance of light blue/white and red. The light blue/white indicates buildings and pavement, and the red indicates the grass and trees that may line the streets and surround individual dwellings.

Questions for Further Investigation

What is the dominant land cover type in your area?

How many different land cover types are there in your GLOBE Study Site?

What land cover types look similar? Why?

How do the land cover types in your area affect the air temperature near the surface of the ground? Where in your GLOBE Study Site would you find cooler air temperatures on a warm, sunny day?

Do you expect much surface run-off from precipitation in the dominant land cover types in your area? Why?

If you had never visited your area but had a Landsat image, what aspects of the local environment would you perceive correctly and what would you not be able to perceive?

What could you do to improve your overall accuracy?

How accurate is your map if someone wanted to find a good place to have a picnic in the woods?

How accurate is your map if you wanted to see how many times you correctly identified a park or playing field?

How could next year's class use your data to create a better student classified map?

If you live in coastal or estuarine areas, how would the position of the tides (high or low) affect your land cover mapping?

How would the time of year your satellite image was acquired affect land cover mapping in your part of the world?

What other conditions at the time your image was acquired might influence your land cover mapping?

How do land cover and soil relate across your GLOBE Study Site?

Manual Land Cover Mapping Learning Activity

Field Guide

Task

Create a land cover type map by identifying the areas of different land cover in hard copies of true-color and false-color infrared Landsat satellite images.

What You Need

❑ Manual Mapping: A Tutorial for the Beverly, MA Image

❑ True-color and False-color Infrared prints of Landsat image of the 15 km x 15 km GLOBE Study Site or color copies of the GLOBE Study Site

❑ Blank transparencies or plastic sheets

❑ Tape

❑ Local topographic maps or transparencies of local topographic maps

❑ Fine point felt-tipped permanent markers

❑ MUC Field Guide or MUC System Table and MUC Glossary of Terms

What To Do

1. Tape a blank transparency sheet over the false-color infrared satellite image.
2. Mark the corners of the satellite image and label the top of the image on your blank transparency. If it moves, you can put it back where it belongs using these marked corners. This will also allow you to move the transparency to the true-color image.
3. Outline areas of similar land cover using the markers. If you have enough colors, use a different color to represent each area that you feel is a distinctive land cover type.
4. Assign each area a MUC class from the *MUC Field Guide* or *MUC System Table* and *MUC Glossary of Terms*, using your knowledge of the area.
5. If you cannot label an area, discuss the best possible choice of land cover type with your classmates or ask a person in your class who lives near the area to visit it on their way to or from school.
6. If there are any areas left to identify, visit the site and perform the *Land Cover Sample Site Protocol*.
7. Label the map completely. It may help to place the transparency on a blank, white sheet of paper to check for unlabeled areas.

Some hints to help with false-color infrared images:

- Red represents actively growing green vegetation (pink areas often represent grasslands, bright red represents hardwoods and fields, dark red represents evergreens).
- Black represents water or a cloud shadow.
- Blue–white represents urban areas, exposed rock, sand, and bare soils.

Frequently Asked Questions

1. What if I cannot identify a vegetated land cover type from the image to all four levels of MUC?

If you cannot identify the entire MUC class for an area, you will need to visit this area and use the *Land Cover Sample Site Protocol* and any necessary biometry measurements to complete the MUC identification.

2. What if two groups disagree on the MUC value of an area in our image?

If groups cannot agree on the MUC value of an area, you will need to carry out the *Land Cover Sample Site Protocol* and any biometry measurements necessary to settle the disagreement, unless you know someone who lives nearby who can validate the ground cover there.

3. What do we do if there is an area in our image for which nobody knows the MUC value?

Again, the only way to know for certain is to visit the site and collect field data.

4. We have a water body that is not black, but green, or even brown. What does this mean?

In both true color and false-color infrared images, water is normally black. An exception is the very clear water found in parts of the Caribbean. If your water appears brown, green or grey, it usually indicates that there is some material on the surface of the water. This may be plant growth, or suspended sediment that is being transported by the water.

Manual Mapping Learning Activity –Looking at the Data

Are the data reasonable?

After creating a land cover map from your Landsat image, you should determine whether the types of land cover that you identified are reasonable and accurate for the area that you live in. For instance, if you are located in a mid-latitude temperate climate, does your map include land cover types only found in the equatorial tropical zone? Does it make sense to have land cover types only found in extremely dry desert-like areas? Do you have classes for mountainous areas when you are located in a coastal lowland? Ask yourself questions like these about your own land cover type map. Check the MUC classes and definitions to determine whether the land cover classes in your map make sense for your GLOBE Study Site.

Next, look at where each of these land cover types are located on your map. Using your knowledge of the area and other sources of information like a print-out of your Landsat image, topographic maps and aerial photos (if available), do the locations of the land cover types make sense? If not, which land cover types do not make sense?

After looking at your map and seeing whether it is reasonable, you are now ready to perform a quantitative accuracy assessment. The *Accuracy Assessment Tutorial* (found in the *Appendix*) provides an example showing how to organize your data and perform the accuracy assessment.

What do scientists look for in these data?

Remote sensing scientists do not have one acceptable overall accuracy percentage to guide them when making a map from satellite imagery. Required accuracy levels depend on the objective of the map. It is very interesting to study the error matrix and observe what land cover classes are being confused with each other. All errors are not equal. In most cases, it would be far worse to label an area as water when it is conifer forest than it would be to label a conifer woodland as a conifer forest. In addition, remote sensing scientists try to improve their maps using the information gained in the error matrix. These attempts may involve collecting more land cover data to assist in the mapping, studying the spectral response patterns of land cover types, and/or applying different classification techniques. Land cover mapping from satellite imagery is often an iterative process and accuracy assessment can take place many times before a final map is achieved. Once scientists have an assessed map, they use it to answer the questions they set out to answer. They may compare the amounts and locations of natural and developed areas, the percentages of land cover types that are important to the community such as agriculture, wetlands, transportation, recreation areas, etc. or specific locations of habitats they are studying.

An Example of Student Inquiry

A group of 12 students living in Washington, DC, United States set out to create a land cover map of their area. They looked at the Landsat image of their GLOBE Study Site and decided that the map would get finished faster if they divided the Landsat image into four parts. The 12 students formed four groups of three students each. Each group was responsible for labeling all the different land cover types for the section of the image assigned to them. After completing the sections, the four parts would be put back together to create one map of the entire GLOBE Study Site.

Their teacher used MultiSpec software to divide the image into four parts and used a color printer to print each part on a separate sheet of paper. She decided to enlarge the image this way because she was familiar with the software and had access to a color printer. Otherwise she would have enlarged the image using a color copier.

Group A had the southwest quadrant of their GLOBE Study Site. After reviewing *Manual Mapping: A Tutorial for the Beverly, MA, Image*, the students in Group A examined the image of their section. Two of the students identified where they lived. The other student lived in a different part of the city. The students used a topographic map and a tourist map to help identify the MUC classes of the different

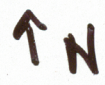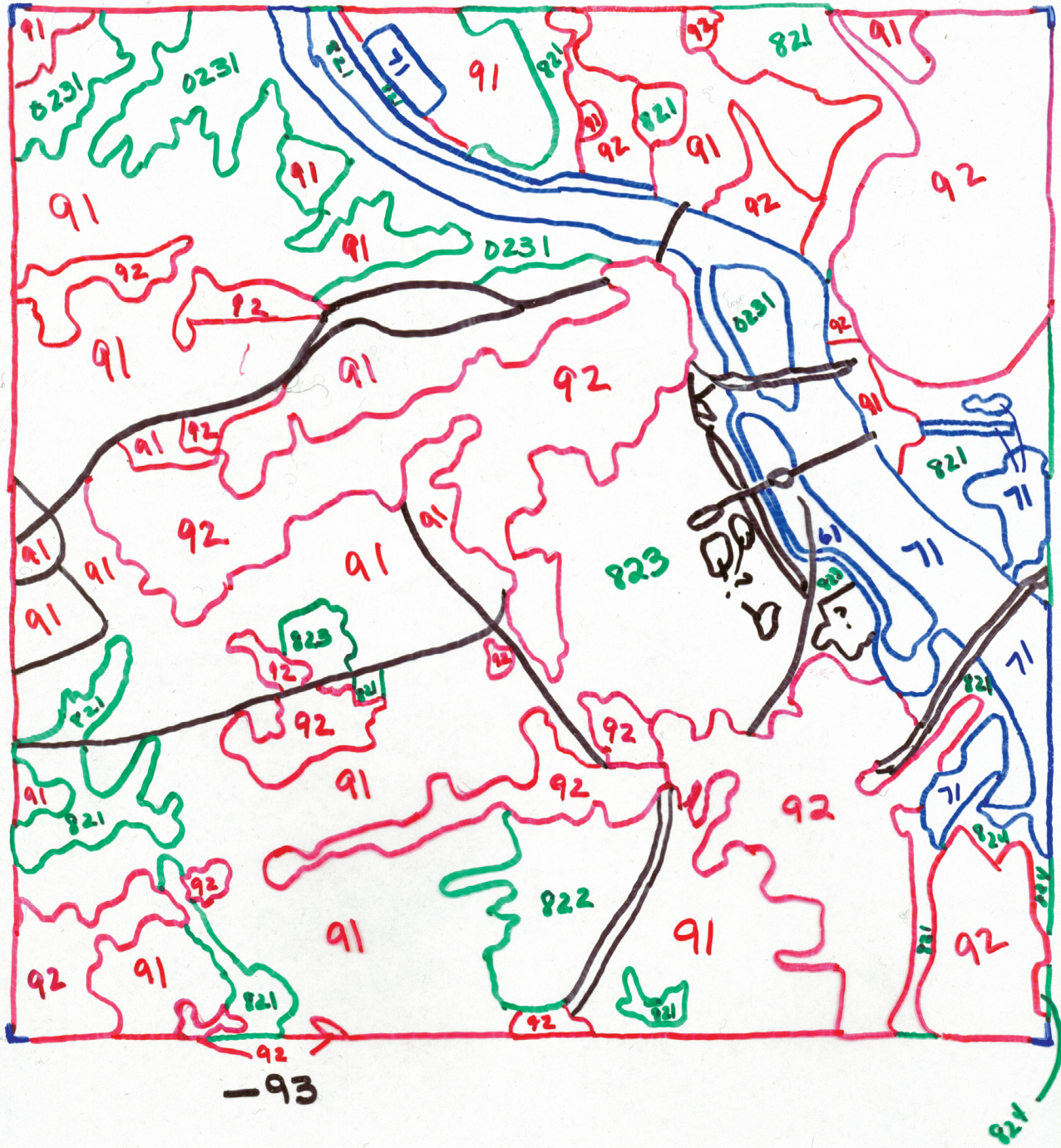*Figure BIO-MA-1: GLOBE Study Site Subset of Washington, DC*
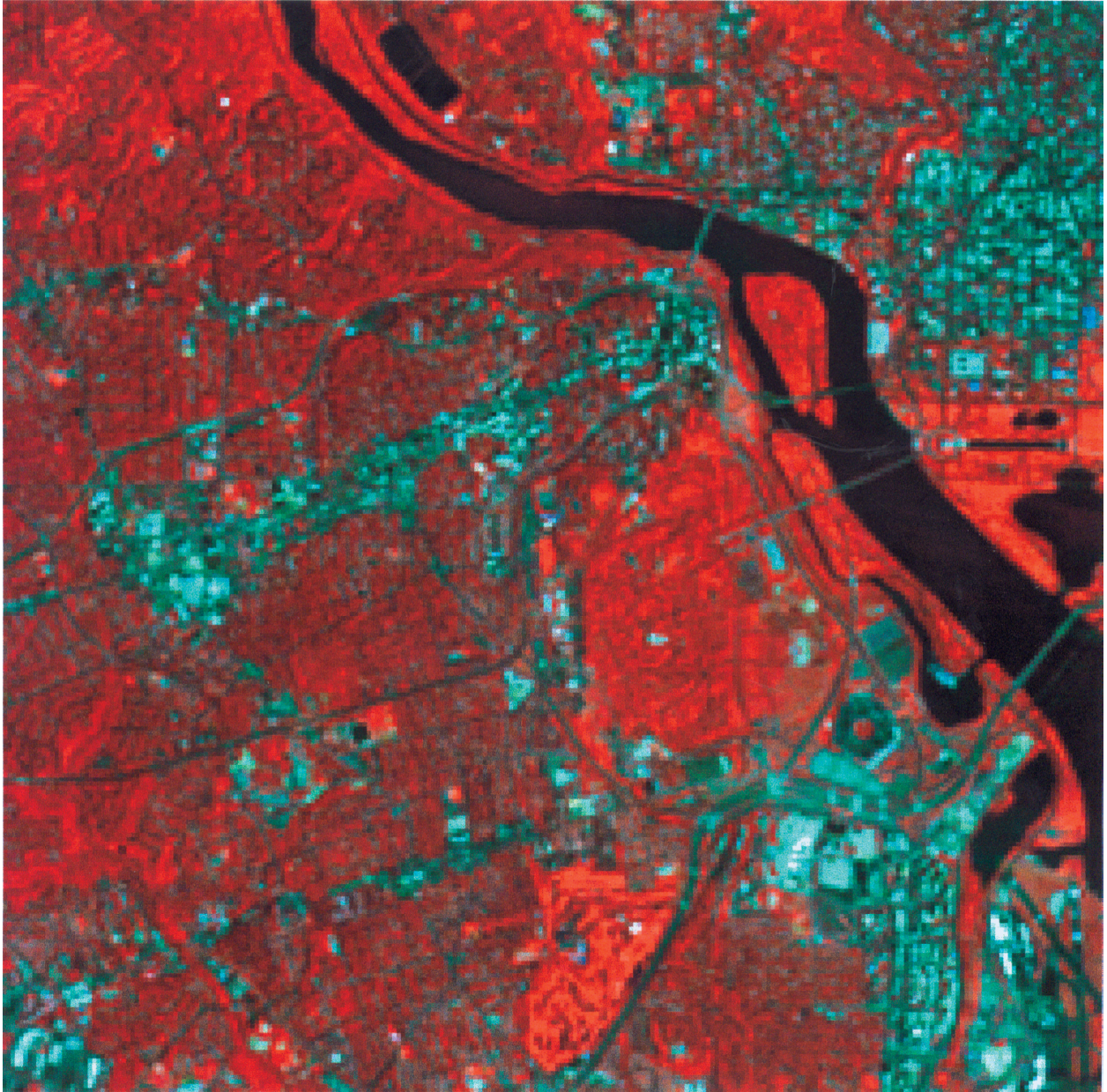
Figure BIO-MA-2: Manual Map of GLOBE Study Site Subset

land cover types. Using color felt-tip pens, they outlined different areas of similar color. They had pens of four different colors so they assigned a color for each MUC class group. For instance, red was used for some urban classes (MUC 91 and 92). Black was used for transportation (MUC 93). Blue was used for water (MUC 7). However, they did not have enough different colors for all the MUC classes, so they decided to use green for the different vegetated areas.

While making the map, one student commented that the residential areas had a "patchy" look, meaning that those areas were not all one color. Blue and red pixels were intermixed on the false-color image. He wasn't sure whether he should outline each pixel or small group of pixels individually or lump the blue and red mixture together. He noticed that this texture was fairly consistent and that groups of pixels with similar red or blue colors were less than 3 x 3 pixel squares. He lived in one of the residential areas and thought that the blue indicated roads, driveways and houses and that red indicated the vegetation in yards and along streets. Because the pixel groups were small and residential areas have a mixture of vegetation and built things, he suggested grouping the mixture as one land cover type, MUC 91 (Residential). Another student commented that the image contained many roads of different sizes. After discussing, the group decided to only identify roads that were large and could be clearly seen and separated from other land cover types like

MUC 91 (Residential) and 92 (Commercial and Industrial). They labeled the roads fitting these criteria as MUC 93 (Transportation).

They were very proud of their completed map and were eager to then see how accurate their map was. After reading the *Accuracy Assessment Tutorial*, they selected 10 sites to visit and perform the *Land Cover Sample Site Protocol*. They chose a Saturday when all three of them were available for the data collection. One of their parents agreed to drive them around. They borrowed a GPS receiver, and gathered a camera, film, compass, *Data Sheets* and *Field Guides*. They went to the sites and collected data. One student entered the data on the GLOBE website.

Following the instructions of the *Accuracy Assessment Tutorial*, they created a table comparing their map classifications and the validation data from the Sample Sites. See Figure BIO-MA-3.

After creating the table, they made a difference/error matrix (Figure BIO-MA-4). They calculated an overall accuracy of 80%. They felt pleased with what they did and were curious how well the other groups did and what the overall accuracy of the map of the entire GLOBE Study Site would be after all the groups combine their sections together.

Figure BIO-MA-3: Student Inquiry Completed Accuracy Assessment Work Sheet

Completed Accuracy Assessment Work Sheet

Site Name	Student Map Classification Data from GLOBE Study Site	Validation Data from Land Cover Sample Site	✓	✗
1. Potomac River by 14th Street bridge	71	71	✓	
2. Grass by airport	821	824		✗
3. Gary's neighborhood	91	91	✓	
4. Courthouse Metro shops	92	92	✓	
5. Phil's neighborhood	91	91	✓	
6. Potomac Park	0222	0231		✗
7. Park near hospital	821	821	✓	
8. Arlington Cemetery	823	823	✓	
9. Roosevelt Island	0231	0231	✓	
10. Georgetown area	92	92	✓	

MUC Class List

0222 – Closed Forest, Mainly Deciduous, Cold-Deciduous with Evergreens, With Evergreen Needle-Leaved Trees

0231 – Closed Forest, Mainly Deciduous, Cold-Deciduous without Evergreen Trees, Temperate Lowland and Submontane Broad-Leaved

71 - Open Water, Freshwater

821 – Cultivated Land, Non-Agriculture, Parks and Athletic Fields

823 – Cultivated Land, Non-Agriculture, Cemeteries

824 – Cultivated Land, Non-Agriculture, Other Non-Agriculture

91 - Urban, Residential

92 – Urban, Commercial and Industrial

93 – Urban, Transportation

Figure BIO-MA-4: Student Inquiry Difference/Error Matrix

Difference/Error Matrix

	MUC 71	MUC 821	MUC 91	MUC 92	MUC 0222	MUC 823	MUC 824	MUC 0231	Row Totals
MUC 71									1
MUC 821									2
MUC 91									2
MUC 92									2
MUC 0222									1
MUC 823									1
MUC 824									0
MUC 0231									1
Column Totals	1	1	2	2	0	1	1	2	10

Overall Accuracy: 8 ÷ 10 x 100 = 80%