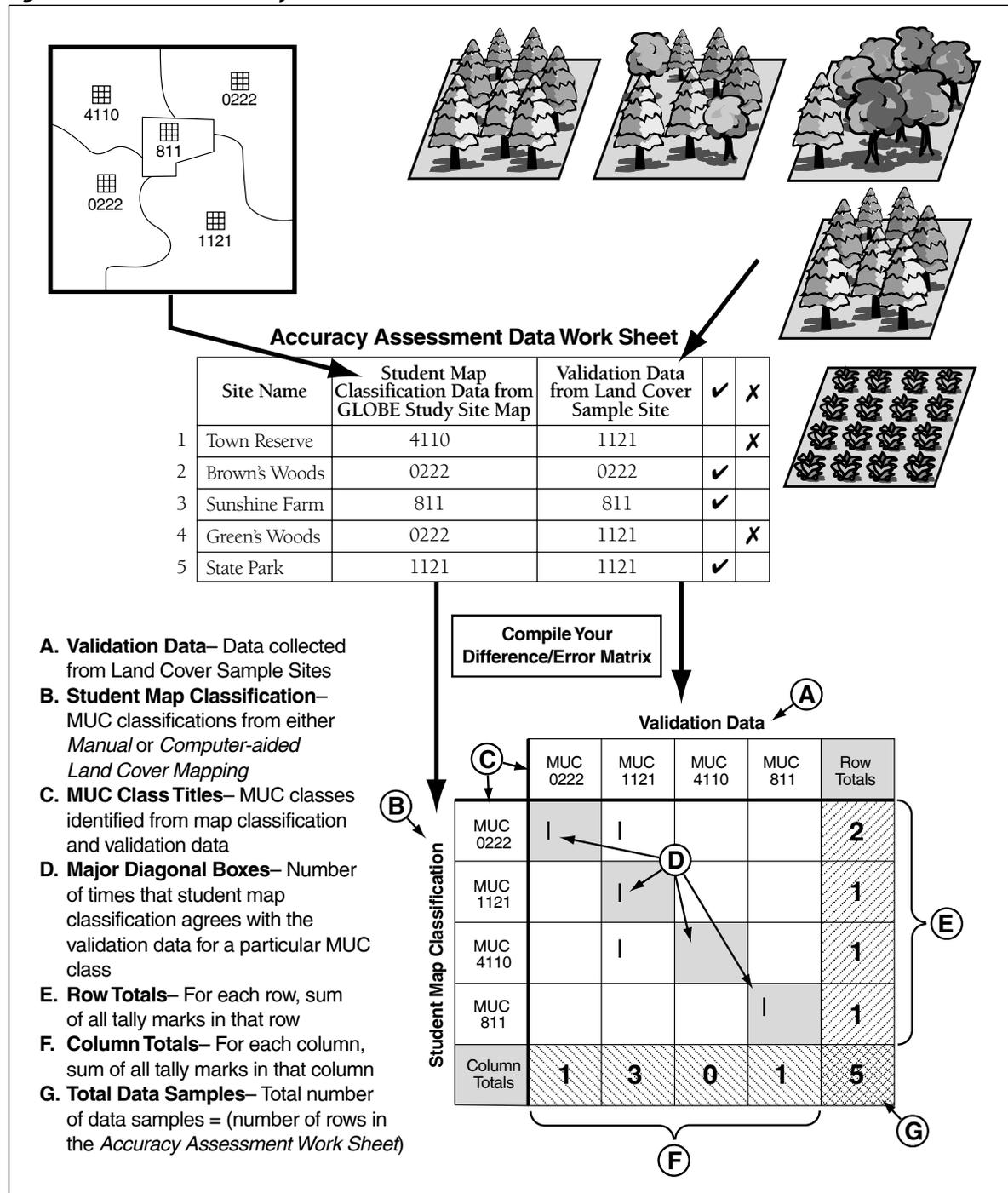# Accuracy Assessment Tutorial

After you make a land cover type map by using the *Manual* or *Computer-aided Land Cover Mapping Protocol* and collect many Land Cover Sample Site data, you are ready to assess the accuracy of your map. Use this Accuracy Assessment Tutorial as a guide. There is also an example *Accuracy Assessment Work Sheet* so you can practice first.

Figure LAND-AP-2 illustrates the map making and accuracy assessment process. First, students collect land cover sample site data and make a land cover map. Then, the student map data and the validation data (from additional Land Cover Sample Sites) are compared in an *Accuracy Assessment Work Sheet*. Finally, the data are compiled in a difference/error matrix. Using this matrix, accuracy assessment percentages can be calculated.

Figure LAND-AP-2: Accuracy Assessment Process

Accuracy Assessment Data Work Sheet

	Site Name	Student Map Classification Data from GLOBE Study Site Map	Validation Data from Land Cover Sample Site	✔	✗
1	Town Reserve	4110	1121		✗
2	Brown's Woods	0222	0222	✔	
3	Sunshine Farm	811	811	✔	
4	Green's Woods	0222	1121		✗
5	State Park	1121	1121	✔	

Compile Your Difference/Error Matrix

A. **Validation Data**– Data collected from Land Cover Sample Sites
B. **Student Map Classification**– MUC classifications from either *Manual* or *Computer-aided Land Cover Mapping*
C. **MUC Class Titles**– MUC classes identified from map classification and validation data
D. **Major Diagonal Boxes**– Number of times that student map classification agrees with the validation data for a particular MUC class
E. **Row Totals**– For each row, sum of all tally marks in that row
F. **Column Totals**– For each column, sum of all tally marks in that column
G. **Total Data Samples**– Total number of data samples = (number of rows in the *Accuracy Assessment Work Sheet*)

Validation Data

Student Map Classification	MUC 0222	MUC 1121	MUC 4110	MUC 811	Row Totals
MUC 0222	I	I			2
MUC 1121		I			1
MUC 4110		I			1
MUC 811				I	1
Column Totals	1	3	0	1	5

There are several accuracy assessment percentages that can be calculated. They are defined below.

Accuracy Assessment Percentages

Overall Accuracy indicates how well the map identifies all land cover types on the ground.

Producer's Accuracy indicates what percentage of the time a particular land cover type on the ground was identified as that land cover type on the map. It expresses how well the map producer identified a land cover type on the map from the satellite imagery data.

User's Accuracy indicates what percentage of the time a particular land cover type on the map is really that land cover type on the ground. It expresses how well a person using the map will find that land cover type on the ground.

Helpful Hints:

- There are two options for students depending on ability level. Younger students can enter the data from the *Accuracy Assessment Work Sheet* onto the GLOBE Web site and it will produce the Difference/Error Matrix, Overall Accuracy, Producer's and User's Accuracy for them. For older students or a more math-oriented class, students can follow the *Accuracy Assessment Tutorial* and create the matrix from the *Accuracy Assessment Work Sheet*. After they have entered the data into the GLOBE Web site, they can compare their results to the ones generated by GLOBE.
- The accuracy assessment can be repeated when more validation data have been collected. The statistical validity of the accuracy assessment matrix improves as more samples are used.
- An accuracy assessment can be performed on only a portion of the map.
- **Land Cover Sample Site data, which were not used in the development of the map, are used to create the difference/ error matrix.**
- Some of the error in a map made from satellite imagery may be related to the

fundamental limitation of the satellite image data as a tool in distinguishing land cover classes.

- Ideally, you should have validation samples for every type of land cover in your GLOBE Study Site. It may be desirable to only generate the matrix for the 3-5 most common land cover types.
- Collecting validation data is a time consuming process. It may take numerous classes to put together enough data for a valid matrix.
- Create and rely on your GLOBE learning community to gather enough data for this protocol.
- You can use the *Sample Completed Accuracy Assessment Work Sheet* for extra practice.
- Doing the *Bird Beak Accuracy Assessment Learning Activity* will help you prepare for this tutorial.

Completed Accuracy Assessment Work Sheet

	Site Name	Student Map Classification Data from GLOBE Study Site	Validation Data from Land Cover Sample Site	✔	✗
1	Town Reserve	4110	1121		✗
2	Brown's Woods	0222	0222	✔	
3	Sunshine Farm	811	811	✔	
4	Green's Woods	0222	1121		✗
5	State Park	1121	1121	✔	

The first time through this tutorial, use the Completed *Accuracy Assessment Work Sheet* above to follow the steps.

What You Need

- Landsat TM satellite images of the GLOBE Study Site

- Your student classified land cover map

- MUC data from Land Cover Sample Sites

- *Accuracy Assessment Work Sheet*

- *Accuracy Assessment Tutorial*

- Pen or pencil

- Blank paper

- Calculator (optional)

- Ruler/straight edge (optional)

What To Do

1. Complete the *Accuracy Assessment Work Sheet.*

a. Gather the MUC validation data if it has not already been organized for you.

b. Fill in the *Accuracy Assessment Work Sheet* using the MUC data and your student classified land cover map.

　1. Find a land cover type on your map, write the name of the area and its MUC code classification on the *Accuracy Assessment Work Sheet.*

　2. Look through the validation data (Land Cover Sample Site data) to find the MUC classification you recorded when you visited the site. Record this MUC on the *Accuracy Assessment Work Sheet.*

　3. Repeat this process (Steps 1 and 2) until you have covered every area on your student classified land cover map.

c. Complete the table by putting a "✔" when the two MUC classes agree and a "✗" when they do not.

2. Build an empty difference/error matrix.

   a. There should be a column and row in the matrix for every MUC Class that occurs on your *Accuracy Assessment Work Sheet.*
   b. Add two extra rows and two extra columns for the titles and totals.

Note: The example difference/error matrix is shaded to help show the titles, totals, and data in agreement. There is no need to shade your matrix.

	MUC	MUC	MUC	MUC	
MUC					
MUC					
MUC					
MUC					

3. Label Your Difference/Error Matrix with Titles and MUC Classes

   a. Label the top, "Validation Data."
   b. Label the left side, "Student Map Classification."
   c. Label the columns and rows of the difference/error matrix with your MUC classes from the *Accuracy Assessment Work Sheet.* Put the MUC classes in the same order from the upper left-hand corner going down (row titles) and across (column titles).

   Note: The MUC classes in your matrix may be different. This matrix was created using the example *Accuracy Assessment Work Sheet* on the previous page.

   d. Label the last row "Column Totals."
   e. Label the last column, "Row Totals."

Validation Data

Student Map Classification		MUC 0222	MUC 1121	MUC 4110	MUC 811	Row Totals
	MUC 0222					
	MUC 1121					
	MUC 4110					
	MUC 811					
	Column Totals					

4. Tally each row of data from the completed *Accuracy Assessment Work Sheet.*

a. Find the row in your matrix matching the Student Map Classification MUC Class.

E.g., In the first row of the completed *Accuracy Assessment Work Sheet,* the Student Map Classification MUC class is 4110.

b. Find the column in your matrix matching the Validation Data MUC Class.

E.g., In the first row of the completed *Accuracy Assessment Work Sheet,* the Validation Data MUC Class is 1121.

Validation Data

Student Map Classification	MUC 0222	MUC 1121	MUC 4110	MUC 811	Row Totals
MUC 0222					
MUC 1121					
MUC 4110					
MUC 811					
Column Totals					

Validation Data

Student Map Classification	MUC 0222	MUC 1121	MUC 4110	MUC 811	Row Totals
MUC 0222					
MUC 1121					
MUC 4110					
MUC 811					
Column Totals					

c. Put a tally mark (I) in the box where the row and column overlap.

d. Repeat these steps to tally all the rows of data in your *Accuracy Assessment Work Sheet.*

Validation Data

Student Map Classification	MUC 0222	MUC 1121	MUC 4110	MUC 811	Row Totals
MUC 0222					
MUC 1121					
MUC 4110		I			
MUC 811					
Column Totals					

Validation Data

Student Map Classification	MUC 0222	MUC 1121	MUC 4110	MUC 811	Row Totals
MUC 0222	I	I			
MUC 1121		I			
MUC 4110		I			
MUC 811				I	
Column Totals					

5. Calculate Totals

a. *Calculate Row Totals* – For each row, add up all tally marks in the row and put that value in the *Row Total* box for that row.

b. *Calculate Column Totals* – For each column, add up all tally marks in the column and put that value in the *Column Total* box for that column.

Validation Data

Student Map Classification	MUC 0222	MUC 1121	MUC 4110	MUC 811	Row Totals
MUC 0222	I	I			**2**
MUC 1121		I			
MUC 4110		I			
MUC 811				I	
Column Totals					

Validation Data

Student Map Classification	MUC 0222	MUC 1121	MUC 4110	MUC 811	Row Totals
MUC 0222	I	I			**2**
MUC 1121		I			**1**
MUC 4110		I			**1**
MUC 811				I	**1**
Column Totals	**1**				

c. Total Data Samples

Add up the *Row Totals* boxes. 2 + 1 + 1 + 1 = 5
Add up the *Column Totals* boxes. 1 + 3 + 0 + 1 = 5
The sum of the column totals should equal the sum of the row totals. This should be equal to the total number of data samples (rows) on your *Accuracy Assessment Work Sheet.*
Put this number in the bottom right box (where *Row Totals* and *Column Totals* overlap).
If the sum of the row totals does not equal the sum of the column totals, recheck your math and tallies.

Validation Data

		MUC 0222	MUC 1121	MUC 4110	MUC 811	Row Totals
Student Map Classification	MUC 0222	I	I			2
	MUC 1121		I			1
	MUC 4110		I			1
	MUC 811				I	1
	Column Totals	1	3	0	1	5

6. Calculate the Accuracy Assessment Percentages

a. *Calculate Overall Accuracy*

$$\text{Overall Accuracy} = \frac{\text{sum of major diagonal tallies}}{\text{total number of samples}} \times 100$$

Add the tallies in all the boxes on the major diagonal (shaded) of your matrix except the lower right-hand *Total* box. Divide this sum by the total number of samples (the value in the lower right-hand *total* box). Multiply by 100 to convert it to a percentage.

$$\text{Overall Accuracy} = \frac{(1 + 1 + 0 + 1)}{5} \times 100 = 60\%$$

Validation Data

		MUC 0222	MUC 1121	MUC 4110	MUC 811	Row Totals
Student Map Classification	MUC 0222	I	I			2
	MUC 1121		I			1
	MUC 4110		I			1
	MUC 811				I	1
	Column Totals	1	3	0	1	5

b. *Calculate User's Accuracy*

$$\text{User's Accuracy} = \frac{\text{\# correctly identified}}{\text{Row Total}} \times 100$$

For each MUC class, divide the number of times you correctly identified it (value on major diagonal) by the Row Total for that MUC Class.
E.g., User's Accuracy = $\frac{1}{2}$ X 100 = 50% for MUC 0222

Validation Data

		MUC 0222	MUC 1121	MUC 4110	MUC 811	Row Totals
Student Map Classification	MUC 0222	I	I			2
	MUC 1121		I			1
	MUC 4110		I			1
	MUC 811				I	1
	Column Totals	1	3	0	1	5

c. *Calculate Producer's Accuracy*

$$\text{Producer's Accuracy} = \frac{\text{\# correctly identified}}{\text{Column Total}} \times 100$$

For each MUC class, divide the number of times you correctly identified it (value on major diagonal) by the Column Total for that MUC Class.
E.g., Producer's Accuracy = $\frac{1}{1}$ X 100 = 100% for MUC 0222

Validation Data

		MUC 0222	MUC 1121	MUC 4110	MUC 811	Row Totals
Student Map Classification	MUC 0222	I	I			2
	MUC 1121		I			1
	MUC 4110		I			1
	MUC 811				I	1
	Column Totals	1	3	0	1	5

Sample Completed
Accuracy Assessment Work Sheet

	Site Name	Student Map Classification Data from GLOBE Study Site	Validation Data from Land Cover Sample Sites	✔	✗
1	Woodward's Valley	0222	1222		✗
2	Bunyan Trail Woodland	4213	1222		✗
3	State Forest Land	0222	0222	✔	
4	The Woods North of School	1222	1222	✔	
5	Brer's Preserve	2231	2231	✔	
6	Shrubland East of Gravel	1222	2231		✗
7	Nature Conservancy Land	2231	62		✗
8	Janice Denver's Property	4233	4213		✗
9	Moosehead Hill	4233	4233	✔	
10	Wetland Behind Food Store	2231	62		✗
11	The Gravel Mine	56	56	✔	
12	Calypso Lake	71	71	✔	
13	Junior's Farm	811	811	✔	
14	St. Augustine Farm	811	811	✔	
15	Johann's Neighborhood	91	91	✔	

MUC Class List

0222 – Closed Forest, Mainly Deciduous, Cold-Deciduous with Evergreens, With Evergreen Needle-Leaved Trees
1222 – Woodland, Mainly Deciduous, Cold-Deciduous with Evergreens, With Evergreen Needle-Leaved Trees
2231 – Shrubland or Thicket, Mainly Deciduous, Cold-Deciduous, Temperate
4213 – Herbaceous Vegetation, Medium Tall Graminoid, With Trees Covering 10-40%, Trees: Broad-Leaved Deciduous
4223 – Herbaceous Vegetation, Medium Tall Graminoid, With Trees Covering <10%, Trees: Broad-Leaved Deciduous
4233 – Herbaceous Vegetation, Medium Tall Graminoid, With Shrubs, Shrubs: Broad-Leaved Deciduous
4313 – Herbaceous Vegetation, Short Graminoid, With Trees Covering 10-40%, Trees: Broad-Leaved Deciduous
56 – Barren Land, Other
62 – Wetland, Palustrine
71 – Open Water, Freshwater
811 – Cultivated Land, Agriculture, Row Crop and Pasture
823 – Cultivated Land, Non-Agriculture, Cemeteries
91 – Urban, Residential

Difference/Error Matrix for
"Sample Completed Accuracy Assessment Work Sheet"

Validation Data

Student Map Classification	MUC 0222	MUC 1222	MUC 2231	MUC 4213	MUC 4233	MUC 56	MUC 62	MUC 71	MUC 811	MUC 91	Row Totals
MUC 0222	I	I									2
MUC 1222		I	I								2
MUC 2231			I				II				3
MUC 4213		I									1
MUC 4233				I	I						2
MUC 56						I					1
MUC 62											0
MUC 71								I			1
MUC 811									II		2
MUC 91										I	1
Column Totals	1	3	2	1	1	1	2	1	2	1	15

Accuracy Assessment Percentages for
"Sample Completed Accuracy Assessment Work

Overall Accuracy
9 ÷ 15 x 100 = 60%

User's Accuracies

MUC Class	Calculation	User's Accuracy
0222	1 ÷ 2 x 100	50%
1222	1 ÷ 2 x 100	50%
2231	1 ÷ 3 x 100	33%
4213	0 ÷ 1 x 100	0%
4233	1 ÷ 2 x 100	50%
56	1 ÷ 1 x 100	100%
62	0	NA
71	1 ÷ 1 x 100	100%
811	2 ÷ 2 x 100	100%
91	1 ÷ 1 x 100	100%

Producer's Accuracies

MUC Class	Calculation	Producer's Accuracy
0222	1 ÷ 1 x 100	100%
1222	1 ÷ 3 x 100	33%
2231	1 ÷ 2 x 100	50%
4213	0 ÷ 1 x 100	0%
4233	1 ÷ 1 x 100	100%
56	1 ÷ 1 x 100	100%
62	0 ÷ 2 x 100	0%
71	1 ÷ 1 x 100	100%
811	2 ÷ 2 x 100	100%
91	1 ÷ 1 x 100	100%