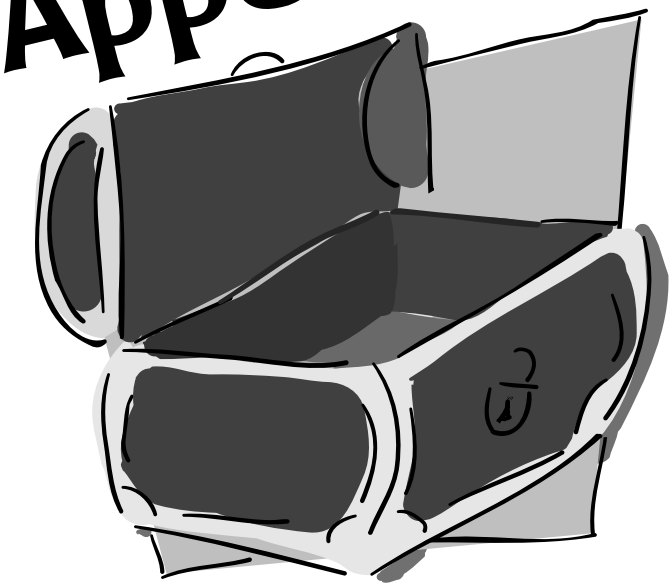
Appendix



Clinometer Sheet

Table of Tangents

Table of Cosines

MUC Classification Practice Examples

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

Accuracy Assessment Tutorial

Land Cover Sample Site Data Sheet

Canopy and Ground Cover Data Sheet

Graminoid, Tree, and Shrub Height Data Sheet

Alternative Clinometer Techniques Data Sheets

Tree Circumference Data Sheet

Graminoid Biomass Data Sheet

Accuracy Assessment Work Sheet

Fire Fuel Protocol: Center Plot Data Sheet

Fire Fuel Protocol: Transect Measurements Data Sheet

MUC System Glossary

Land Cover Glossary of Terms

Clinometer Sheet

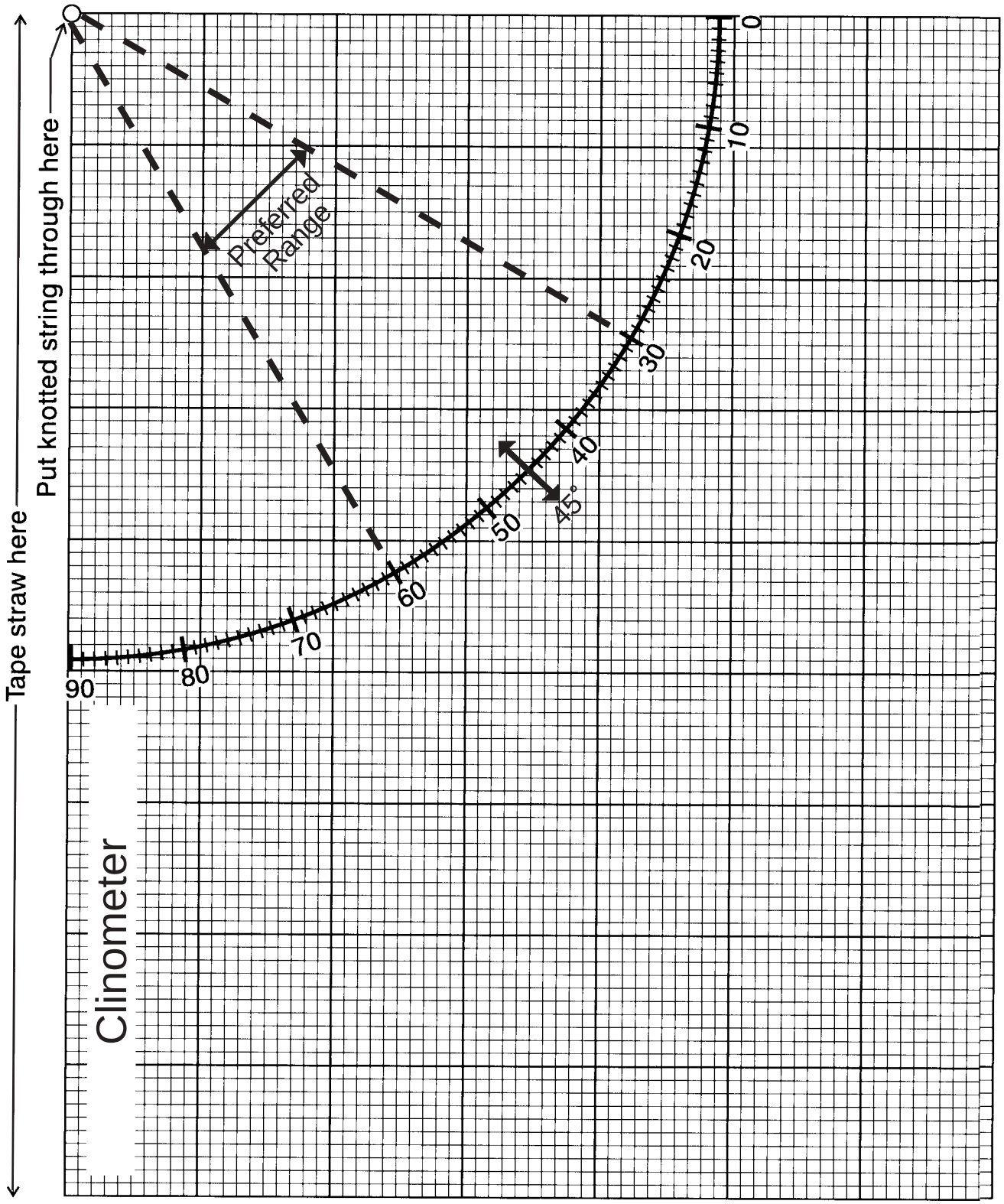


Table LAND-A-1: Table of Tangents

Angle	Tan.	Angle	Tan.	Angle	Tan.	Angle	Tan.	Angle	Tan.
1°	.02	17	.31	33	.65	49	1.15	65	2.14
2	.03	18	.32	34	.67	50	1.19	66	2.25
3	.05	19	.34	35	.70	51	1.23	67	2.36
4	.07	20	.36	36	.73	52	1.28	68	2.48
5	.09	21	.38	37	.75	53	1.33	69	2.61
6	.11	22	.40	38	.78	54	1.38	70	2.75
7	.12	23	.42	39	.81	55	1.43	71	2.90
8	.14	24	.45	40	.84	56	1.48	72	3.08
9	.16	25	.47	41	.87	57	1.54	73	3.27
10	.18	26	.49	42	.90	58	1.60	74	3.49
11	.19	27	.51	43	.93	59	1.66	75	3.73
12	.21	28	.53	44	.97	60	1.73	76	4.01
13	.23	29	.55	45	1.00	61	1.80	77	4.33
14	.25	30	.58	46	1.04	62	1.88	78	4.70
15	.27	31	.60	47	1.07	63	1.96	79	5.14
16	.29	32	.62	48	1.11	64	2.05	80	5.67

Example: Assume you have established a baseline distance of 60.0 meters. Assume that you have measured the tree top to an angle of 34°. From the Table, you will see that the tangent of 34° is 0.67. Therefore, the tree height above your eye height is 60.0 m x .67 = 40.2 meters. By adding your eye height above the ground (1.5 m), the total tree height is 41.7 meters.

Not Part of Clinometer*

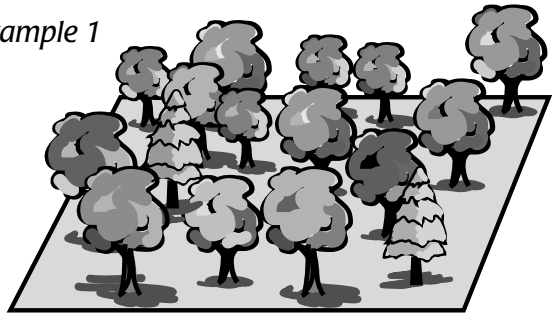
Angle	COS	Angle	COS	Angle	COS	Angle	COS	Angle	COS
1°	1.00	17	0.96	33	0.84	49	0.66	65	0.42
2	1.00	18	0.95	34	0.83	50	0.64	66	0.41
3	1.00	19	0.95	35	0.82	51	0.63	67	0.39
4	1.00	20	0.94	36	0.81	52	0.62	68	0.37
5	1.00	21	0.93	37	0.80	53	0.60	69	0.36
6	0.99	22	0.93	38	0.79	54	0.59	70	0.34
7	0.99	23	0.92	39	0.78	55	0.57	71	0.33
8	0.99	24	0.91	40	0.77	56	0.56	72	0.31
9	0.99	25	0.91	41	0.75	57	0.54	73	0.29
10	0.98	26	0.90	42	0.74	58	0.53	74	0.28
11	0.98	27	0.89	43	0.73	59	0.52	75	0.26
12	0.98	28	0.88	44	0.72	60	0.50	76	0.24
13	0.97	29	0.87	45	0.71	61	0.48	77	0.22
14	0.97	30	0.87	46	0.69	62	0.47	78	0.21
15	0.97	31	0.86	47	0.68	63	0.45	79	0.19
16	0.96	32	0.85	48	0.67	64	0.44	80	0.17

* For use with *Two-Triangle Alternative Technique to Measure Tree Height Field Guides*

MUC Classification Practice Examples

The following three examples provide students additional practice assigning MUC classes. In the first example, found in the MUC System section of the *Investigation Instruments,* students follow along step-by–step with the process. The three examples given below are for your students to try for themselves. Students should be able to accurately assign a MUC class by the time they complete the last example. Answers are at the bottom of each page. Student will need additional practice in the field in order to feel confident assigning MUC types but these examples will help students become familiar with the *MUC Field Guide* or *MUC System Table* and *MUC Glossary of Terms.*

MUC Classification Example 1



You perform your canopy cover and ground cover measurements, recording the number of times you saw vegetation through your densiometer and the number of times you saw sky. You calculate a canopy cover of 70% and note that the crowns of trees are not touching each other. From these data you know that the MUC Level 1 class is _____
(MUC)

_____
(MUC Class Name)

Each time you see canopy vegetation through your densiometer, you also record and tally the tree type. It is 80% deciduous. This means that your MUC Level 1 and 2 class is ___ ___
(MUC)

_____
(MUC Class Name)

There are not many climbers or epiphytes in this area and there are evergreens. There is a winter frost in the unfavorable season. This gives you a MUC Level 1, 2, and 3 class of ___ ___ ___
(MUC)

_____
(MUC Class Name)

The evergreen trees have needle leaves. The complete MUC class is ___ ___ ___ ___, called
(MUC)

_____
(MUC Class Name)

Answer: MUC 1222

MUC Classification Example 2

You live in a lowland temperate region. You select a land cover site that is mostly trees with the crowns touching each other, but about 20% of the ground area has houses on it. After measuring, the canopy is a 60% hemisclerophyllous evergreen and 40% deciduous mix.

Level 1: Look in the *MUC System Table* and check the Level 1 choices. When you think you have the Level 1 class, check the *MUC Glossary* to be sure. Write the answer in the correct space below.

Level 2: Look in the *MUC System Table* and check the Level 2 choices. There should only be a few. Reread the description given above and the definitions in the *MUC Glossary*. When you think you have the Level 2 class, write it below.

Level 3: Look in the *MUC System Table* and check the Level 3 choices. There should be quite a few, but look at them carefully, some will not fit your description at all. In reality, you will only have a few options again! Reread the description given above and the definitions in the *MUC Glossary*. When you think you have the Level 3 class, write it below.

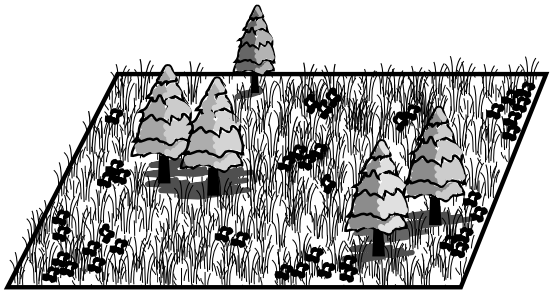
Level 4: Look in the *MUC System Table* and check the Level 4 choices. There should only be a few. Reread the description given above and the definitions in the *MUC Glossary*. When you think you have the Level 4 class, write it below.

MUC Class _____ _____ _____ _____
Level 1 Level 2 Level 3 Level 4

_____
(MUC Class Name)

Answer: MUC 0161

MUC Classification Example 3



After you perform your canopy and ground cover measurements, you calculate that the canopy cover is 20% and composed of a single species of pine tree (needle-leaved). Your ground cover is 90% herbaceous vegetation. It is composed of 85% graminoid and 15% forb. Most of the graminoid vegetation is over 3 meters tall.

What is the MUC class for this land cover sample site? ___ ___ ___ ___

_____

(MUC Class Name)

Answer: MUC 4110

Manual Mapping

A Tutorial for the Beverly, MA, Image

The following tutorial is provided as an example of how a manual land cover map is made for the Beverly, MA Landsat Thematic Mapper (TM) image. After completing this tutorial as a training exercise, each step presented should also be done by your students, using the TM image of your own GLOBE Study Site (your 15 km x 15 km area.) Figure LAND-AP-1 shows a false-color infrared image of the Beverly, MA image, and will be used to illustrate the process of performing a manual land cover mapping. Note that water and vegetation types are more readily distinguished if the false-color infrared image is used. However, you also want to keep your "true-color" image handy, because it is useful for distinguishing developed areas.

The following steps are used in the manual mapping method.

1. Select the Landsat TM satellite image to be mapped. In the false-color infrared image, actively growing green vegetation will appear red (hardwoods and fields are bright red to pink, evergreens are dark red to black), water is black, while urban areas and bare soils are blue.
2. Overlay an 8.5 x 11 inch sheet of clear plastic on top of the colored print of the image, using tape to hold it firmly in place. Once the overlay is in place, mark the location of the image edges on the overlay so that it can be placed in exactly the same position if it is removed. This will also allow you to place the overlay on either the true color or false-color infrared image to take advantage of the discrimination capabilities of each type of image.
3. The mapping process involves carefully outlining the different land cover types seen on the image, using either colored crayons or felt-tip marking pens. Use different colors to represent different land cover classes if possible. Assign each the appropriate number for its specific MUC class. Be certain to identify each area with the most detailed MUC value for its class.

The illustrations accompanying this tutorial illustrate the steps in developing a manual land cover map. For clarity, the individual steps are shown on separate illustrations, then assembled to show the final map. In practice, each step is done on the same sheet, gradually building a complete map.

- Outline water bodies, as shown in Step 1. Here we see Marine Open Water, MUC 72, and Fresh Open Water, MUC 71. Note that for Open Water, the MUC scheme only contains two levels.
- In the illustration for Step 2, "Barren" areas, labeled MUC 52 (Sandy) and 53 (Bare Rock) are outlined. The Urban Residential (91) and Commercial (92) areas are also discriminated.
- In Step 3, the remaining major features are developed, including:

MUC 63 — Estuarine
MUC 93 — Urban Transportation
MUC 811 — Row Crops/Pasture
MUC 822 — Golf Courses
MUC 823 — Cemeteries

Also added are the vegetated areas:

MUC 0192 — Evergreen Temperate Closed Forest
MUC 0222 — Deciduous Closed Forest with Evergreens and Shrubs

- Step 4 presents the final product, a labeled land cover type map of the Beverly area. Your students should decide on the final format of your own map.

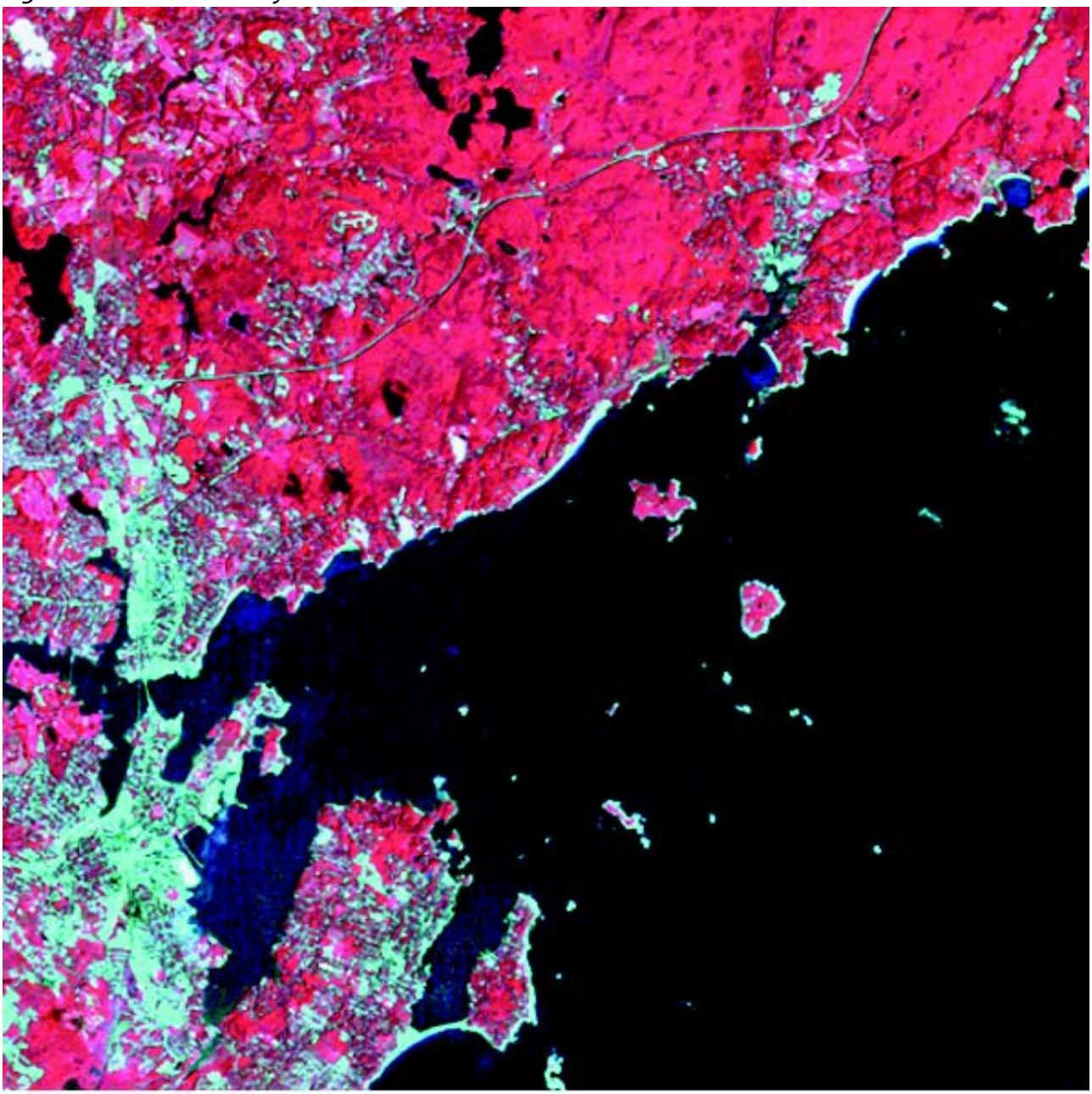
Since the land cover types in your local area may be very different from those in Beverly, MA, you may certainly want to proceed with a different order to outlining MUC classes. Remember to take advantage of both the true-color and false-color infrared images provided to your school.

If there are areas on your image for which your students are not sure of the specific MUC class, have students decide how they can verify what is in that location. This activity is likely to take several class periods to complete. Have your students be as careful and specific as possible in outlining and assigning classes to the various land cover areas in their image.

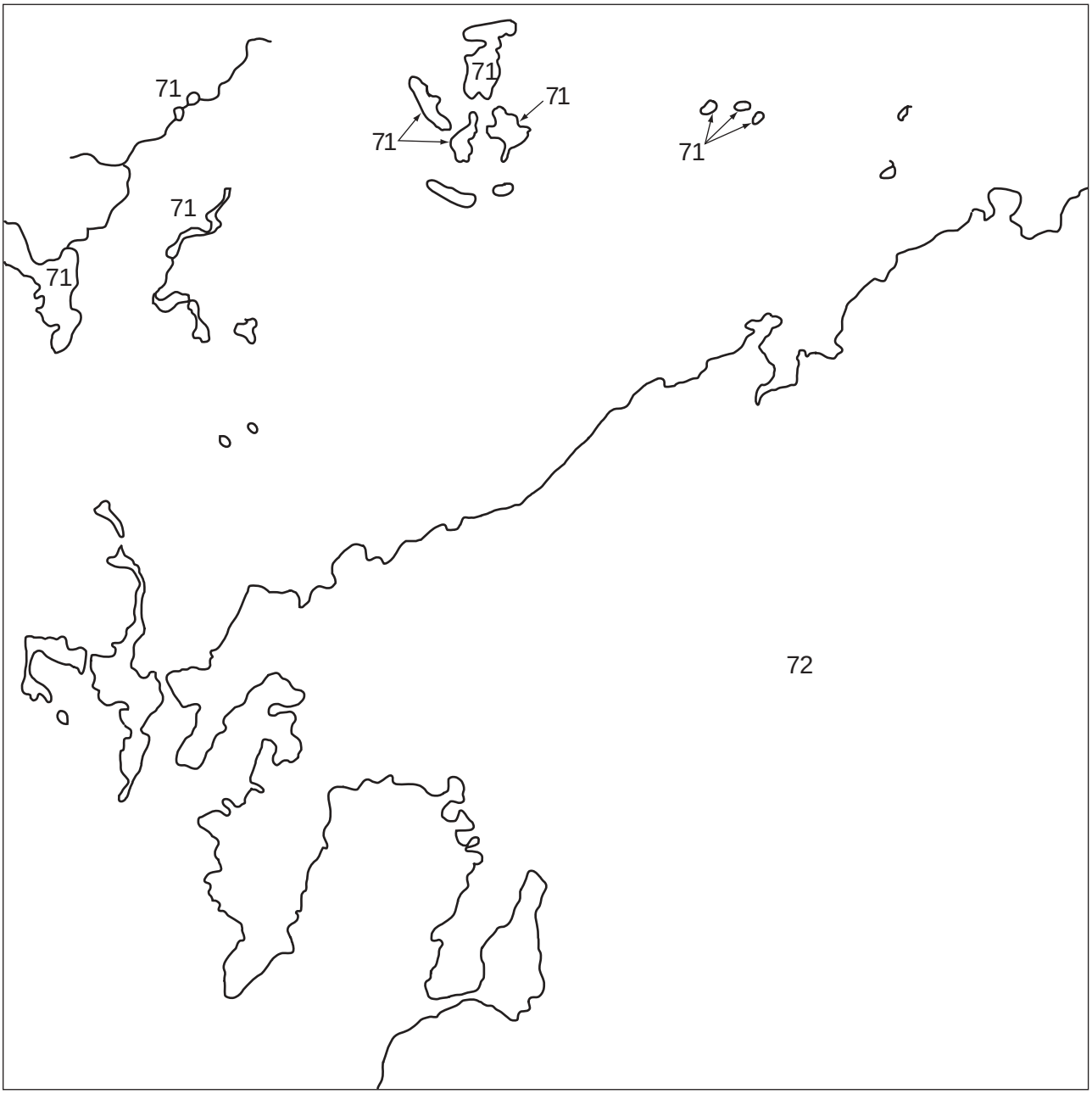
Once your Land Cover Map is completed, you will need to determine its accuracy. This is called "Accuracy Assessment," and is described in the *Accuracy Assessment Tutorial*.

During the validation process, you will report your validation data as Land Cover Sample Sites. Once your map is validated, a copy, along with your validation data, should be submitted to GLOBE by following the directions given in the *How to Submit Photos and Maps* section of the *Implementation Guide*.

Figure LAND-AP-1: Beverly Landsat Scene



Step 1

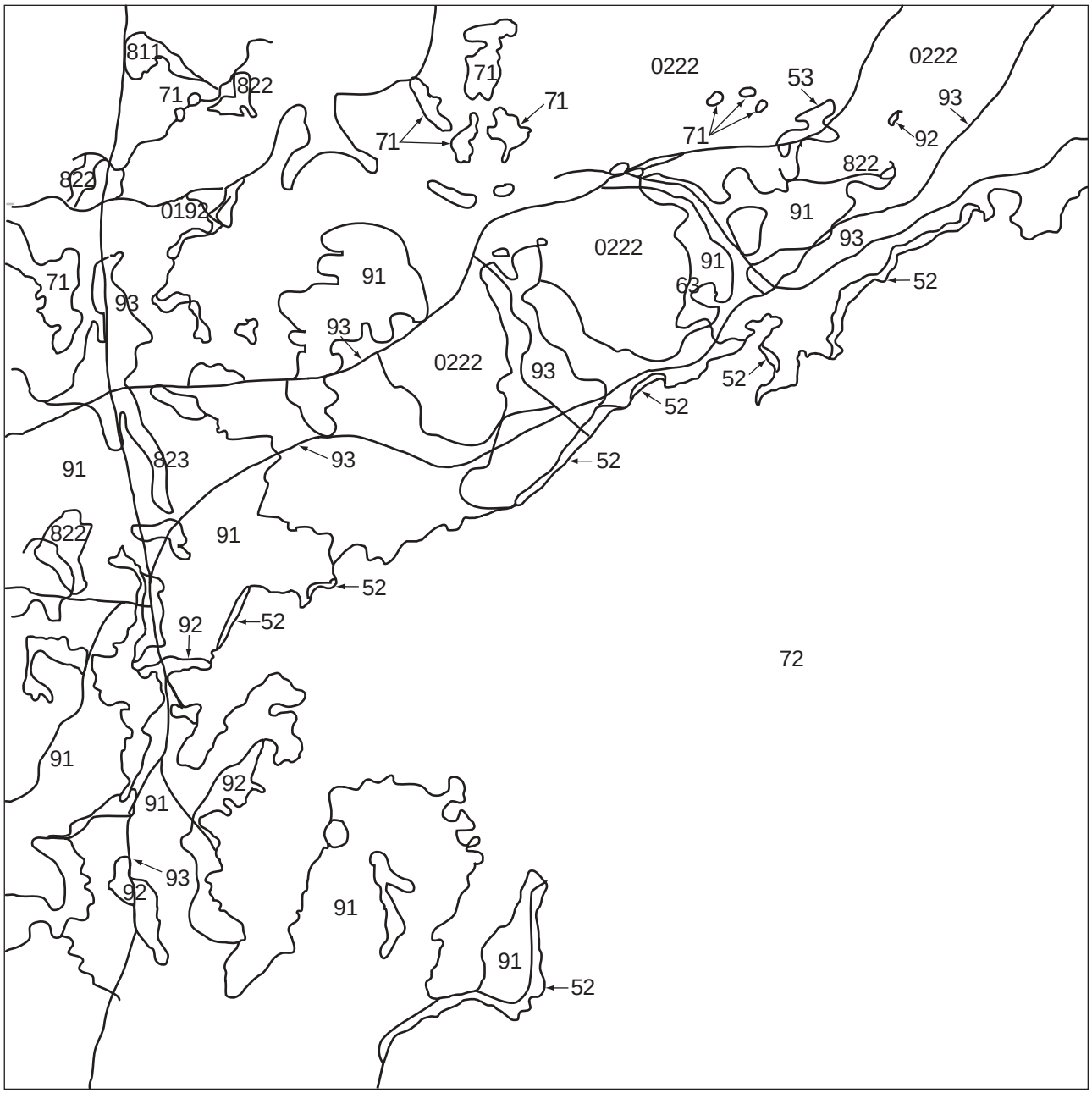


Step 2

Step 3

811
822
0222
0222
93
822
822
0192
63
93
0222
63
93
93
0222
93
823
93
822
822
93

Step 4

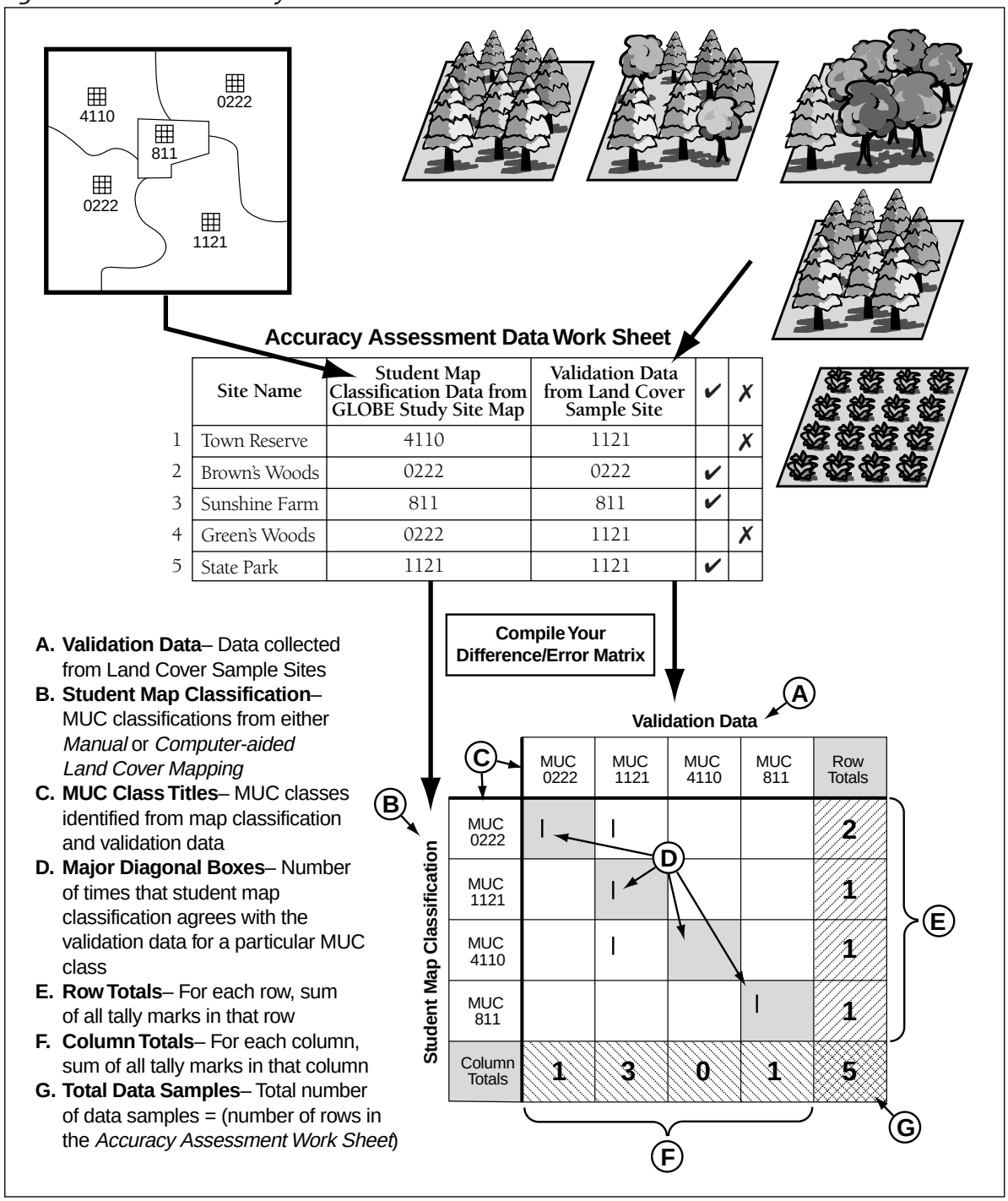

811
71
822
71
71
71
0222
53
0222
93
71
92
822
822
0192
91
93
0222
91
63
52
71
93
91
93
0222
93
52
52
91
823
93
52
822
91
52
92
52
72
91
92
91
93
92
91
91
52

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



	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	✔	

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.

Student Map Classification \ Validation Data	MUC 0222	MUC 1121	MUC 4110	MUC 811	Row Totals
MUC 0222					
MUC 1121					
MUC 4110					
MUC 811					
Column Totals					

Student Map Classification \ Validation Data	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.

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

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

Student Map Classification \ Validation Data	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.

Student Map Classification \ Validation Data	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					

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.

Student Map Classification \ Validation Data	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

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

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

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

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 = $^1/_2$ X 100 = 50% for MUC 0222

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

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 = $^1/_1$ X 100 = 100% for MUC 0222

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

For more practice:

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 Sheet"*

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%

Questions for Further Investigation

- 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?
- Which were better – your producer's or user's accuracies? Why do you think that is?
- How could next year's class use your data to create a better Student Classified Map?

Land Cover Investigation

Sample Site Data Sheet

School Name: _____

Measurement Time: _____
Year Month Day Hour (UT)

Recorded By: _____

LOCATION

Site Name: _____

City/State/Country: _____

Locational Data: Source: ☐ **GPS** ☐ **Other** _____

For GPS data, record from *GPS Investigation Data Sheet* or *Offset Data Sheet*

Latitude	Longitude	Elevation
_____ decimal degrees	_____ decimal degrees	_____ meters
☐ North ☐ South	☐ East ☐ West	

MUC TO THE MOST DETAILED LEVEL

MUC Class: ____ ____ ____ ____

MUC Land Cover Type Name: _____

_____

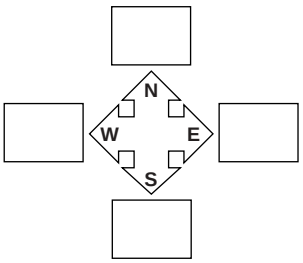
METADATA (Comments)

_____

_____

_____

PHOTO NUMBER AND ORIENTATION



Land Cover Investigation

Canopy and Ground Cover Data Sheet*

School Name: _____ Site: _____

Measurement Time: _____
Year Month Day Hour (UT)

Recorded By: _____

	1. **Canopy Observations** T = Tree Canopy SB = Shrub Canopy – = Sky	2. **Canopy Type** E = Evergreen D = Deciduous – = Sky	3. **Ground Observations** G = Green Cover B = Brown Cover – = No Cover	4. **Ground Vegetation Type** GD = Graminoid FB = Forb OG = Other Green Veg. SB = Shrub DS = Dwarf-Shrub	5. **Canopy Species or Common Name**	6. **Shrub Cover** + = Tallest vegetation is a shrub – = All other	7. **Dwarf Shrub Cover** + = Tallest vegetation is a dwarf shrub – = All other
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							

	1. **Canopy Observations** T = Tree Canopy SB = Shrub Canopy – = Sky	2. **Canopy Type** E = Evergreen D = Deciduous – = Sky	3. **Ground Observations** G = Green Cover B = Brown Cover – = No Cover	4. **Ground Vegetation Type** GD = Graminoid FB = Forb OG = Other Green Veg. SB = Shrub DS = Dwarf-Shrub	5. **Canopy Species or Common Name**	6. **Shrub Cover** + = Tallest vegetation is a shrub – = All other	7. **Dwarf Shrub Cover** + = Tallest vegetation is a dwarf shrub – = All other
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							
40							

Summary of Tree Canopy Observations	
Total "T"	
Total "–"	
Total Observations	
% Tree Canopy	

Summary of Canopy Type	
Total "E"	
Total "D"	
Total Observations	
% Evergreen (E)	
% Deciduous (D)	

Summary of Ground Observations	
Total "G"	
Total "B"	
Total "–"	
Total Observations	
% Ground	

Summary of Ground Vegetation Type	
Total "GD"	
Total "FB"	
Total "OG"	
Total "SB"	
Total "DS"	
Total Observations	
% Graminoid (GD)	
% Forb (FB)	
% Other Green (OG)	

Summary of Shrub Cover	
Total "+" in col. 6	
Total Observations	
% of Shrub Cover	

Summary of Dwarf Shrub Cover	
Total "+" in col. 7	
Total Observations	
% of Dwarf Shrub Cover	

Land Cover Investigation

Graminoid, Tree and Shrub Height Data Sheet

School Name: _____ Site: _____

Measurement Time: _____
Year Month Day Hour (UT)

Recorded By: _____

Clinometer Data

*Dominant Species _____ _____	Clinometer Reading (°)	TAN of Clinometer Reading	Distance from Tree (m)	Eye Height (m)	*Vegetation Height (m)	*Average Height (m)
Specimen 1.						
Specimen 2.						
Specimen 3.						
Specimen 4.						
Specimen 5.						

*Co-Dominant Species_____ _____	Clinometer Reading (°)	TAN of Clinometer Reading	Distance from Tree (m)	Eye Height (m)	*Vegetation Height (m)	*Average Height (m)
Specimen 1.						
Specimen 2.						
Specimen 3.						
Specimen 4.						
Specimen 5.						

Tree Height = (TAN of Clinometer Reading x Distance from Tree) + Eye Height

Note: Measure each tree three times and average the three height values. If all three values are within 1 meter of the average, report the values. If not, repeat the measurements until they are within 1 meter of their average, and then report these values.

* Use these columns for measuring the height of graminoids, shrubs, and dwarf-shrubs. Use all the columns if you use your clinometer to measure height.

Land Cover Investigation

Measure Tree Height on Level Ground: Simplified Clinometer Technique Data Sheet

School Name: _____ Site: _____

Measurement Time: _____
Year Month Day Hour (UT)

Recorded By: _____

Clinometer Data

Dominant Species _____ _____	Clinometer Reading (°)	Tree Height (m) (Distance from Base of Tree (m)and Up to Eyes)	Average Tree Height (m)
Specimen 1.	45°		
Specimen 2.	45°		
Specimen 3.	45°		
Specimen 4.	45°		
Specimen 5.	45°		

Co-Dominant Species _____ _____	Clinometer Reading (°)	Tree Height (m) (Distance from Base of Tree (m)and Up to Eyes)	Average Tree Height (m)
Specimen 1.	45°		
Specimen 2.	45°		
Specimen 3.	45°		
Specimen 4.	45°		
Specimen 5.	45°		

Note: Measure each tree three times and average the three height values. If all three values are within 1 meter of the average, report the values. If not, repeat the measurements until they are within 1 meter of their average, and then report these values.

Land Cover Investigation

Measure Tree Height on a Slope: Stand by Tree Data Sheet

School Name: _____ Site: _____

Measurement Time: _____
Year Month Day Hour (UT)

Recorded By: _____

Clinometer Data

Dominant Species _____ _____	Clinometer Reading (˚)	TAN of Clinometer Reading	Height to 0˚ on Tree (m)	Distance to Tree (m)	Tree Height (m)	Average Tree Height (m)
Specimen 1.						
Specimen 2.						
Specimen 3.						
Specimen 4.						
Specimen 5.						

Co-Dominant Species_____ _____	Clinometer Reading (˚)	TAN of Clinometer Reading	Height to 0˚ on Tree (m)	Distance to Tree (m)	Tree Height (m)	Average Tree Height (m)
Specimen 1.						
Specimen 2.						
Specimen 3.						
Specimen 4.						
Specimen 5.						

Tree Height = [(TAN of Clinometer Reading) x (Distance to Tree)] + (Height to 0˚ on Tree)

Note: Measure each tree three times and average the three height values. If all three values are within 1 meter of the average, report the values. If not, repeat the measurements until they are within 1 meter of their average, and then report these values.

Land Cover Investigation

Measure Tree Height on a Slope: Two-Triangle with Feet Higher than Tree Base Technique Data Sheet

School Name: _____ Site: _____

Measurement Time: _____
Year Month Day Hour (UT)

Recorded By: _____

Clinometer Data

Dominant Species _____	1st Clinometer Reading (°)	TAN of 1st Clinometer Reading	2nd Clinometer Reading (°)	TAN of 2nd Clinometer Reading	3rd Clinometer Reading (°)	COS of 3rd Clinometer Reading	Distance to the Tree (m)	Baseline Calculation (m)	Tree Height (m)	Average Tree Height (m)
Specimen 1.										
Specimen 2.										
Specimen 3.										
Specimen 4.										
Specimen 5.										

Baseline = (Distance to the Tree) x (COS of 3rd Clinometer Reading)

Tree Height = [(TAN of 1st Clinometer Reading) x (Baseline)] + [(TAN of 2nd Clinometer Reading) x (Baseline)]

Note: Measure each tree three times and average the three height values. If all three values are within 1 meter of the average, report the values. If not, repeat the measurements until they are within 1 meter of their average, and then report these values.

Land Cover Investigation

Measure Tree Height on a Slope: Two-Triangle with Feet Higher than Tree Base Technique Data Sheet – Page 2

School Name: _____ Site: _____

Measurement Time: _____
Year Month Day Hour (UT)

Recorded By: _____

Clinometer Data

Co-Dominant Species _____	1st Clinometer Reading (°)	TAN of 1st Clinometer Reading	2nd Clinometer Reading (°)	TAN of 2nd Clinometer Reading	3rd Clinometer Reading (°)	COS of 3rd Clinometer Reading	Distance to the Tree (m)	Baseline Calculation (m)	Tree Height (m)	Average Tree Height (m)
Specimen 1.										
Specimen 2.										
Specimen 3.										
Specimen 4.										
Specimen 5.										

Baseline = (Distance to the Tree) x (COS of 3rd Clinometer Reading)

Tree Height = [(TAN of 1st Clinometer Reading) x (Baseline)] + [(TAN of 2nd Clinometer Reading) x (Baseline)]

Note: Measure each tree three times and average the three height values. If all three values are within 1 meter of the average, report the values. If not, repeat the measurements until they are within 1 meter of their average, and then report these values.

Land Cover Investigation

Measure Tree Height on a Slope: Two-Triangle with Feet Lower than Tree Base Technique Data Sheet

School Name: _____ Site: _____

Measurement Time: _____
Year Month Day Hour (UT)

Recorded By: _____

Clinometer Data

Dominant Species _____	1st Clinometer Reading (°)	TAN of 1st Clinometer Reading	2nd Clinometer Reading (°)	TAN of 2nd Clinometer Reading	3rd Clinometer Reading (°)	COS of 3rd Clinometer Reading	Distance to the Tree (m)	Baseline Calculation (m)	Tree Height (m)	Average Tree Height (m)
Specimen 1.										
Specimen 2.										
Specimen 3.										
Specimen 4.										
Specimen 5.										

Baseline = (Distance to the Tree) x (COS of 3rd Clinometer Reading)

Tree Height = [(TAN of 1st Clinometer Reading) x (Baseline)] – [(TAN of 2nd Clinometer Reading) x (Baseline)]

Note: Measure each tree three times and average the three height values. If all three values are within 1 meter of the average, report the values. If not, repeat the measurements until they are within 1 meter of their average, and then report these values.

Land Cover Investigation

Measure Tree Height on a Slope: Two-Triangle with Feet Lower than Tree Base Technique Data Sheet – Page 2

School Name: _____ Site: _____

Measurement Time: _____
Year Month Day Hour (UT)

Recorded By: _____

Clinometer Data

Co-Dominant Species _____	1st Clinometer Reading (°)	TAN of 1st Clinometer Reading	2nd Clinometer Reading (°)	TAN of 2nd Clinometer Reading	3rd Clinometer Reading (°)	COS of 3rd Clinometer Reading	Distance to the Tree (m)	Baseline Calculation (m)	Tree Height (m)	Average Tree Height (m)
Specimen 1.										
Specimen 2.										
Specimen 3.										
Specimen 4.										
Specimen 5.										

Baseline = (Distance to the Tree) x (COS of 3rd Clinometer Reading)

Tree Height = [(TAN of 1st Clinometer Reading) x (Baseline)] – [(TAN of 2nd Clinometer Reading) x (Baseline)]

Note: Measure each tree three times and average the three height values. If all three values are within 1 meter of the average, report the values. If not, repeat the measurements until they are within 1 meter of their average, and then report these values.

Land Cover Investigation

Tree Circumference Data Sheet

School Name: _____ Site: _____

Measurement Time: _____
Year Month Day Hour (UT)

Recorded By: _____

Tree Circumference Measurements

Dominant Species:	**Tree circumference (cm)**
1.	
2.	
3.	
4.	
5.	

Co-Dominant Species:	**Tree circumference (cm)**
1.	
2.	
3.	
4.	
5.	

Land Cover Investigation

Graminoid Biomass Data Sheet

School Name: _____ Site: _____

Measurement Time: _____
Year Month Day Hour (UT)

Recorded By: _____

Graminoid Biomass Measurements

Sample Number	Color	Mass of Sample and Bag (g)	Mass of Empty Bag (g)	Graminoid Biomass (g)
1.	Green			
	Brown			
2.	Green			
	Brown			
3.	Green			
	Brown			

Graminoid Biomass = Mass of Sample and Bag – Mass of Empty Bag

Accuracy Assessment

Work Sheet

	Site Name	Student Map Classification from GLOBE Study Site	Validation Data from Land Cover Sample Sites	✔	✗
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Fire Fuel Protocol

Center Plot Data Sheet

School Name: _____

Observer Names: _____

Date: _____ Study Site Name (give your site a unique name): _____

Aspect: _____ degrees True North (enter 0 for sites with no slope)

Overall slope of stand: looking up _____ slope degrees looking down _____ slope degrees

Heights of trees or shrubs in dominant stratum:

Tree or Shrub	Height(m)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Average height of dominant stratum = (sum of heights) ÷ (total number of trees and shrubs)

Average height: _____

Heights of the base of crowns in lowest stratum:

Tree or Shrub	Height(m)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Average height of base of crowns = (sum of heights) ÷ (total number of trees and shrubs)

Average height: _____

Comments: _____

_____

_____

Fire Fuel Protocol:

Transect Measurements Data Sheet

School Name: _____

Observer Names: _____

Date: _____ Study Site Name (give your site a unique name): _____

Number of Transects: _____

Woody Fuel Counts

	Transect 1	Transect 2	Transect 3	Transect 4
Direction of transect (True North)	90°	330°	270°	210°
Slope of transect (degrees)				
0-1 cm diameters (5-7 m mark)				
1-3 cm diameters (5-10 m mark)				
3-8 cm diameters (5-25 m mark)				

	Transect 5	Transect 6	Transect 7
Direction of transect (True North)	150°	90°	30°
Slope of transect (degrees)			
0-1 cm diameters (5-7 m mark)			
1-3 cm diameters (5-10 m mark)			
3-8 cm diameters (5-25 m mark)			

MUC Glossary of Terms

This glossary provides definitions, decision criteria, and examples for the land cover types outlined in the Modified UNESCO Classification (MUC) System. The land cover types are organized numerically in the same order as the classes appear in the MUC System Table. Miscellaneous terms used in the glossary are defined in the section following the numbered MUC definitions.

The MUC Glossary of Terms contains four columns of information:

1. **MUC Class** – the number used to classify each land cover type.
2. **MUC Name** – the name used to describe each land cover type.
3. **MUC Level** – the hierarchical level of the MUC System for each MUC Class from 1 (general classes) to 4 (detailed classes).
4. **Definitions** – definitions, decision criteria, and examples used to define each MUC Class.

References

A land use and land cover classification system for use with remote sensor data. J.R. Anderson, E.E. Hardy, J.T. Roach, and R.E. Witmer. U.S. Geol. Surv. Professional Paper, 1976.

The Atmosphere: An Introduction to Meteorology, 6th Ed. Lutgens, Fredrick K. & Tarbuck, Edward J. Englewood Cliffs, NJ: Prentice Hall, Inc., 1995.

Biology of Plants, 5th Ed. Raven, Peter H., Evert, Ray F., & Eichhorn, Susan E. New York, NY: Worth Publishers, 1992.

Classification of wetlands and deepwater habitats of the United States. L.M. Cowardin, V. Carter, F.C. Golet, and E.T. LaRoe. U.S. Fish and Wildlife Service. FWS/OBS-79/31, 1979.

International classification and mapping of vegetation. United Nations Educational, Scientific and Cultural Organization. Switzerland: UNESCO, 1973.

NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation. J.E. Dobson et al. NOAA Technical Report NMFS 123, 1995.

MUC (Modified UNESCO Classification) System Glossary

MUC Class	MUC Name	MUC Level	Definitions
0	**Closed Forest**	**level 1**	**Formed by trees at least 5 meters tall with their crowns (i.e. branches) interlocking. The tree canopy covers at least 40% of the ground.**
01	Mainly Evergreen	level 2	Within *Closed Forest* (0). The canopy is never without green foliage. At least 50% of the trees that reach the canopy are evergreen. Individual trees may shed their leaves.
011	Tropical Wet (Rain)	level 3	Within *Mainly Evergreen Closed Forest* (01). Often called a tropical rain forest. Consisting mainly of broad-leaved evergreen trees, neither cold nor drought resistant. Truly evergreen, i.e. the forest canopy remains green all year though a few individual trees may be leafless for a few weeks. Leaves of many species have "drip tips."
0111	Lowland	level 4	Within *Tropical Wet Mainly Evergreen Closed Forest* (011). Consists usually of numerous species of fast growing trees, many exceeding 50 meters tall, generally with smooth, often thin bark, some with buttresses. Emergent trees or at least a very uneven canopy often present. Undergrowth is sparse, composed mainly of tree seedlings. Palms and other tuft trees usually are rare. Crustose lichens and green algae are present, and climbing vines are usually only abundant in extremely humid regions (e.g., Sumatra, Atrato Valley, Columbia).
0112	Submontane	level 4	Within *Tropical Wet Mainly Evergreen Closed Forest* (011). Emergent trees are largely absent and the canopy is relatively even. Forbs are common in the undergrowth. Vascular epiphytes and vines are abundant. E.g., Atlantic slopes of Costa Rica.
0113	Montane	level 4	Within *Tropical Wet Mainly Evergreen Closed Forest* (011). Trees are less than 50 meters tall, have crowns that extend relatively far down the stem, and often have rough bark. Undergrowth abundant, often with ferns, herbs, mosses, and small palms. E.g., Sierra de Talamanca, Costa Rica.
0114	Subalpine	level 4	Within *Tropical Wet Mainly Evergreen Closed Forest* (011). Occurs at elevations above montane forests, with characteristic vegetation, which is dependent on latitude.
0115	Cloud	level 4	Within *Tropical Wet Mainly Evergreen Closed Forest* (011). Trees are gnarled, have rough bark and are rarely greater than 20 meters tall. Tree crowns, branches, and trunks are burdened with epiphytes, mainly chamaephytic bryophytes. Also, the ground is covered with hygromorphic chamaephytes such as *Selaginella* and ferns. E.g., Blue Mountains, Jamaica.
012	Tropical and Subtropical Seasonal	level 3	Within *Mainly Evergreen Closed Forest* (01). Consisting mainly of broad-leaved evergreen trees. Foliage reduction during the dry season is noticeable, often as partial shedding. Transitional between Tropical Wet Forest and Tropical and Subtropical Semi-deciduous.
0121	Lowland	level 4	Within *Tropical and Subtropical Evergreen Seasonal Closed Forest* (012). Consists of fast growing trees, many exceeding 50 meters tall and usually forming an uneven canopy. Undergrowth is sparse, lichen and green algae are present, and climbing vines are absent.
0122	Submontane	level 4	Within *Tropical and Subtropical Evergreen Seasonal Closed Forest* (012). Trees form an even canopy. Forbs are common in the undergrowth. Vascular epiphytes and vines are abundant.
0123	Montane	level 4	Within *Tropical and Subtropical Evergreen Seasonal Closed Forest* (012). Trees are less than 50 meters tall, have crowns that extend relatively far down the stem and have rough bark. There are no tree ferns; instead, evergreen shrubs are most common.

0124	Subalpine	level 4	Within *Tropical and Subtropical Evergreen Seasonal Closed Forest* (012). This forest resembles the Winter-rain Evergreen Broad-leaved Sclerophyllous dry forest and usually occurs above the cloud forest. Trees are mostly evergreen sclerophyllous trees, smaller than 20 meters with little or no undergrowth, few climbing vines, and few epiphytes, except lichens.
013	Tropical and Subtropical Semi-Deciduous	level 3	Within Mainly *Evergreen Closed Forest* (01). Most of the upper canopy trees are drought-deciduous; many of the understory trees and shrubs are evergreen and more or less sclerophyllous. However, evergreen and deciduous woody plants and shrubs are not always separated by layers; they may occur mixed within the same layer, or shrubs may be primarily deciduous and trees evergreen. Nearly all trees have bud protection and leaves without "drip tips." Trees have rough bark, except some bottle trees, which may be present.
0131	Lowland	level 4	Within *Mainly Evergreen Tropical and Subtropical Semi-deciduous Closed Forest* (013). The taller trees may be bottle trees (e.g., *Ceiba*). There are practically no epiphytes present. The undergrowth is composed of shrubs and seedlings. Succulents such as thin-stemmed caespitose cacti may be present. Vines occur occasionally. A sparse layer of herbaceous vegetation may also be present.
0133	Montane and Cloud	level 4	Within *Mainly Evergreen Tropical and Subtropical Semi-deciduous Closed Forest* (013). This forest is similar to a Semi-deciduous Lowland Forest, however, the canopy is lower and covered with xerophytic epiphytes such as *Tillandsia usneoides*.
014	Subtropical Wet	level 3	Within *Mainly Evergreen Closed Forest* (01). Present only locally and in small fragmentary stands, because the subtropical climate typically has a dry season. It usually grades into Tropical Wet Forest (e.g., Queensland, Australia and Taiwan). Some shrubs may grow in the understory. Seasonal temperature change occurs between summer and winter. There is a more pronounced temperature difference between summer and winter than the (Tropical Wet) Montane Forest (0113).
0141	Lowland	level 4	Within *Mainly Evergreen Subtropical Wet Closed Forest* (014). Consists usually of numerous species of fast growing trees, many exceeding 50 meters tall, generally with smooth, often thin bark, some with buttresses. Emergent trees or at least a very uneven canopy often present. Undergrowth is sparse, composed mainly of tree seedlings. Palms and other tuft trees usually are rare. Crustose lichens and green algae are present, and climbing vines are usually only abundant in extremely humid regions.
0142	Submontane	level 4	Within *Mainly Evergreen Subtropical Wet Closed Forest* (014). Emergent trees are largely absent and the canopy is relatively even. Forbs are common in the undergrowth. Vascular epiphytes and vines are abundant.
0143	Montane	level 4	Within *Mainly Evergreen Subtropical Wet Closed Forest* (014). Trees are less than 50 meters tall, have crowns that extend relatively far down the stem, and often have rough bark. Undergrowth abundant, often with ferns, herbs, mosses, and small palms.
0144	Subalpine	level 4	Within *Mainly Evergreen Subtropical Wet Closed Forest* (014). Occurs at elevations above montane forests, with characteristic vegetation, which is dependent on latitude.
0145	Cloud	level 4	Within *Mainly Evergreen Subtropical Wet Closed Forest* (014). Trees are gnarled, have rough bark and are rarely greater than 20 meters tall. Tree crowns, branches, and trunks are burdened with epiphytes, mainly chamaephytic bryophytes. Also, the ground is covered with hygromorphic chamaephytes (e.g., *Selaginella* and herbaceous ferns).
015	Temperate or Subpolar Wet	level 3	Within *Mainly Evergreen Closed Forest* (01). Occurs only in the extremely oceanic, nearly frost-free climates of the southern hemisphere, mainly in Chile. Consisting mostly of truly evergreen hemisclerophyllous trees and shrubs. Rich in epiphytic mosses, liverworts, and lichens that grow on trees, and in ground-rooted herbaceous ferns.
0151	Temperate	level 4	Within *Mainly Evergreen Temperate or Subpolar Wet Closed Forest* (015). Trees are generally greater than 10 meters tall. Vascular epiphytes and vines may be present.

0152	Subpolar	level 4	Within *Mainly Evergreen Temperate or Subpolar Wet Closed Forest* (015). Trees are generally less than 10 meters tall and often have reduced leaf size. There are few vascular epiphytes present. E.g., beech forests of New Zealand.
016	Temperate with Broad-Leaved Deciduous	level 3	Within *Mainly Evergreen Closed Forest* (01). Requires adequate summer rainfall. This is a mixed evergreen-deciduous class. The dominant trees are mainly hemisclerophyllous evergreen trees (more than 50% of the canopy) and shrubs, and the subdominant trees are deciduous broad-leaved trees and shrubs (more than 25% of the canopy). Rich in perennial herbaceous plants. Very few or no vascular epiphytes and vines.
0161	Lowland	level 4	Within *Temperate Deciduous Broad-Leaved Mainly Evergreen Closed Forest* (016). Consists usually of numerous species of fast growing trees, many exceeding 50 meters tall, generally with smooth, often thin bark, some with buttresses. Emergent trees or at least a very uneven canopy often present. Undergrowth is sparse, composed mainly of tree seedlings. Palms and other tuft trees usually are rare. Crustose lichens and green algae are present, and climbing vines are usually only abundant in extremely humid regions.
0162	Submontane	level 4	Within *Temperate Deciduous Broad-Leaved Mainly Evergreen Closed Forest* (016). Emergent trees are largely absent and the canopy is relatively even. Forbs are common in the undergrowth. Vascular epiphytes and vines are abundant.
0163	Montane	level 4	Within *Temperate Deciduous Broad-Leaved Mainly Evergreen Closed Forest* (016). Trees are less than 50 meters tall, have crowns that extend relatively far down the stem, and often have rough bark. Undergrowth abundant, often with ferns, herbs, mosses, and small palms.
0164	Subalpine	level 4	Within *Temperate Deciduous Broad-Leaved Mainly Evergreen Closed Forest* (016). Occurs at elevations above montane forests, with characteristic vegetation, which is dependent on latitude.
017	Winter-Rain Broad-Leaved Sclerophyllous	level 3	Within *Mainly Evergreen Closed Forest* (01). Often understood as Mediterranean, but present also in southwestern Australia, Chile, and other locations. The climate has a pronounced summer drought. Consisting mainly of sclerophyllous evergreen trees and shrubs, most of which have rough bark. There is very little herbaceous undergrowth. No vascular and few non-flowering epiphytes and lichens, but evergreen woody vines are present.
0171	Lowland and Submontane >50m	level 4	Within *Winter-Rain Evergreen Broad-Leaved Sclerophyllous Closed Forest* (017). Dominated by trees over 50 meters tall (at least 50% of the canopy) such as giant eucalyptus (e.g., *Eucalyptus regnans* in Victoria, Australia and *E. diversicolor* in Western Australia).
0172	Lowland and Submontane <50m	level 4	Within *Winter-Rain Evergreen Broad-Leaved Sclerophyllous Closed Forest* (017). Dominated by trees less than 50 meters tall (more than 50% of the canopy). E.g., Californian live-oak forests.
018	Tropical and Subtropical Needle-Leaved	level 3	Within *Mainly Evergreen Closed Forest* (01). Consisting mainly of needle-leaved or scale-leaved evergreen trees (more than 50% of the canopy). Broad-leaved trees may be present. Vascular epiphytes and vines rarely present. Species typical of the tropical/subtropical zone.
0181	Lowland and Submontane	level 4	Within *Tropical and Subtropical Needle-Leaved Mainly Evergreen Closed Forest* (018). E.g., the pine forests of Honduras and Nicaragua.
0182	Montane and Subalpine	level 4	Within *Tropical and Subtropical Needle-Leaved Mainly Evergreen Closed Forest* (018). E.g., the pine forests of the Philippines and southern Mexico.
019	Temperate and Subpolar Needle-Leaved	level 3	Within *Mainly Evergreen Closed Forest* (01). Consisting mainly of needle-leaved or scale-leaved evergreen trees (more than 50% of the canopy), but broad-leaved trees may be present. Vascular epiphytes and vines are rarely present. Species typical of the temperate/subpolar zone.
0191	Giant (> 50m)	level 4	Within *Temperate and Subpolar Needle-Leaved Mainly Evergreen Closed Forest* (019). Dominated by trees (at least 50% of the canopy) greater than 50 meters tall (e.g., *Sequoia* and *Pseudo-tsuga* forest in the Pacific West of North America).

0192	Irregularly Rounded Crowns	level 4	Within *Temperate and Subpolar Needle-Leaved Mainly Evergreen Closed Forest* (019). Dominated by trees 45-50 meters tall (more than 50% of the canopy), with broad, irregularly rounded crowns (e.g., *Pinus* spp.).
0193	Conical Crowns	level 4	Within *Temperate and Subpolar Needle-Leaved Mainly Evergreen Closed Forest* (019). Dominated by trees 45-50 meters tall (more than 50% of the canopy), with conical crowns (like most *Picea* and *Abies*). E.g., California red fir forests.
0194	Cylindrical Crowns	level 4	Within *Temperate and Subpolar Needle-Leaved Mainly Evergreen Closed Forest* (019). Dominated by trees 45-50 meters tall (more than 50% of the canopy), with crowns with very short branches and therefore a narrow cylindrical shape.
02	Mainly Deciduous	level 2	Within *Closed Forest* (0). The majority of trees (more than 50% of the canopy) shed their foliage simultaneously in connection with the unfavorable season (drought or cold).
021	Tropical and Subtropical Drought-Deciduous	level 3	Within *Mainly Deciduous Closed Forest* (02). The unfavorable season is mainly characterized by drought, in most cases by winter-drought. Foliage is shed regularly every year. Most trees have relatively thick, fissured bark.
0211	Broad-Leaved Lowland and Submontane	level 4	Within *Tropical and Subtropical Drought-Deciduous Closed Forest* (021). Practically no evergreen plants in stratum except some succulents. Woody and herbaceous vines and deciduous bottle-trees are present occasionally. Sparse herbaceous vegetation present in the undergrowth. E.g., the broad-leaved deciduous forests of northwestern Costa Rica.
0212	Montane and Cloud	level 4	Within *Tropical and Subtropical Drought-Deciduous Closed Forest* (021). Some evergreen species are present in the understory. Drought resistant epiphytes are present or abundant, often of the bearded form (e.g., *Usnea* or *Tillandsia usneoides*). This formation is not frequent, but well developed. E.g., in northern Peru.
022	Cold-Deciduous with Evergreens	level 3	Within *Mainly Deciduous Closed Forest* (02). The unfavorable season is mainly characterized by winter frost. Deciduous broad-leaved trees are dominant (more than 50% of the canopy), but evergreen species are present (more than 25% of the canopy) as part of the main canopy or the understory. Climbers and vascular epiphytes are scarce or absent.
0221	With Evergreen Broad-Leaved Trees and Climbers	level 4	Within *Cold-Deciduous with Evergreens Closed Forest* (022). Rich in epiphytes, including mosses. Vascular epiphytes may be present at the base of tree stems. Climbing vines may be common on flood plains. Ex. *Ilex aquifolium* and *Hedera helix* in western Europe and *Magnolia* spp. in North America.
0222	With Evergreen Needle-Leaved Trees	level 4	Within *Cold-Deciduous with Evergreens Closed Forest* (022). With evergreen needle-leaved trees such as hemlock (*Tsuga*) and pine (*Pinus*). E.g., the maple-hemlock or oak-pine forests of Northeastern, U.S.A.
023	Cold-Deciduous without Evergreen Trees	level 3	Within *Mainly Deciduous Closed Forest* (02). Deciduous trees are absolutely dominant (more than 75% of the canopy). Evergreen herbs and some evergreen shrubs (less than 2 meters tall) may be present. Climbers insignificant but may be common on flood plains. Vascular epiphytes are absent (except occasionally at the lower base of the tree). Mosses, liverworts and particularly lichens are always present.
0231	Temperate Lowland and Submontane Broad-Leaved	level 4	Within *Cold-Deciduous without Evergreen Trees Closed Forest* (023). Trees are up to 50 meters tall. Epiphytes are primarily algae and crustose lichens. E.g., the Mixed Mesophytic Forest of U.S.A.
0232	Montane and Boreal	level 4	Within *Cold-Deciduous without Evergreen Trees Closed Forest* (023). Trees may be up to 50 meters tall, but in montane or boreal forest normally not taller than 30 meters. Epiphytes are primarily lichens and bryophytes. This class includes lowland or submontane in topographic positions with high atmospheric humidity.
0233	Subalpine and Subpolar	level 4	Within *Cold-Deciduous without Evergreen Trees Closed Forest* (023). Trees are not taller than 20 meters and tree trunks are frequently gnarled. Epiphytes are lichens and bryophytes, and are more abundant than in the Montane or Boreal class (0232). This class often grades into woodland.

03	Extremely Xeromorphic (Dry)	level 2	Within *Closed Forest* (0). Dense stands of trees adapted to dry conditions, such as bottle trees, tuft trees with succulent leaves and stem succulents. Undergrowth has shrubs adapted to dry conditions, succulent perennial herbs and annual and perennial herbaceous plants. Often grades into woodland.
031	Sclerophyllous-Dominated	level 3	Within *Extremely Xeromorphic Closed Forest* (03). There is a predominance of sclerophyllous trees, many of which have bulbous stem bases largely embedded in the soil.
032	Thorn-Dominated	level 3	Within *Extremely Xeromorphic Closed Forest* (03). Species with thorns are dominant (more than 50% of the canopy).
0321	Mixed Deciduous-Evergreen	level 4	Within *Extremely Xeromorphic Thorn-Dominated Closed Forest* (032). Both deciduous and evergreen thorn species are more than 25% of the tree canopy.
0322	Purely Deciduous	level 4	Within *Extremely Xeromorphic Thorn-Dominated Closed Forest* (032). Deciduous thorn species are absolutely dominant (more than 75% of the canopy).
033	Mainly Succulent	level 3	Within *Extremely Xeromorphic Closed Forest* (03). Tree-formed (scapose) and shrub-formed (caespitose) succulents are very frequent (more than 50% of the canopy), but other trees and shrubs adapted to dry conditions are usually present as well.
1	**Woodland**	**level 1**	**Comprised of open stands of trees at least 5 meters tall with crowns not interlocking. The tree canopy covers at least 40% of the ground. Definitions for Mainly Evergreen Woodland, Mainly Deciduous Woodland, and Extremely Xeromorphic Woodland are similar to forest definitions, with sparser stocking of individual trees.**
11	Mainly Evergreen	level 2	Within *Woodland* (1). The canopy is never without green foliage. At least 50% of the trees that reach the canopy are evergreen. Individual trees may shed their leaves.
111	Broad-Leaved	level 3	Within *Mainly Evergreen Woodland* (11). Mainly sclerophyllous broad-leaved trees and shrubs, with no epiphytes.
112	Needle-Leaved	level 3	Within *Mainly Evergreen Woodland* (11). Trees are mainly needle- or scale-leaved (more than 50% of the canopy). Crowns of many trees extend to the base of the stem or are very branchy.
1121	Irregularly Rounded Crowns	level 4	Within *Mainly Evergreen Needle-Leaved Woodland* (112). Dominated by trees (more than 50% of the canopy) with broad, irregularly rounded crowns (e.g., *Pinus*).
1122	Conical Crowns	level 4	Within *Mainly Evergreen Needle-Leaved Woodland* (112). Dominated by trees (more than 50% of the canopy) with conical crowns. Mostly in subalpine areas.
1123	Cylindrical Crowns	level 4	Within *Mainly Evergreen Needle-Leaved Woodland* (112). Dominated by trees (more than 50% of the canopy) with crowns with very short branches and therefore a narrow cylindrical shape (e.g., Picea in the boreal regions).
12	Mainly Deciduous	level 2	Within *Woodland* (1). The majority of trees (more than 50% of the canopy) shed their foliage simultaneously in connection with the unfavorable season (drought or cold).
121	Drought-Deciduous	level 3	Within *Mainly Deciduous Woodland* (12). The unfavorable season is mainly characterized by drought, in most cases by winter-drought. Foliage is shed regularly every year. Most trees have relatively thick, fissured bark.
1211	Broad-Leaved Lowland and Submontane	level 4	Within *Drought-Deciduous Woodland* (121). Practically no evergreen plants in any stratum except some succulents. Woody and herbaceous vines and deciduous bottle-trees are present. Sparse herbaceous vegetation present in the undergrowth.
1212	Montane and Cloud	level 4	Within *Drought-Deciduous Woodland* (121). Some evergreen species are present in the understory. Drought resistant epiphytes are present or abundant, often of the bearded form (e.g., *Usnea* or *Tillandsia usneoides*). This formation is not frequent, but well developed. E.g., in northern Peru.

122	Cold-Deciduous with Evergreens	level 3	Within *Mainly Deciduous Woodland* (12). The unfavorable season is mainly characterized by winter frost. Deciduous broad-leaved trees are dominant (more than 50% of the canopy), but evergreen species are present (more than 25% of the canopy) as part of the main canopy or the understory. Climbers and vascular epiphytes are scarce or absent.
1221	With Evergreen Broad-Leaved Trees and Climbers	level 4	Within *Cold-Deciduous with Evergreens Woodland* (122). Rich in epiphytes, including mosses. Vascular epiphytes may be present at the base of tree stems. Climbing vines may be common on flood plains. *Ilex aquifolium* and *Hedera helix* in western Europe and *Magnolia* spp. in North America are examples of this class type.
1222	With Evergreen Needle-Leaved Trees	level 4	Within *Cold-Deciduous with Evergreens Woodland* (122). With evergreen needle-leaved trees such as hemlock (*Tsuga*) and pine (*Pinus*). E.g., the maple-hemlock or oak-pine woodlands of Northeastern, U.S.A.
123	Cold-Deciduous without Evergreen Trees	level 3	Within *Mainly Deciduous Woodland* (12). Cold-deciduous tree species are absolutely dominant (more than 75% of the canopy). Evergreen herbs and some evergreen shrubs (less than 2 meters tall) may be present. Climbers insignificant but may be common on flood plains. Vascular epiphytes are absent (except occasionally at the lower base of the tree). Mosses, liverworts and particularly lichens are always present. Most frequent in the subarctic region, elsewhere only in swamps or bogs.
1231	Broad-Leaved	level 4	Within *Cold-Deciduous without Evergreen Trees Woodland* (123). Broad-leaved deciduous species are absolutely dominant (more than 75% of the canopy).
1232	Needle-leaved	level 4	Within *Cold-Deciduous without Evergreen Trees Woodland* (123). Needle-leaved deciduous species are absolutely dominant (more than 75% of the canopy).
1233	Mixed	level 4	Within *Cold-Deciduous without Evergreen Trees Woodland* (123). Both broad-leaved and needle leaved deciduous species provide more than 25% of the canopy.
13	Extremely Xeromorphic (Dry)	level 2	Within *Woodland* (1). Stands of trees and shrubs adapted to dry conditions, such as bottle trees, tuft trees with succulent leaves and stem succulents. Undergrowth has shrubs adapted to dry conditions, succulent perennial herbs and annual and perennial herbaceous plants. Woodlands may grade into forests.
131	Sclerophyllous-Dominated	level 3	Within *Extremely Xeromorphic Woodland* (13). There is a predominance of sclerophyllous trees, many of which have bulbous stem bases largely embedded in the soil.
132	Thorn-Dominated	level 3	Within *Extremely Xeromorphic Woodland* (13). Species with thorns are dominant (more than 50% of the canopy).
1321	Mixed Deciduous-Evergreen	level 4	Within *Extremely Xeromorphic Thorn-Dominated Woodland* (132). Both deciduous species and evergreen species are more than 25% of the tree canopy. See definitions of Mainly Evergreen Woodland, class 11 and Mainly Deciduous Woodland (MUC Class 12).
1322	Purely Deciduous	level 4	Within *Extremely Xeromorphic Thorn-Dominated Woodland* (132). Deciduous thorn species are absolutely dominant (more than 75% of the canopy). See definition of Mainly Deciduous Woodland (MUC Class 12).
133	Mainly Succulent	level 3	Within *Extremely Xeromorphic Woodland* (13). Tree-formed (scapose) and shrub-formed (caespitose) succulents are very frequent(more than 50% of the tree canopy), but other trees and shrubs adapted to dry conditions are usually present as well.
2	**Shrubland or Thicket**	**level 1**	**The shrub canopy covers at least 40% of the ground and is composed of matted, clumped or clustered woody plants 0.5 to 5 meters tall.** ***Shrubland:* most of the individual shrubs are not touching each other; often with grass growing between shrubs. Shrublands are also further defined (like Forests and Woodlands) as Evergreen Broad-leaved, Evergreen Needle-leaved, Mainly Deciduous, etc.** ***Thicket:* individual shrub branches are interlocked.**

21	Mainly Evergreen	level 2	Within *Shrubland or Thicket* (2). The canopy is never without green foliage. At least 50% of the shrubs that reach the canopy are evergreen. Individual shrubs may shed their leaves.
211	Broad-Leaved	level 3	Within *Mainly Evergreen Shrubland or Thicket* (21). Evergreen broad-leaved species are dominant (more than 50% of the canopy).
2111	Low Bamboo	level 4	Within *Mainly Evergreen Broad-Leaved Shrubland or Thicket* (211). Bamboo species are dominant. (Lignified creeping graminoid nano- or microphanerophytes).
2112	Tuft-Tree	level 4	Within *Mainly Evergreen Broad-Leaved Shrubland or Thicket* (211). Composed of small trees and woody shrubs. E.g., Mediterranean dwarf palms shrubland or Hawaiian tree fern thicket or shrubland.
2113	Broad-Leaved Hemi-Sclerophyllous	level 4	Within *Mainly Evergreen Broad-Leaved Shrubland or Thicket* (211). Matted or clumped shrubs and plants with large soft leaves (caespitose, creeping or lodged nano- or microphanerophytes). E.g., subalpine *Rhododendron* thickets, or *Hibiscus tiliaeceus* matted thickets of Hawaii.
2114	Broad-Leaved Sclerophyllous	level 4	Within *Mainly Evergreen Broad-Leaved Shrubland or Thicket* (211). Dominated by broad-leaved sclerophyllous shrubs and immature trees (e.g., chapparal or macchia). May often merge with parkland, grassland or heath.
2115	Suffruticose	level 4	Within *Mainly Evergreen Broad-Leaved Shrubland or Thicket* (211). Stand of semi-lignified nanophanerophytes that in dry years may shed part of their shoot systems (e.g., *Cistus* heath).
212	Needle-Leaved or Microphyllous	level 3	Within *Mainly Evergreen Shrubland or Thicket* (21). Dominant species (more than 50% of the canopy) have either needle leaves or small leaves.
2121	Needle-Leaved	level 4	Within *Mainly Evergreen Needle-Leaved or Microphyllous Shrubland or Thicket* (212). Composed of creeping or lodged needle-leaved shrubs (e.g., *Pinus mughus*, "Krummholz").
2122	Microphyllous	level 4	Within *Mainly Evergreen Needle-Leaved or Microphyllous Shrubland or Thicket* (212). Evergreen species have small leaves, (e.g., desert plants) or leaves with a single unbranched vein. Mostly in tropical subalpine belts.
22	Mainly Deciduous	level 2	Within *Shrubland or Thicket* (2). The majority of shrubs (more than 50% of the canopy) shed their foliage simultaneously in connection with the unfavorable season (cold or drought).
221	Drought-Deciduous with Evergreen Woody Plants	level 3	Within *Mainly Deciduous Shrubland or Thicket* (22). Drought-deciduous shrubs are dominant (greater than 50% of the canopy) and are mixed with at least 25% evergreen woody plants. The unfavorable season is mainly characterized by drought.
222	Drought-Deciduous without Evergreen Woody Plants	level 3	Within *Mainly Deciduous Shrubland or Thicket* (22). Drought-deciduous shrubs are absolutely dominant (more than 75% of the canopy). The unfavorable season is mainly characterized by drought.
223	Cold-Deciduous	level 3	Within *Mainly Deciduous Shrubland or Thicket* (22). The unfavorable season is mainly characterized by winter frost. Deciduous shrubs are dominant (more than 50% of the canopy).
2231	Temperate	level 4	Within *Cold-Deciduous Shrubland or Thicket* (223). Composed of dense scrub without, or with very little herbaceous undergrowth. Very few to no cryptogams.
2232	Subalpine and Subpolar	level 4	Within *Cold-Deciduous Shrubland or Thicket* (223). Composed of upright or lodged matted shrubs with great vegetative regeneration capacity and usually covered by snow for at least half a year.
23	Extremely Xeromorphic (Subdesert) Shrubland	level 2	Within *Shrubland or Thicket* (2). Very open stands of shrubs with various adaptations to dry conditions, such as: extremely thickened, hardened foliage; very reduced leaves; green branches without leaves; or succulent stems, some of them with thorns.

231	Mainly Evergreen	level 3	Within *Extremely Xeromorphic Shrubland* (23). The canopy is never without green foliage. At least 50% of the shrubs that reach the canopy are evergreen. In extremely dry years some leaves and shoot portions may be shed.
2311	Purely Evergreen	level 4	Within *Mainly Evergreen Extremely Xeromorphic Shrubland* (231). Composed of broad-leaved mostly sclerophyllous shrubs (e.g., mulga scrub in Australia) leafless green-stemmed plants (e.g. *Retama retam*) or succulents dominated by variously branched stem and leaf succulents.
2312	Semi-Deciduous	level 4	Within *Mainly Evergreen Extremely Xeromorphic Shrubland* (231). May consist of either facultatively deciduous shrubs (e.g., *Atriplex-Kochia* saltbush in Australia and North America) or a combination of evergreen and deciduous shrubs (i.e. evergreen shrubs are dominant, deciduous shrubs cover more than 25%).
232	Mainly Deciduous	level 3	Within *Extremely Xeromorphic Shrubland* (23). The majority of shrubs (more than 50% of the canopy) shed their foliage simultaneously in connection with the unfavorable season (cold or drought).
2321	Without Succulents	level 4	Within *Mainly Deciduous Extremely Xeromorphic Shrubland* (232). Succulents cover less than 25% of the ground.
2322	With Succulents	level 4	Within *Mainly Deciduous Extremely Xeromorphic Shrubland* (232). Succulents cover at least 25% of the ground.
3	**Dwarf-Shrubland or Dwarf- Thicket**	**level 1**	**Shrubs rarely exceed 50 cm in height (sometimes called heaths or heathlike formations). The shrub canopy covers at least 40% of the ground. The shrub cover density distinguishes between Dwarf-Shrubland and Dwarf-Thicket classes.** ***Dwarf-Shrubland*: individual dwarf-shrubs are isolated or in clumps.** ***Dwarf-Thicket*: individual shrub branches are interlocked.**
31	Mainly Evergreen	level 2	Within *Dwarf-Shrubland or Dwarf-Thicket* (3). The canopy is never without green foliage. At least 50% of the shrubs that reach the canopy are evergreen. Individual shrubs may shed their leaves.
311	Dwarf-Thicket	level 3	Within *Mainly Evergreen Dwarf-Shrubland or Dwarf-Thicket* (31). Composed of densely closed dwarf-shrub cover, which dominates the landscape.
3111	Caespitose	level 4	Within *Mainly Evergreen Dwarf-Thicket* (311). Shrub branches stand upright and are often occupied by lichens (foliose). Cushion-shaped mosses, lichens and other herbaceous plants are often found on the ground (e.g., *Calluna* heath).
3112	Creeping	level 4	Within *Mainly Evergreen Dwarf-Thicket* (311). Shrub branches creep along the ground. Variously combined with shrubs (e.g., thallochamaephytes) with branches that may be embedded (e.g., *Loiseleuria* heath).
312	Dwarf-Shrubland	level 3	Within *Mainly Evergreen Dwarf-Shrubland or Dwarf-Thicket* (31). Open or less dense cover of dwarf-shrubs. Shrub canopies are not interlocked. Herbaceous vegetation (i.e. grasses and forbs) covers less than 25% of the ground.
3121	Cushion	level 4	Within *Mainly Evergreen Dwarf-Shrubland* (312). Shrubs are isolated in clumps forming dense cushions and are often thorny (e.g., *Astragalus*- and *Acantholimon* "porcupine"-heath of the East Mediterranean mountains).
313	Mixed Evergreen and Herbaceous Dwarf-Shrubland	level 3	Within *Mainly Evergreen Dwarf-Shrubland or Dwarf-Thicket* (31). Shrub canopies are not interlocked. Evergreen shrubs are mixed with herbaceous vegetation (at least 25% of the ground).
3131	True Evergreen and Herbaceous Mixed	level 4	Within *Mixed Evergreen and Herbaceous Dwarf-Shrubland* (313). True Evergreen individuals do not seasonally shed parts of their shoot systems. E.g., *Nardus Calluna*-heath.
3132	Partial Evergreen and Herbaceous Mixed	level 4	Within *Mixed Evergreen and Herbaceous Dwarf-Shrubland* (313). Many individuals shed parts of their shoot systems during the dry season (e.g., *Phyrgana* in Greece).
32	Mainly Deciduous	level 2	Within *Dwarf-Shrubland or Dwarf-Thicket* (3). The majority of shrubs (more than 50% of the canopy) shed their foliage simultaneously in connection with the unfavorable season (cold or drought).

321	Facultative Drought-Deciduous	level 3	Within *Mainly Deciduous Dwarf-Shrubland or Dwarf-Thicket* (32). Dwarf-shrubs shed their foliage only in extremely dry years.
322	Obligate Drought-Deciduous	level 3	Within *Mainly Deciduous Dwarf-Shrubland or Dwarf-Thicket* (32). Densely closed dwarf-shrubs lose all or at least part of their leaves in the dry season.
3221	Caespitose Dwarf-Thicket	level 4	Within *Obligate Drought-Deciduous Dwarf-Shrubland or Dwarf-Thicket* (322). Shrub branches stand upright and are often occupied by lichens (foliose). Cushion-shaped mosses, lichens and other herbaceous plants are often found on the ground (e.g., *Calluna* heath).
3222	Creeping Dwarf-Thicket.	level 4	Within *Obligate Drought-Deciduous Dwarf-Shrubland or Dwarf-Thicket* (322). Shrub branches creep along the ground. Variously combined with shrubs (i.e. thallochamaephytes) with branches that may be embedded (e.g., *Loiseleuria* heath).
3223	Cushion Dwarf-Shrubland	level 4	Within *Obligate Drought-Deciduous Dwarf-Shrubland or Dwarf-Thicket* (322). Shrubs are isolated in clumps forming dense cushions and are often thorny.
3224	Mixed Dwarf-Shrubland	level 4	Within *Obligate Drought-Deciduous Dwarf-Shrubland or Dwarf-Thicket* (322). Deciduous and evergreen dwarf-shrubs, caespitose herbaceous plants, succulent perennial herbs, and other species intermixed.
323	Cold-Deciduous	level 3	Within *Mainly Deciduous Dwarf-Shrubland or Dwarf-Thicket* (32). Densely closed dwarf-shrubs shed foliage at the beginning of a cold season. Richer in mosses and ferns than the Obligate Drought-deciduous Dwarf Thicket or Shrubland class (322).
3231	Caespitose Dwarf-Thicket	level 4	Within *Cold-deciduous Dwarf-Shrubland or Dwarf-Thicket* (323). Shrub branches stand upright and are often occupied by lichens (foliose). Cushion-shaped mosses, lichens and other herbaceous plants are often found on the ground.
3232	Creeping Dwarf-Thicket	level 4	Within *Cold-deciduous Dwarf-Shrubland or Dwarf-Thicket* (323). Shrub branches creep along the ground; combined with shrubs with branches that may be embedded.
3233	Cushion Dwarf-Shrubland	level 4	Within *Cold-deciduous Dwarf-Shrubland or Dwarf-Thicket* (323). Shrubs are isolated in clumps forming dense cushions and are often thorny.
3234	Mixed Dwarf-Shrubland	level 4	Within *Cold-deciduous Dwarf-Shrubland or Dwarf-Thicket* (323). Deciduous and evergreen dwarf-shrubs, caespitose herbaceous plants, succulent perennial herbs, and other species intermixed.
33	Extremely Xeromorphic (Subdesert) Dwarf-Shrubland	level 2	Within *Dwarf-Shrubland or Dwarf-Thicket* (3). Composed of open formations of dwarf-shrubs, succulents, and herbaceous plants adapted to survive or to avoid a long dry season. Mostly subdesertic.
331	Mainly Evergreen	level 3	Within *Extremely Xeromorphic Dwarf-Shrubland* (33). The canopy is never without green foliage. At least 50% of the shrubs that reach the canopy are evergreen. In extremely dry years some leaves and shoot portions may be shed.
3311	Purely Evergreen	level 4	Within *Mainly Evergreen Extremely Xeromorphic Dwarf-Shrubland* (331). Composed of broad-leaved mostly sclerophyllous shrubs, leafless green-stemmed plants, or succulents dominated by variously branched stem and leaf succulents.
3312	Semi-Deciduous	level 4	Within *Mainly Evergreen Extremely Xeromorphic Dwarf-Shrubland* (331). May consist of either facultatively deciduous shrubs or a combination of evergreen and deciduous shrubs (i.e. evergreen shrubs are dominant, deciduous shrubs cover more than 25%).
332	Mainly Deciduous	level 3	Within *Extremely Xeromorphic Dwarf-Shrubland* (33). The majority of shrubs (more than 50% of the canopy) shed their foliage simultaneously in connection with the unfavorable season (cold or drought).
3321	Without Succulents	level 4	Within *Mainly Deciduous Extremely Xeromorphic Dwarf-Shrubland* (332). Succulents cover less than 25% of the ground.

3322	With Succulents	level 4	Within *Mainly Deciduous Extremely Xeromorphic Dwarf-Shrubland* (332). Succulents cover at least 25% of the ground.
34	Tundra	level 2	Within *Dwarf-Shrubland or Dwarf-Thicket* (3). Slowly growing, low formations, consisting mainly of dwarf-shrubs, graminoids, mosses, liverworts and lichens, found beyond the subpolar tree line. Often showing plant patterns caused by freezing movements of the soil. Except in boreal regions, dwarf-shrub formations above the mountain tree line should not be called tundra, because they are, as a rule, richer in dwarf-shrubs and grasses, and grow taller due to greater solar radiation in lower latitudes.
341	Mainly Bryophyte	level 3	Within *Tundra Dwarf-Shrubland or Dwarf-Thicket* (34). Dominated by mats or small cushions of chamaephytic mosses (more than 50% of the vegetative cover). Groups of dwarf-shrubs are as a rule scattered irregularly and are not very dense. The general aspect is more or less dark green, olive green or brownish.
3411	Caespitose	level 4	Within *Mainly Bryophyte Tundra Dwarf-Shrubland or Dwarf-Thicket* (341). Clumped or clustered dwarf-shrubs are present.
3412	Creeping	level 4	Within *Mainly Bryophyte Tundra Dwarf-Shrubland or Dwarf-Thicket* (341). Creeping or matted dwarf-shrubs are present.
342	Mainly Lichen	level 3	Within *Tundra Dwarf-Shrubland or Dwarf-Thicket* (34). Mats of fruticose lichens dominate (more than 50% of the vegetative cover), giving the formation a more or less pronounced gray aspect. Mostly evergreen, creeping or cushion-shaped dwarf-shrubs are present.
4	**Herbaceous Vegetation**	**level 1**	**Dominated by herbaceous growth of two major types: graminoids and forbs. Graminoids include all herbaceous grasses and grass-like plants such as sedges (*Carex*), rushes (*Juncus*), and cattails (*Typha*). Forbs are broad-leaved herbaceous plants such as clover (*Trifolium*), sunflowers (*Helianthus*), ferns, and milkweeds (*Asclepias*). Total ground coverage must be greater than 60% herbaceous vegetation.**
41	Tall Graminoid	level 2	Within *Herbaceous Vegetation* (4). Plant community consists of dominant grasses over 2 meters tall when flowering or mature (more than 50% of the herbaceous vegetation). Forbs may be present but comprise less than 50% of herbaceous vegetation.
411	With Trees Covering 10-40%	level 3	Within *Tall Graminoid Herbaceous Vegetation* (41). May be with or without shrubs. This is somewhat like a very open woodland with more or less continuous ground cover (over 60%) of tall graminoids.
4110	Trees: Needle-Leaved Evergreen	level 4	Within *Tall Graminoid Herbaceous Vegetation with Trees Covering 10-40%* (411). Needle-leaved evergreen species are greater than 50% of the tree canopy.
4111	Trees: Broad-Leaved Evergreen	level 4	Within *Tall Graminoid Herbaceous Vegetation with Trees Covering 10-40%* (411). Broad-leaved evergreen species are greater than 50% of the tree canopy.
4112	Trees: Broad-Leaved Semi-Evergreen	level 4	Within *Tall Graminoid Herbaceous Vegetation with Trees Covering 10-40%* (411). Trees present are at least 25% each of broad-leaved evergreen and broad-leaved deciduous trees.
4113	Trees: Broad-Leaved Deciduous	level 4	Within *Tall Graminoid Herbaceous Vegetation with Trees Covering 10-40%* (411). Broad-leaved species are greater than 50% of the tree canopy. The area is seasonally flooded. E.g., Northeast Bolivia.
412	With Trees Covering <10%	level 3	Within *Tall Graminoid Herbaceous Vegetation* (41). Grassland with trees covering less than 10% of the ground, with or without shrubs.
4120	Trees: Needle-Leaved Evergreen	level 4	Within *Trees Covering <10% Tall Graminoid Herbaceous Vegetation* (412). Needle-leaved evergreen species are greater than 50% of the tree canopy.
4121	Trees: Broad-Leaved Evergreen	level 4	Within *Trees Covering <10% Tall Graminoid Herbaceous Vegetation* (412). Broad-leaved evergreen species are greater than 50% of the tree canopy.

4122	Trees: Broad-Leaved Semi-Evergreen	level 4	Within *Trees Covering <10% Tall Graminoid Herbaceous Vegetation* (412). Trees present are at least 25% each of broad-leaved evergreen and broad-leaved deciduous trees.
4123	Trees: Broad-Leaved Deciduous	level 4	Within *Trees Covering <10% Tall Graminoid Herbaceous Vegetation* (412). Broad-leaved species are greater than 50% of the tree canopy. The area is seasonally flooded.
4124	Tropical and Subtropical with Trees and Shrubs in Tufts on Termite Nests	level 4	Within *Trees Covering <10% Tall Graminoid Herbaceous Vegetation* (412). Tropical or subtropical tall grassland with trees and/or shrubs growing in tufts on termite nests. Also called termite savannah.
413	With Shrubs	level 3	Within *Tall Graminoid Herbaceous Vegetation* (41). The shrub canopy must cover more than 25% of the ground.
4130	Shrubs: Needle-Leaved Evergreen	level 4	Within *Tall Graminoid Herbaceous Vegetation with Shrubs* (413). Needle-leaved evergreen species are greater than 50% of the shrub canopy.
4131	Shrubs: Broad-Leaved Evergreen	level 4	Within *Tall Graminoid Herbaceous Vegetation with Shrubs* (413). Broad-leaved evergreen species are greater than 50% of the shrub canopy.
4132	Shrubs: Broad-Leaved Semi-Evergreen	level 4	Within *Tall Graminoid Herbaceous Vegetation with Shrubs* (413). Shrubs present are at least 25% each of broad-leaved evergreen and broad-leaved deciduous.
4133	Shrubs: Broad-Leaved Deciduous	level 4	Within *Tall Graminoid Herbaceous Vegetation with Shrubs* (413). Broad-leaved species are greater than 50% of the shrub canopy. The area is seasonally flooded.
4134	Tropical and Subtropical with Trees and Shrubs in Tufts on Termite Nests	level 4	Within *Tall Graminoid Herbaceous Vegetation with Shrubs* (413). Tropical or subtropical tall grassland with trees and/or shrubs growing in tufts on termite nests. Also called termite savannah.
414	With Tuft Plants	level 3	Within *Tall Graminoid Herbaceous Vegetation* (41). The canopy of the tuft plants (usually palms) must cover more than 25% of the ground.
4141	Tropical with Palms	level 4	Within *Tall Graminoid Herbaceous Vegetation with Tuft Plants* (414). Tropical grasslands with palms. E.g., the palm savannas of *Arocomia totai* and *Attalea princeps* north of Santa Cruz de la Sierra, Bolivia.
415	Without Woody Synusia	level 3	Within *Tall Graminoid Herbaceous Vegetation* (41). Grasslands without trees or shrubs.
4151	Tropical	level 4	Within *Tall Graminoid Herbaceous Vegetation Without Woody Synusia* (415). Tropical grassland as in various low-latitude regions of Africa. Often seasonally flooded (e.g., Compos de Varzea of the lower Amazon Valley), (e.g., Papyrus swamps of the upper Nile Valley).
42	Medium Tall Graminoid	level 2	Within *Herbaceous Vegetation* (4). The dominant grasses are 50 cm to 2 m tall when flowering or mature (greater than 50% of the herbaceous vegetation). Forbs may be present but comprise less than 50% of the herbaceous vegetation.
421	With Trees Covering 10-40%	level 3	Within *Medium Tall Graminoid Herbaceous Vegetation* (42). May be with or without shrubs. This is somewhat like a very open woodland with more or less continuous ground cover of medium tall graminoids.
4210	Trees: Needle-Leaved Evergreen	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation with Trees Covering 10-40%* (421). Needle-leaved evergreen species are greater than 50% of the tree canopy.
4211	Trees: Broad-Leaved Evergreen	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation with Trees Covering 10-40%* (421). Broad-leaved evergreen species are greater than 50% of the tree canopy.

4212	Trees: Broad-Leaved Semi-Evergreen	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation with Trees Covering 10-40%* (421). Trees present are at least 25% each of broad-leaved evergreen and broad-leaved deciduous trees.
4213	Trees: Broad-Leaved Deciduous	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation with Trees Covering 10-40%* (421). Broad-leaved species are greater than 50% of the tree canopy. The area is seasonally flooded.
422	With Trees Covering <10%	level 3	Within *Medium Tall Graminoid Herbaceous Vegetation* (42). Grassland with trees covering less than 10% of the ground, with or without shrubs.
4220	Trees: Needle-Leaved Evergreen	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation with Trees Covering <10%* (422). Needle-leaved evergreen species are greater than 50% of the tree canopy.
4221	Trees: Broad-Leaved Evergreen	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation with Trees Covering <10%* (422). Broad-leaved evergreen species are greater than 50% of the tree canopy.
4222	Trees: Broad-Leaved Semi-Evergreen	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation with Trees Covering <10%* (422). Trees present are at least 25% each of broad-leaved evergreen and broad-leaved deciduous trees.
4223	Trees: Broad-Leaved Deciduous	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation with Trees Covering <10%* (422). Broad-leaved species are greater than 50% of the tree canopy. The area is seasonally flooded.
4224	Tropical and Subtropical with Trees and Shrubs in Tufts on Termite Nests	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation with Trees Covering <10%* (422). Tropical or subtropical medium tall grassland with trees and/or shrubs growing in tufts on termite nests. Also called termite savannah.
423	With Shrubs	level 3	Within *Medium Tall Graminoid Herbaceous Vegetation* (42). The shrub canopy must cover more than 25% of the ground.
4230	Shrubs: Needle-Leaved Evergreen	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation with Shrubs* (423). Needle-leaved evergreen species are greater than 50% of the shrub canopy.
4231	Shrubs: Broad-Leaved Evergreen	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation with Shrubs* (423). Broad-leaved species are greater than 50% of the shrub canopy.
4232	Shrubs: Broad-Leaved Semi-Evergreen	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation with Shrubs* (423). Shrubs present are at least 25% each of broad-leaved evergreen and broad-leaved deciduous.
4233	Shrubs: Broad-Leaved Deciduous	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation with Shrubs* (423). Broad-leaved evergreen species are greater than 50% of the shrub canopy. The area is seasonally flooded.
4234	Tropical and Subtropical with Trees and Shrubs in Tufts on Termite Nests	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation with Shrubs* (423). Tropical or subtropical medium tall grassland with trees and/or shrubs growing in tufts on termite nests. Also called termite savannah.
4235	Woody Synusia of Deciduous Thorny Shrubs	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation with Shrubs* (423). Consists of deciduous thorny shrubs covering at least 25% of the ground. E.g., the tropical thorn bush savannah of the Sahel region in Africa with *Acacia tortilis*, *A. senegal* and other species.
424	Open Synusia of Tuft Plants	level 3	Within *Medium Tall Graminoid Herbaceous Vegetation* (42). The canopy of the tuft plants (usually palms) must cover more than 25% of the ground.

4241	Subtropical with Open Palm Groves	level 4	Within *Open Synusia of Tuft Plants Medium Tall Graminoid Herbaceous Vegetation* (424). Medium tall grassland with open groves of palms (e.g., Corrientes, Argentina). Some areas are seasonally flooded (e.g., *Mauritia* palm groves in the Colombian and Venezuelan Ilanos).
425	Without Woody Synusia	level 3	Within *Medium Tall Graminoid Herbaceous Vegetation* (42). Medium tall grasslands without trees or shrubs (less than 25% of the ground).
4251	Mainly Sod Grasses	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation Without Woody Synusia* (425). Perennial, highly branched, creeping grass, which binds the sand or soils with its root system. E.g., St. Augustine grass (*Stenotaphrum secundatum*), the tall-grass prairie in eastern Kansas, or on sandy soil or dunes, such as the communities of *Andropogon hallii* in the Nebraska Sand Hills. In some locations the grassland is wet or flooded most of the year (e.g., Typha swamps). If that is the case classify as a wetland. See MUC class 6.
4252	Mainly Bunch Grasses	level 4	Within *Medium Tall Graminoid Herbaceous Vegetation Without Woody Synusia* (425). Grasses that chiefly grow in tufts forming an irregular textured surface. E.g., the hard tussock (*Festuca novae-zelandiae*) grasslands in New Zealand.
43	Short Graminoid	level 1	Within *Herbaceous Vegetation* (4). The dominant grasses are less than 50 cm tall when flowering or mature (more than 50% of the herbaceous vegetation). Forbs may be present but they comprise less than 50% of the herbaceous vegetation.
431	With Trees Covering 10-40%	level 3	Within *Short Graminoid Herbaceous Vegetation* (43). May be with or without shrubs. This is somewhat like a very open woodland with more or less continuous ground cover of short graminoids.
4310	Trees: Needle-Leaved Evergreen	level 4	Within *Short Graminoid Herbaceous Vegetation with Trees Covering 10-40%* (431). Needle-leaved evergreen species are greater than 50% of the tree canopy.
4311	Trees: Broad-Leaved Evergreen	level 4	Within *Short Graminoid Herbaceous Vegetation with Trees Covering 10-40%* (431). Broad-leaved evergreen species are greater than 50% of the tree canopy.
4312	Trees: Broad-Leaved Semi-Evergreen	level 4	Within *Short Graminoid Herbaceous Vegetation with Trees Covering 10-40%* (431). Trees present are at least 25% each of broad-leaved evergreen and broad-leaved deciduous trees.
4313	Trees: Broad-Leaved Deciduous	level 4	Within *Short Graminoid Herbaceous Vegetation with Trees Covering 10-40%* (431). Broad-leaved species are greater than 50% of the tree canopy. The area is seasonally flooded.
432	With Trees Covering <10%	level 3	Within *Short Graminoid Herbaceous Vegetation* (43). Grassland with trees covering less than 10% of the ground, with or without shrubs.
4320	Trees: Needle-Leaved Evergreen	level 4	Within *Short Graminoid Herbaceous Vegetation with Trees Covering <10%* (432). Needle-leaved evergreen species are greater than 50% of the tree canopy.
4321	Trees: Broad-Leaved Evergreen	level 4	Within *Short Graminoid Herbaceous Vegetation with Trees Covering <10%* (432). Broad-leaved evergreen species are greater than 50% of the tree canopy.
4322	Trees: Broad-Leaved Semi-Evergreen	level 4	Within *Short Graminoid Herbaceous Vegetation with Trees Covering <10%* (432). Trees present are at least 25% each of broad-leaved evergreen and broad-leaved deciduous trees.
4323	Trees: Broad-Leaved Deciduous	level 4	Within *Short Graminoid Herbaceous Vegetation with Trees Covering <10%* (432). Broad-leaved species are greater than 50% of the tree canopy. The area is seasonally flooded.
4324	Tropical and Subtropical with Trees and Shrubs in Tufts on Termite Nests	level 4	Within *Short Graminoid Herbaceous Vegetation with Trees Covering <10%* (432). Tropical or subtropical short grassland with trees and/or shrubs growing in tufts on termite nests. Also called termite savannah.

433	With Shrubs	level 3	Within *Short Graminoid Herbaceous Vegetation* (43). The shrub canopy must cover more than 25% of the ground.
4330	Shrubs: Needle-Leaved Evergreen	level 4	Within *Short Graminoid Herbaceous Vegetation with Shrubs* (433). Needle-leaved evergreen species are greater than 50% of the shrub canopy.
4331	Shrubs: Broad-Leaved Evergreen	level 4	Within *Short Graminoid Herbaceous Vegetation with Shrubs* (433). Broad-leaved evergreen species are greater than 50% of the shrub canopy.
4332	Shrubs: Broad-Leaved Semi-Evergreen	level 4	Within *Short Graminoid Herbaceous Vegetation with Shrubs* (433). Shrubs present are at least 25% each of broad-leaved evergreen and broad-leaved deciduous.
4333	Shrubs: Broad-Leaved Deciduous	level 4	Within *Short Graminoid Herbaceous Vegetation with Shrubs* (433). Broad-leaved species are greater than 50% of the shrub canopy. The area is seasonally flooded.
4334	Tropical and Subtropical with Trees and Shrubs in Tufts on Termite Nests	level 4	Within *Short Graminoid Herbaceous Vegetation with Shrubs* (433). Tropical or subtropical short grassland with trees and/or shrubs growing in tufts on termite nests. Also called termite savannah.
4335	Woody Synusia of Deciduous Thorny Shrubs	level 4	Within *Short Graminoid Herbaceous Vegetation with Shrubs* (433). Consists of deciduous thorny shrubs covering at least 25% of the ground.
434	Open Synusia of Tuft Plants	level 3	Within *Short Graminoid Herbaceous Vegetation* (43). The canopy of the tuft plants (usually palms) must cover more than 25% of the ground.
4341	Subtropical with Open Palm Groves	level 4	Within *Open Synusia of Tuft Plants Short Graminoid Herbaceous Vegetation* (434). Short grassland with open groves of palms. The canopy of palms must cover more than 25% of the ground.
435	Mainly Bunch Grasses with Woody Synusia	level 3	Within *Short Graminoid Herbaceous Vegetation* (43). Grasses that grow in tufts, with woody plants interspersed.
4351	Tropical Alpine with Tuft Plants	level 4	Within *Mainly Bunch Grasses with Woody Synusia Short Graminoid Herbaceous Vegetation* (435). This grassland often contains *Espeletia, Lobelia, Senecio,* microphyllous dwarf-shrubs, and cushion plants (often with woolly leaves). Above the timberline in low latitudes. E.g., Paramo and related vegetation types without snow in the alpine regions of Kenya, Colombia, Venezuela, etc.
4352	Tropical Alpine without Tuft Plants	level 4	Within *Mainly Bunch Grasses with Woody Synusia Short Graminoid Herbaceous Vegetation* (435). Similar to Tropical Alpine with Tuft Plants (4351) but very open and without tuft plants. In these grasslands there is frequent nocturnal snowfall (though the snow is gone by 9 a.m.). E.g., the Super-Paramo (i.e. above Paramo) of J. Cuatrescasas.
4353	Tropical and Subtropical Alpine with Open Stands of Evergreens	level 4	Within *Mainly Bunch Grasses with Woody Synusia Short Graminoid Herbaceous Vegetation* (435). This grassland may also have deciduous shrubs and dwarf shrubs. E.g., Puna south of Oruro, Bolivia.
4354	With Dwarf Shrubs	level 4	Within *Mainly Bunch Grasses with Woody Synusia Short Graminoid Herbaceous Vegetation* (435). Consists of bunch grass with varying coverage of dwarf shrubs. Cushion plants may also grow in this grassland, and may be locally more important than the dwarf-shrubs. E.g., Puna south of Oruro, Bolivia.
436	Without Woody Synusia	level 3	Within *Short Graminoid Herbaceous Vegetation* (43). Short grasslands without trees or shrubs.

4361	Short-Grass Communities	level 4	Within *Short Graminoid Herbaceous Vegetation Without Woody Synusia* (436). These communities may fluctuate in structure and floristic composition due to greatly fluctuating precipitation of the semi-arid climate. E.g., short-grass (*Bouteloua gracilis* and *Buchloe dactyloides*) prairie of eastern Colorado.
4362	Bunch-Grass Communities	level 4	Within *Short Graminoid Herbaceous Vegetation Without Woody Synusia* (436). E.g., blue tussock (*Poa cloensoi*) communities of New Zealand, and alpine dry Puna with *Festuca orthophylla* of northern Chile and southern Bolivia.
437	Short to Medium Tall Mesophytic Communities	level 3	Within *Short Graminoid Herbaceous Vegetation* (43). Plants growing in or adapted to a moderately moist environment.
4371	Sod Grass Communities	level 4	Within *Short to Medium Tall Mesophytic Communities Short Graminoid Herbaceous Vegetation* (437). The grassland is often rich in forbs, and occurs in lower altitudes with a cool, humid climate in North America and Eurasia. Many plants may remain at least partly green during the winter, even below the snow in the higher latitudes.
4372	Alpine and Subalpine Meadows	level 4	Within *Short to Medium Tall Mesophytic Communities Short Graminoid Herbaceous Vegetation* (437). These grasslands are usually moist much of the summer due to snow melt water. May be rich in forbs (e.g., Olympic Peninsula, Washington); rich in dwarf-shrubs (e.g., the Rocky Mountains of Colorado); snow-bed communities rich in small forbs and/or forb-like dwarf-shrubs (e.g., *Salix herbacea*); or avalanche meadows, occurring as narrow strips of grassland between forests on steep slopes of high mountains where avalanches, descending annually in spring, prevent forest growth.
44	Forb Vegetation	level 2	Within *Herbaceous Vegetation* (4). Broad-leaved herbaceous plants dominate the plant community, such as clover, sunflowers (*Helianthus*), ferns, and milkweeds (*Asclepias*) (all plants except grasses). Forbs cover at least 50% of the herbaceous area. Grasses may be present but often less than (often much less than) 50%.
441	Tall Communities	level 3	Within *Forb Herbaceous Vegetation* (44). The dominant forb growth forms are more than 1 meter tall when fully developed.
4411	Fern Thickets	level 4	Within *Tall Forb Communities Herbaceous Vegetation* (441). Ferns occur sometimes in nearly pure stands, especially in humid climates (e.g., *Pteridium aquilinum*).
4412	Mainly Annual	level 4	Within *Tall Forb Communities Herbaceous Vegetation* (441). Annual forbs, which germinate in the beginning and die at the end of each growing season, are the dominant form (greater than 50% of forb vegetation).
4413	Mainly Perennial Flowering Forbs and Ferns	level 4	Within *Tall Forb Communities Herbaceous Vegetation* (441). Some part of the plant is alive all year round.
442	Low Communities	level 3	Within *Forb Herbaceous Vegetation* (44). These communities are dominated by forbs less than 1 meter tall when fully developed.
4421	Mainly Perennial Flowering Forbs and Ferns	level 4	Within *Low Forb Communities Herbaceous Vegetation* (442). Some part of the plant is alive all year round.

4422	Mainly Annual	level 4	Within *Low Forb Communities Herbaceous Vegetation* (442). Annual forbs, which germinate in the beginning and die at the end of each growing season, are the dominant form (greater than 50% of forb vegetation). There are several types of low annual forbs: *Ephemeral forb communities in tropical and subtropical regions*: Forbs grow with very little precipitation where, from autumn to spring, clouds moisten vegetation and soil. The dry season aspect is desert-like. E.g., the coastal hills of Peru and northern Chile *Ephemeral or episodical forb communities of arid regions*: The "flowering desert" consists of mostly fast growing forbs, sometimes concentrated in depressions where water can accumulate in shrub or dwarf shrub formations of arid regions. E.g., the Sonoran Desert.
5	**Barren Land**	**level 1**	**Land with less than 40% vegetative cover. Barren land has a limited ability to support life, and is usually made up of thin soil, sand, or rocks.**
51	Dry Salt Flats	level 2	Occur on flat floored bottoms of interior desert basins. High concentrations of salts are present due to extensive water evaporation.
52	Sandy Areas	level 2	Accumulations of sand/gravel (e.g., beaches or dunes).
53	Bare Rock	level 2	Exposed bedrock, desert pavement, scarps, talus slides, volcanic material, rock glaciers and other accumulations of rock without vegetative cover.
54	Perennial Snowfields	level 2	Accumulations of snow and ice that did not entirely melt during the previous summer, occurring where the daily average temperature is 0°C (32°F) in the warmest summer months.
55	Glaciers	level 2	Snow compacted into firn and finally to ice under weight of successive annual accumulations. Re-frozen melt water contributes to increasing density of the glacial ice mass. All glaciers exhibit evidence of present or past motions (moraines, crevasses, etc.).
56	Other	level 2	Dirt, gravel, other loose rock, etc.
6	**Wetland**	**level 1**	**Marshes, swamps, bogs and other types of wetlands that are periodically or constantly saturated during the growing season. This periodic or constant saturation produces soils with special chemical characteristics and vegetation specifically adapted to wet conditions. The area must have at least 40% vegetative cover to be classified as a wetland.**
61	Riverine	level 2	Wetlands adjacent to a fresh water river channel (riparian wetlands).
62	Palustrine	level 2	Wetlands dominated by trees, shrubs, persistent emergents (plants), mosses, lichens, etc. The wetlands surround water that is less than 1 hectare in size, has no active channel or tide, is less than 2 meters deep, and has low salinity. The water should be included as part of the wetland.
63	Estuarine	level 2	Wetlands occurring adjacent to a tidal channel, or in and adjacent to the intertidal zone. An estuary is a water passage where the tide meets the current of a stream. Deepwater tidal habitats and adjacent tidal wetlands are usually semi-enclosed by land but have open, partially obstructed, or sporadic access to ocean water (at least occasionally diluted by freshwater runoff from the land).
64	Lacustrine	level 2	Wetlands surrounding open water (e.g., ponds and lakes) that are greater than 1 hectare in size and greater than 2 meters deep.
7	**Open Water**	**level 1**	**Lakes, ponds, rivers and oceans. The surface of the land is continually submerged by water greater than 2 meters deep and at least one hectare in size; or continually submerged in an actively flowing channel or subtidal zone. Water should cover greater than 60% of the area.**

71	Freshwater	level 2	Lakes, ponds, and rivers with low salinity.
72	Marine	level 2	Open ocean overlying the continental shelf or an actively flowing tidal channel.
8	**Cultivated Land**	**level 1**	**The ground is covered by greater than 60% non-native cultivated species (e.g., agricultural crops, cultivated short grasses, and lawns) and usually can be distinguished by the regular geometric patterns created by the lawns and fields.**
81	Agriculture	level 2	Land is used for growing crops, orchards, horticulture, feeding livestock, and other agriculture.
811	Row Crop and Pasture	level 3	Examples include corn, wheat, cow pastures, fallow fields, cultivated cranberry bogs, and rice fields.
812	Orchard and Horticulture	level 3	Examples include apple orchards, vineyards, and tree nurseries.
813	Confined Livestock Feeding	level 3	These areas are found on large farms and are used for feeding beef cattle, dairy cows (with confined feedlots), hogs and poultry.
814	Other Agriculture	level 3	Examples include corrals and breeding and training facilities on horse farms.
82	Non-Agriculture	level 2	Land is used for parks, playing fields, cemeteries, and golf courses.
821	Parks and Athletic Fields	level 3	Examples include baseball diamonds, soccer fields, play grounds, and parks.
822	Golf Courses	level 3	Golf Courses
823	Cemeteries	level 3	Cemeteries
824	Other Non-Agriculture	level 3	Any other non-agricultural cultivated areas that do not fit into classes 821, 822 or 823 (parks and playing fields, golf courses, or cemeteries).
9	**Urban**	**level 1**	**Areas developed for residential, commercial, industrial, or transportation uses. Must be greater than 40% urban land cover.**
91	Residential	level 2	Greater than 50% of the urban land cover consists of residential property (e.g., apartments, private dwellings)
92	Commercial and Industrial	level 2	Greater than 50% of the urban land cover consists of commercial or industrial property (e.g., businesses, factories, warehouses)
93	Transportation	level 2	Greater than 50% of the urban land cover consists of transportation routes (e.g., roads, highways, railroads, and airport runways).
94	Other	level 2	At least 50% of the urban land cover consists of developed areas that do not fit into residential, commercial, or transportation categories.

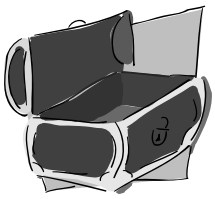
Miscellaneous Definitions	
Annual Plant	Live and grows for only one year or season.
Aspect	View or appearance; a side facing a particular direction.
Boreal	Also called cold temperate zone has a climate with cool wet summers and cold winters lasting more than six months.

Bryophyte	Non-flowering plants (mosses & liverworts) characterized by rhizoids rather than true roots.
Buttresses	Flanges of tissue protruding from the trunk of a tree, tapering outward at the base to give support. Common among large tropical trees.
Caespitose	Arranged or combined in a thick mat or clumps, having a low stem forming a dense turf or sod, growing in clusters.
Canopy	Uppermost layer of vegetation detected by satellite sensors.
Chamaephyte	A perennial plant that has its winter buds placed very close to the soil surface.
Cold-Deciduous	Plants that shed leaves during the cold season.
Crustose Lichens	Lichens that are encrusting. E.g., *Caloplaca saxicola*.
Cultivated Land	Landscaped yards, playing fields, cemeteries, golf courses, and other cultivated vegetated areas should be classified as cultivated land (class 8) if non-native cultivated species is greater than 60% coverage. If the buildings, roads and unnatural structures (bridges, etc.) cover greater than 40% of the land, the area should be classified as urban. If wooded residential neighborhoods have greater than 40% trees covering the ground, the area would be considered forest or woodlands (see classes 0 and 1). If it is difficult to decide upon a cover type, try to determine what the satellite would see. Compare similar areas with the satellite image you receive of your school's location.
Deciduous	Vegetation that sheds its leaves at the end of the growing period or in association with the unfavorable season (drought, cold).
Drip Tips	Extended slender tips of tropical leaves that allow water to roll off the leaf surface.
Drought-Deciduous	Plants that shed their leaves during the dry season.
Emergent	Aquatic plant with the lower part submerged and the upper part extending above the water.
Epiphytes	Plants not connected with the soil, that grow on another plant (upon which it depends for mechanical support) but not for receiving food and water from it, such as certain orchids or ferns.
Facultative	Organisms able to live and thrive under more than one set of conditions.
Firn	Snow that has been partially consolidated, or compacted, by thawing and freezing but not yet converted to glacial ice.
Forb	A broad-leaved herbaceous plant other than a grass such a clover, sunflowers, ferns, and milkweeds.
Fruticose Lichens	Lichens which appear shrubby or hair-like, especially in form.
Graminoid	Grasses and grass-like plants.
Herbaceous	Pertaining to or characteristic of an herb as distinguished from a woody plant. Vascular plant rooted in the ground with foliage that dies back annually. The meristem (stem growth tip) is located just above or below the ground.
Hygromorphic	The form of the plant is altered due to changes in moisture in the plant. E.g., hygromorphic chamaephytes *Selaginella* and herbaceous ferns.
Hemisclerophyllous	Vegetation with slightly thickened foliage, with large soft leaves, that is resistant to water loss. E.g., subalpine *Rhododendron* thickets, or *Hibiscus tiliaeceus* matted thickets of Hawaii.
Lichen	Plant made up of an alga and a fungus living in a symbiotic relationship. Specifically, any of a numerous plants consisting of a fungus, usually of the class *Ascomycetes*, in close combination with certain of the green or blue-green algae, characteristically forming a crustlike, scaly, or branching growth on rocks or tree trunks.

Lignified	Woody, hardened. Has formed or turned into wood through the formation and deposit of lignin in the cell walls.
Lowland	An area of land that is low in relation to the surrounding country. It may be necessary to consult local resources to determine the specific classification. Vegetation will vary depending on both the latitude and the altitude.
Mesophytic	Growing in, or adapted to, a moderately moist environment.
Microphanerophytes	Small flowering plants.
Microphyllous	Having small leaves with a single unbranched vein (e.g., desert plants).
Montane	Of, growing in, or inhabiting mountain areas. It may be necessary to consult local resources to determine the specific classification. Vegetation will vary depending on both the latitude and the altitude.
Nanophanerophytes	Very small flowering plants.
Obligate	Organisms restricted to a particular condition of life (that condition is essential for survival).
Overstory	Uppermost layer of vegetation detected by satellite sensors.
Perennial Plant	Has a life span of more than two years.
Polar	In polar climates, the mean temperature of the warmest month is below 10°C and there is low precipitation distributed over the entire year. There is a short, wet, nightless summer and a very long, cold, dark winter. Generally, the climate is too cold to support the growth of trees.
Saturated	Soaked with moisture - the maximum water holding capacity of a soil.
Scapose	Having a leafless flower stalk growing directly from the ground. E.g., agave/century plant.
Sclerophyllous	Vegetation with thickened, hardened foliage that is resistant to water loss (sclerophylly). E.g., plants of the chapparal (semi-arid Mediterranean) such as toyon, ironwood, manzanita, coyote bush, mountain mahogany, and black sage.
Subalpine	Of, designating, or growing or living in mountainous regions just below the timberline. It may be necessary to consult local resources to determine the specific classification. Vegetation will vary depending on both the latitude and the altitude.
Submontane	Located under or at the base of a mountain or mountain range. It may be necessary to consult local resources to determine the specific classification. Vegetation will vary depending on both the latitude and the altitude.
Subpolar	Transitional between the cold temperate zone and the polar zone. It may be necessary to consult local resources to determine the specific classification. Vegetation will vary depending on both the latitude and the altitude.
Subtropical	From the edge of the tropical zone toward the poles, in the region of the descending air masses, which get warmer as it descends and becomes very dry. Rainfall is very low, and the daytime temperatures are very high because of intense solar radiation. In the winter months, however, the temperature may sink to zero at night as a result of the greater net loss of heat energy in outgoing radiation. This is the hot desert zone.
Succulent	Having thickened, juicy, fleshy tissues (leaves or stems), more or less soft in texture, that conserve moisture. E.g., a sedum or a cactus.
Suffruticose	Has a woody stem or base and is somewhat shrubby.
Synusia	A layer or stratum of a community. A structural unit of a major ecological community characterized by relative uniformity of life form or of height and usually constituting a particular stratum of that community.

Temperate	Temperate zones show greater seasonal temperature changes and can be broken down as follows: *Warm temperate*: mild or no winter and extremely wet, especially in summer. *Typical temperate*: cold, short winters or a winter free of frost and with very cool summers (near the ocean) (e.g., central European or coastal northeastern U.S.A). *Arid temperate*: large temperature contrasts between summer and winter, and little precipitation. *Boreal or cold temperate*: cool wet summers and cold winters lasting more than six months.
Tropical	Lies 40 degrees to the north and south of the equator. A certain seasonal variation in the mean daily temperature is noticeable. Rainfall reaches a maximum in the summer, with a dry season in the cool months. The duration of the cool season increases as the distance from the equator becomes greater, and at the same time the annual rainfall decreases.
Understory	Layer of vegetation that grows beneath the overstory consisting of smaller trees and shrubs.
Wet	Vegetation or environments capable of withstanding or thriving in the presence of much rain.
Xeromorphic	Climatic conditions favorable for the development of vegetation that is adapted to, thrives in, or tolerates an environment that is poor in available moisture.
Xerophyte	A plant which is adapted to and thrives in dry conditions.

Glossary



Accuracy
How close a measurement is to a standard value of that measurement

Assessment
Evaluation of the value of an object

Biogeochemical
Refers to the chemical interactions between the living ("bio") and physical ("geo") components of the Earth system, as in biogeochemical cycles of carbon, nitrogen, etc.

Biomass
The dry weight of vegetation above a unit area of ground, often reported as grams (dry weight) per square meter

Biome
A major ecological community type (as grassland or desert)

Biometry
The process of making biological measurements

Biosphere
The living component of the Earth system, along with the gaseous (atmosphere), liquid (hydrosphere), and solid (geosphere) components

Canopy Cover
The amount of canopy foliage above a given portion of ground is the canopy cover. This will determine the amount of sunlight that reaches that portion of ground.

Catastrophic
Used to describe a sudden, violent event

Characteristics
A distinguishing feature

Classification
Sorting a group of items into well-defined and distinct subsets according to specific criteria

Clinometer
A clinometer is an instrument for measuring the angle of a change in height or elevation.

Criteria
Decision rules that are used to determine into which subset an item is placed during a classification

Deciduous
Refers to trees or shrubs that lose their leaves every year

Default
A preset value that a computer uses or an action that it takes unless it is told otherwise

Densiometer
A device for determining the percentage of canopy closure in a wooded environment

Dichotomous
This is a branching decision tree (decoder) characterized by successive forking into two approximately equal and contradictory divisions, which ultimately leads to only one correct outcome.

Difference/Error Matrix
A graphic method of comparing two data sets for validation

Dominant
A plant or animal that, due to its large numbers or size, influences the conditions of an area and determines what other plants or animals can live there

Ecosystem
System formed by the interactions of a community of living things with its environment

Equatorial
Near the equator

Evapotranspiration
The return of water to the atmosphere by evaporation (from solar energy) and transpiration (plant activity.)

Glossary
List of terms in a special subject with their definitions

Genus (pl. Genera)
This is an inclusive category whose species have more characteristics in common with each other than with species of other genera. Genera, therefore, are collections of closely related species.

Geosphere
The solid component of the Earth system; e.g. rocks, soil, etc.

Gradient
The rate of change in a measured quantity over space or time

Graminoid
Grass-like vegetation

Ground Cover
The amount of ground-level vegetation covering a given area. (For the GLOBE program, "ground level" is defined as "below the observer's knees." Ground cover is expressed as a percentage. E.g. 30% ground cover means that, viewed from above, 30% of the ground surface is obscured by ground-level vegetation.

Herbaceous
A plant or plant part that is not woody

Hierarchical
Having the characteristics of a system of objects ranked one above the other

Homogeneous
Composed of parts that are all the same kind, in this case, the same land cover type

Hydrosphere
The liquid component of the Earth system; e.g. oceans, lakes, rivers, etc.

Iterative
To do something over again or repeatedly

Magnetic North
The direction the compass needle points, rather than true north which is a geographic place

Metadata
Any additional information that cannot be expressed in the measurement data such as historical information, weather conditions, weather effects, and other observations

Methodology
A set of procedures or a planned way of doing this investigation

Multitemporal
Viewed from more than one point in time

NOAA
The National Oceanic and Atmospheric Administration.

Perennating Organs
Parts of plants that live over from one season to another (tubers, rhizomes)

Perturbations
A disturbance in the normal functioning of a system

Phenology
The study of changes over time in an environmental setting

Photointerpretation
The production of a land cover map or identification of specific features by visual inspection of an aerial photo or satellite image

Photosynthetic Potential
The maximum amount of biomass that can be produced in an area

Physiological
Characteristic of, or appropriate to, an organism's healthy or normal functioning

Pixels
The smallest element of an image

Precise
Exact in measuring

Primary Productivity
The rate at which organic material is produced by photosynthesis at a given location. Often represented as grams (dry weight) of Carbon per m^2 per year.

Protocol
A plan for carrying out a scientific study

Sediment
Matter that settles to the bottom eventually but can be carried along in a water body or the air until then

Senescence
The plant growth phase from full maturity to death that is characterized by a loss in dry weight

Spatial
Having to do with space

Species
This is a group of individual plants/ animals that is fundamentally alike.

TM
Thematic Mapper. Carried aboard the Landsat 4 and 5 satellites, this instrument is designed to study surface features in 7 bands covering the visible through thermal infrared regions with a pixel resolution of 30 m in 6 bands and 120 m in the thermal infrared band.

Topographic Map
Map showing detailed features and contour lines of an area

Urban
Areas developed for residential (ex. houses, apartments), commercial (ex. stores), industrial (ex. factories) or transportation (ex. roads) uses

Validation Data
Data necessary to assess the accuracy of a land cover map produced by manual or electronic means.

Variation
A different form of something