MUC System Protocol

Purpose

To classify land cover using the Modified UNESCO Classification (MUC) System

Overview

Students will learn how to use this hierarchical classification system to assign a MUC class to their land cover sample sites.

Time

15 to 45 minutes to make field observations and determine proper MUC class (excluding travel time to and from the site)

Level

All

Frequency

For land cover samples sites: Determine MUC class once during peak foliage

Key Concepts

Canopy cover
Ground cover
Hierarchical land cover classification system

Skills

Using a compass
Measuring distances with paces
Using classification systems
Deciding based on definitions and rules
Identifying tree and ground cover types
Using the MUC system to identify the land cover class of a land cover sample site

Materials and Tools

MUC system and definitions
Compass
Tubular densiometer
Biometry Data Work Sheet

Preparation

Review the MUC system and the classification examples.

Identify MUC classes that are applicable to your local area.

Prerequisites

Leaf Classification Learning Activity

Learn to pace.

Learn to use the compass and densiometer.

Introduction

In GLOBE, we use the Modified UNESCO Classification (MUC) System for classifying land cover. MUC has an ecological basis and follows international standards. The MUC system has four levels of classification arranged hierarchically. As you can see in Tables LAND-P-3 and LAND-P-4 each higher level is based on more detailed properties of land cover. MUC codes of up to four digits are associated with each MUC class with one digit for each level in the class beginning with the lowest level. In assigning a MUC class to a homogeneous area of land cover, always begin at the lowest level (i.e. the first digit of the MUC code) and proceed up the levels one-by-one. The definitions of the MUC classes are given in the *Appendix*, and students should always refer to these definitions rather than trusting their memories or general knowledge when determining the MUC class for an area.

A classification system is a comprehensive set of categories, with labels and definitions, typically arranged in a hierarchy or branching structure. A classification system is used to organize a set of data, such as an inventory of land cover types, into meaningful groups. The classification system must be both *totally exhaustive* and *mutually exclusive*. A *totally exhaustive* classification has an appropriate class for every possible data point (e.g., land cover type). A *mutually exclusive*

Table LAND-P-3: MUC Level 1 and 2

	Level 1	Level 2
Natural Cover	0 Closed Forest	01 Mainly Evergreen Forest 02 Mainly Deciduous Forest 03 Extremely Xeromorphic (Dry) Forest
	1 Woodland	11 Mainly Evergreen Woodland 12 Mainly Deciduous Woodland 13 Extremely Xeromorphic (Dry) Woodland
	2 Shrubland	21 Mainly Evergreen Shrubland 22 Mainly Deciduous Shrubland 23 Extremely Xeromorphic (Dry) Shrubland
	3 Dwarf-shrubland	31 Mainly Evergreen Dwarf-shrubland 32 Mainly Deciduous Dwarf-shrubland 33 Extremely Xeromorphic Dwarf-shrubland 34 Tundra
	4 Herbaceous Vegetation	41 Tall Graminoid 42 Medium Tall 43 Short Graminoid 44 Forb (broad-leaved) Vegetation
	5 Barren Land	51 Dry Salt Flats 52 Sandy Areas 53 Bare Rock 54 Perennial Snowfields 55 Glaciers 56 Other
	6 Wetland	61 Riverine 62 Palustrine 63 Estaurine 64 Lacustrine
	7 Open Water	71 Freshwater 72 Marine
Developed Cover	8 Cultivated Land	81 Agriculture 82 Non-agriculture
	9 Urban	91 Residential 92 Commercial/Industrial 93 Transportation 94 Other

Sources: UNESCO, 1973 and GLOBE, 1996

classification has one and only one appropriate class for every data point. The hierarchical arrangement means that there are multiple levels of classes: level 1 has the most general classes; each higher level in the system increases in detail and multiple detailed classes may be condensed into fewer more general classes. For example:

The MUC System has ten level 1 classes, including *Closed Forest, Woodland,* and *Urban*. See Tables LAND-P-3 and LAND-P-4. The level 2 classes within *Closed Forest* are *Mainly Evergreen Forest, Mainly Deciduous Forest,* and *Extremely Xeromorphic (dry) Forest*. These level 2 classes contain more detail than the level 1 class, *Closed Forest*, and they may all be collapsed into the *Closed Forest* class. In other words, any member of one of these three Level 2 classes is always a member of the *Closed Forest* level 1 class. Table LAND-P-3 is a condensed version of MUC, showing only the level 1 and level 2 classes.

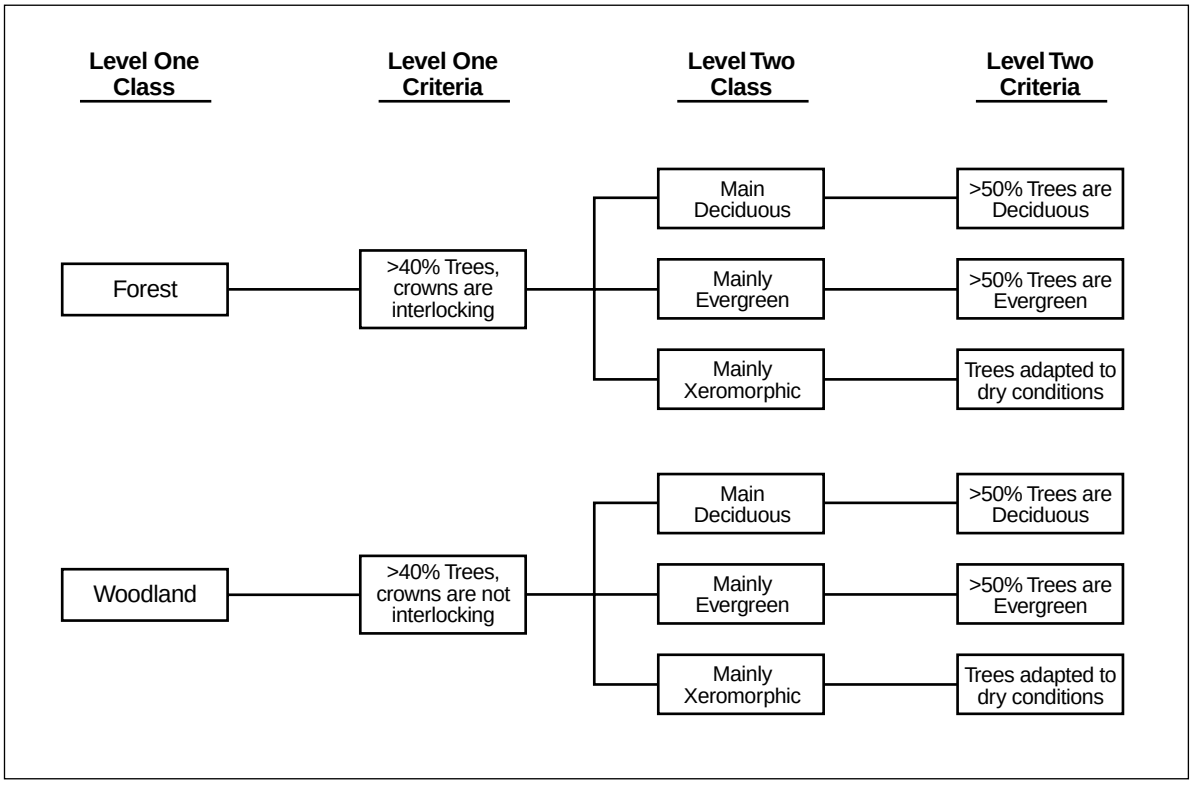
The entire MUC classification system is outlined in Table LAND-P-4. Be aware that this outline contains only the name and identifying code number of each class. The full definition and description of each class is detailed in the Glossary of Terms for the Modified UNESCO Classification System. The Glossary is found in the *Appendix*. Each class is strictly defined by clear decision criteria.

An Example of Determining MUC Class to Level 2

Figure LAND-P-17 illustrates the criteria used to distinguish between Forest and Woodland classes at MUC level 1 criteria used to distinguish between Mainly Deciduous, Mainly Evergreen, and Mainly Xeromorphic cover types at level 2.

More than 40% of the land cover sample must be covered by trees to qualify as forest or woodland. If the tree crowns are interlocking (branches from neighboring trees touch each other) the sample site is considered forest. If the trees are spread farther apart and branches do not touch each other, the sample site is considered woodland. The level 2 classes typically depend on the composition of the level 1 cover type. In this example, the level 2 class for Forest or Woodland depends upon the percentage of deciduous and evergreen trees in the canopy.

Figure LAND-P-17: Applying MUC to Forest and Woodland



LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	NOTES AND EXAMPLES
Natural Cover	01 Mainly Evergreen Forest	011 Tropical Wet (Rain) Forest	0111 Lowland forest	
			0112 Submontane forest	Costa Rica: Atlantic slope
			0113 Montane forest	Costa Rica: Sierra de Talamanca
			0114 "Subalpine" forest	
			0115 Cloud forest	Jamaica: Blue Mountains
		012 Tropical and Subtropical Evergreen Seasonal	0121 Lowland forest	
			0122 Submontane forest	
			0123 Montane forest	
			0124 "Subalpine" forest	
		013 Tropical and Subtropical Semi-deciduous	0131 Lowland forest	*Ceiba spp.*
			0133 Montane or cloud forest	
		014 Subtropical Wet Forest	0141 Lowland forest	Queensland, Australia, and Taiwan
			0142 Submontane forest	
			0143 Montane forest	
			0144 "Subalpine" forest	
			0145 Cloud forest	
		015 Temperate and Subpolar Evergreen Wet Forest	0151 Temperate evergreen wet forest	Chilean Coast
			0152 Subpolar evergreen wet forest	
0 Closed Forest		016 Temperate Evergreen with Deciduous Broad-leaved	0161 Lowland forest	
			0162 Submontane forest	
			0163 Montane forest	
			0164 "Subalpine" forest	
		017 Winter-Rain Evergreen Broad-leaved Sclerophyllous	0171 Lowland and submontane	*Eucalyptus regnans, E. diversicolor*
			0172 Lowland and subm. <50m tall	USA: California live-oak forest
		018 Tropical and Subtropical Evergreen Needle-leaved	0181 Lowland and submontane	*Pinus spp. forest of Honduras and Nicaragua*
			0182 Montane and subalpine	*Pinus spp. forest of Phillippines and southern Mexico*
		019 Temperate and Subpolar Evergreen Needle-leaved	0191 Giant forest (>50 m)	*Sequoia and Pseudotsugaspp., Pacific W. of N. America*
			0192 (Irregularly) Rounded crowns	*Pinus spp.*
			0193 Conical crowns	*Picea and Abies spp.; USA California Red Fir forests*
			0194 Cylindrical crowns	Boreal, short branches

Table LAND-P-4: MUC Level 1 –4 (continued)

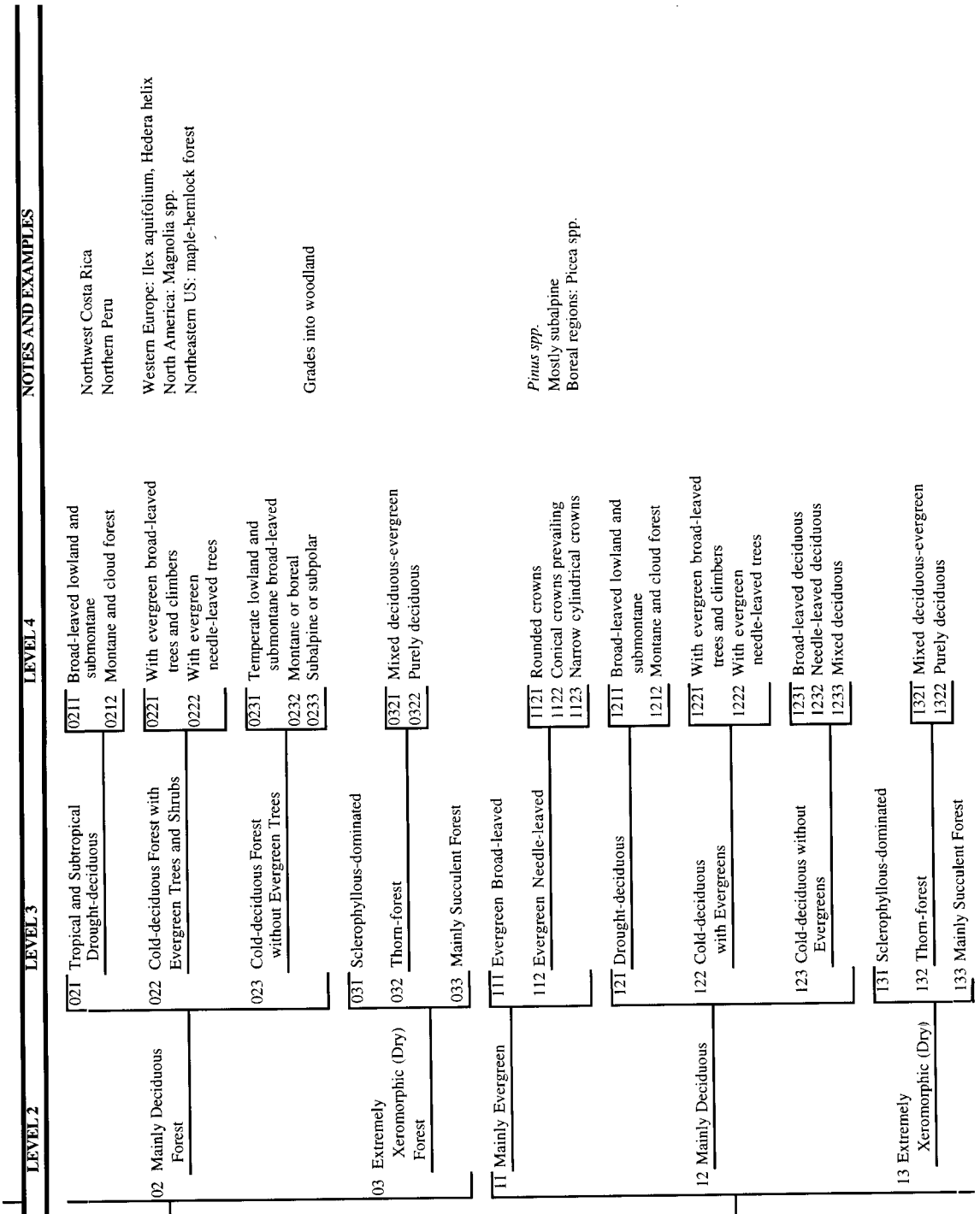


Table LAND-P-4: MUC Level 1 –4 (continued)

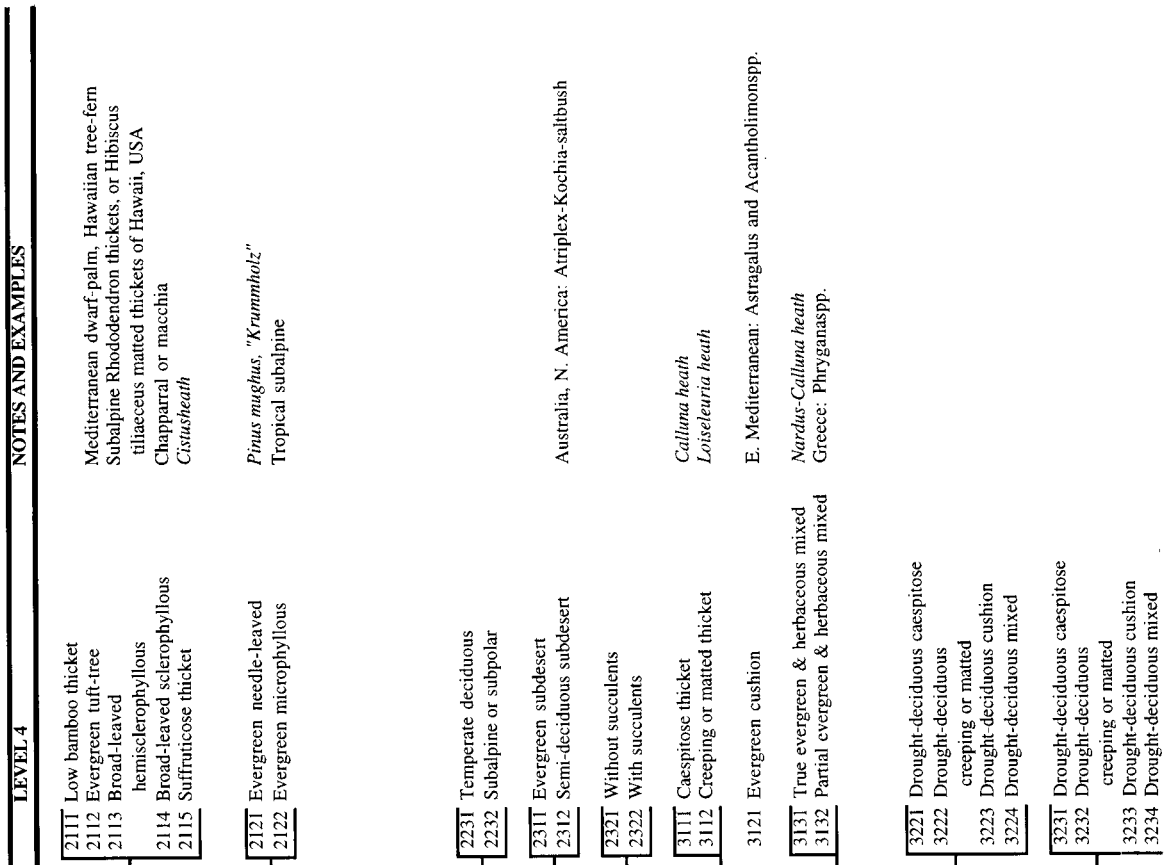


Table LAND-P-4: MUC Level 1 –4 (continued)

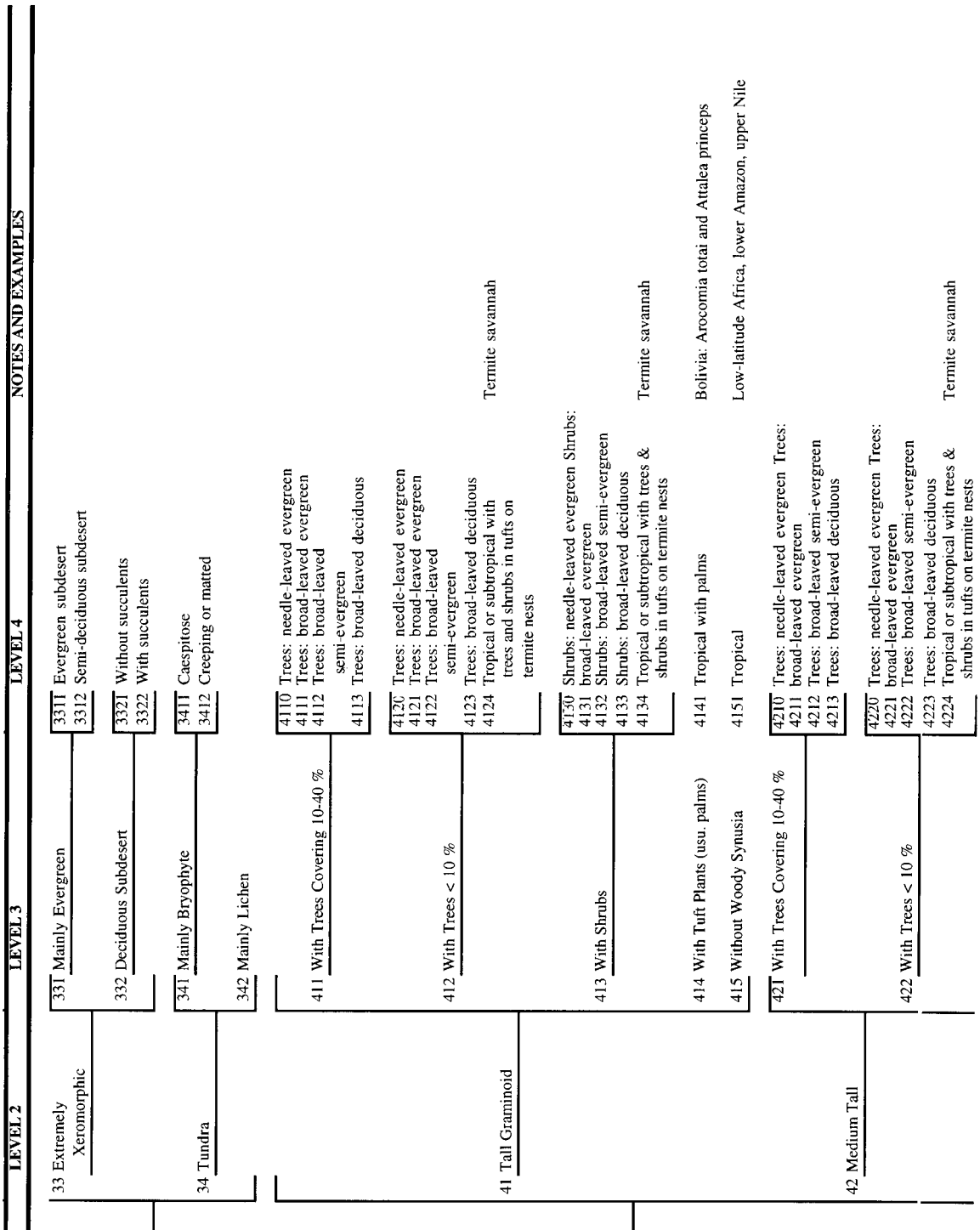


Table LAND-P-4: MUC Level 1 –4 (continued)

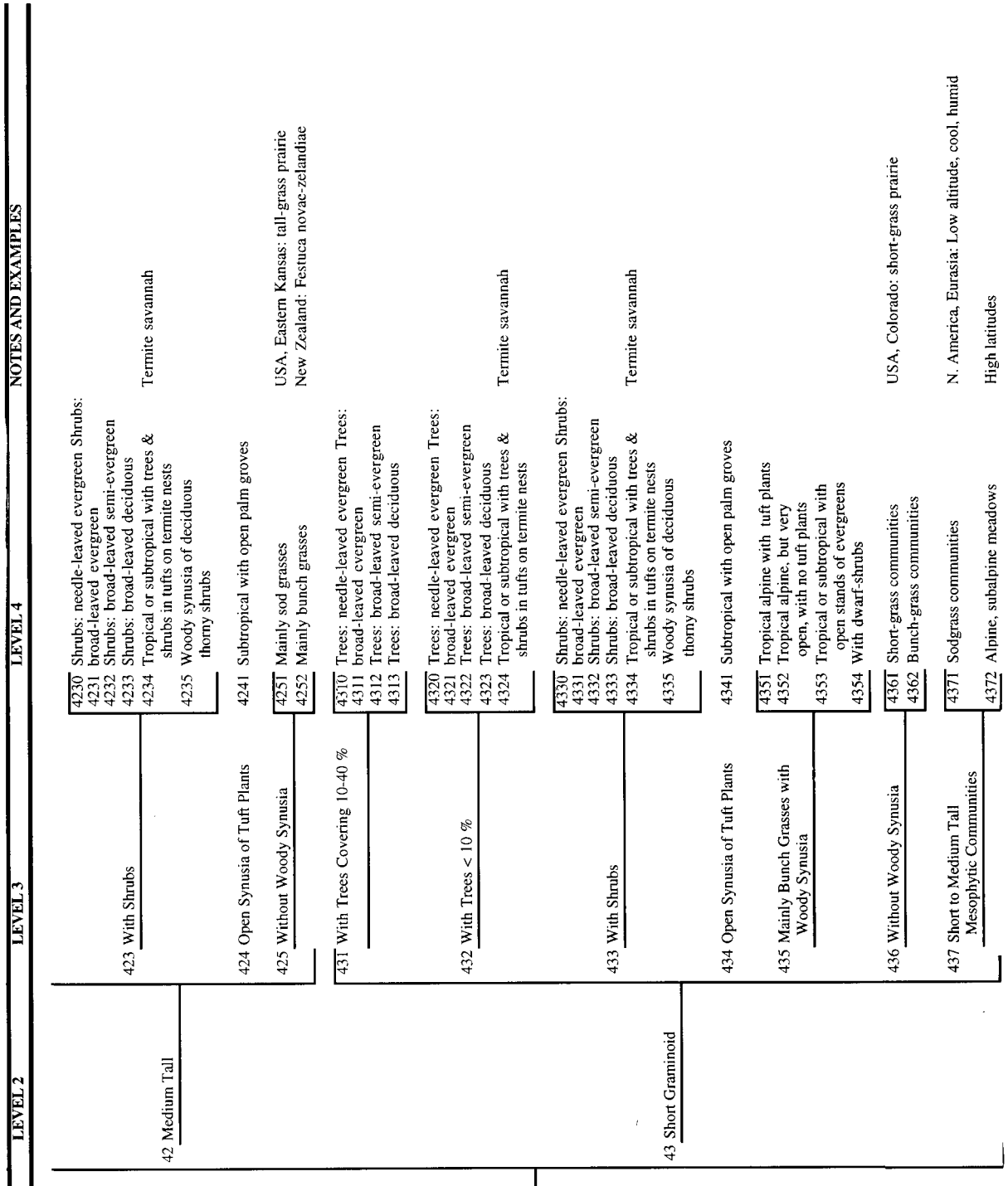


Table LAND-P-4: MUC Level 1 –4 (continued)

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	NOTES AND EXAMPLES
Natural Cover				
4 Herbaceous Vegetation	44 Forb Vegetation	441 Tall Forb Communities	4411 Fern thickets	
			4412 Mainly annual forbs	
		442 Low Forb Communities	4421 Mainly perennial flowering forbs and ferns	
			4422 Mainly annual forbs	
5 Barren Land	51 Dry Salt Flats			
	52 Sandy Areas			
	53 Bare Rock			
	54 Perennial Snowfields			
	55 Glaciers			
	56 Other			
6 Wetland	61 Riverine			
	62 Palustrine			
	63 Estuarine			
	64 Lacustrine			
7 Open Water	71 Freshwater			
	72 Marine			
Developed Cover				
8 Cultivated Land	81 Agriculture	811 Row Crop or Pasture		
		812 Orchard or Horticulture		
		813 Confined Livestock feeding		
		814 Other Agriculture		
	82 Non-agriculture	821 Parks and Athletic fields		
		822 Golf Courses		
		823 Cemeteries		
		824 Other Non-agriculture		
9 Urban	91 Residential			
	92 Commercial/Industrial			
	93 Transportation			
	94 Other			

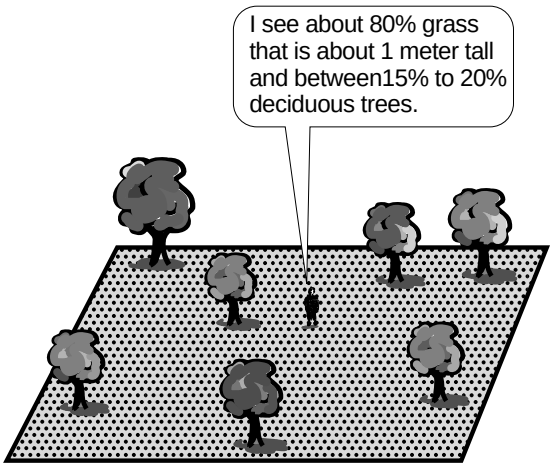
Sources: UNESCO, 1973 and GLOBE, 1996

Additional Examples of How to Use the MUC System

The following examples demonstrate the classification process. Refer to the MUC outline (Table LAND-P-4), and to the MUC Glossary in the *Appendix* as you read them.

Example 1

For your Land Cover Sample Site (90 m x 90 m) you pick a relatively homogeneous area of grasses. About 80% of the site is covered by grass and herbaceous plants about 1 meter tall (a 75/25 mix, respectively), and about 15-20% by broad-leaved deciduous trees.



Level 1: You see on the MUC Classification that class 4, Herbaceous Vegetation is probably the appropriate level 1 class. In the MUC Glossary, you see that class 4 requires greater than 60% total ground coverage of herbaceous vegetation over the entire study site, confirming that class 4 is appropriate.

Level 2: On the *MUC Classification*, you now see four choices at level 2 (41-44). After reviewing the definitions of these four classes in the MUC Glossary, you determine that, since the dominant cover type (herbaceous) is more than 50% grass, the level 2 cover type must be Graminoid. Since the grass is between 50 cm and 2 m tall, you select class 42, Medium Tall Graminoid.

Level 3: On the *MUC Classification*, you now have five Level 3 choices (421-425). Since trees cover 15-20% of the study site, you select Class 421, "With trees covering 10-40%", confirming this selection with the MUC Glossary definition.

Level 4: You now have three choices at Level 4 (4211-4213). Since the trees are broad-leaved deciduous, you select class 4213, and you have completed your MUC level 4 classification.

Example 2

You live in a lowland temperate region. You select a Land Cover Sample Site that is mostly forested with the tree crowns touching each other, but about 20% of the ground area has houses on it. Of the trees, it looks like there are more evergreen than deciduous trees, probably a 60/40 split.

Level 1: On the *MUC Classification* you check your Level 1 choices and find that, since the tree crowns are interlocking, and there is more than 40% canopy cover over the entire study site, Closed Forest, class 0, is the level 1 class.

Level 2: You now have three level 2 choices (01-03). Since at least 50% of the trees that reach the canopy are evergreen, you select class 01, Mainly Evergreen at level 2.

Level 3: You now have nine level 3 choices (011-019), but five are explicitly tropical and subtropical. A sixth choice is a winter-rain category which is also clearly not appropriate. So you have only three categories to seriously consider (015, 016, 019), and after consulting the MUC Glossary you select 016, Temperate Evergreen with Deciduous Broad-leaved.

Level 4: Now you have four level 4 choices (0161-0164). Since you live in a lowland area, class 0161, Lowland forest is the appropriate selection.

How to Classify Land Cover Using the MUC System

When classifying land cover using the MUC system, always begin with the most general classes (level 1) and proceed sequentially to the more detailed (higher level) classes. There are ten level 1 land cover classes in MUC. Eight of these choices are natural land cover and two are developed. At no other level in the MUC system are there more than six land cover choices, and therefore, the level 1 choice among ten classes is the most challenging decision to make. However, given that these ten classes are the most general, the distinctions among them are broad and the decision as to which level 1 land cover class to pick is usually not difficult. Always refer to the definitions for each land cover class to help you in choosing the appropriate class at every level.

How to Classify Land Cover to MUC Level 1

Step 1: Eliminate as many MUC level 1 classes as possible.

- ❑ Compare the Land Cover Sample Site with the definitions of the 10 MUC level 1 classes.
- ❑ Usually there are only a few level 1 classes that can possibly match your site; eliminate the others from consideration.

Step 2: Make any measurements necessary to determine the MUC level 1 class.

- ❑ Perform measurements of tree height, canopy cover, or ground cover and identify dominant and co-dominant species as necessary to distinguish between different MUC level 1 classes. Follow the appropriate portions of the Biometry Protocol. In many cases no measurements will be necessary.
- ❑ Using the quantitative measurements, resolve any questions and assign a MUC level 1 class to this site.

Step 3: Check your assignment.
Read the definitions for the MUC levels 2, 3, and 4 for your chosen MUC level 1 class that are possible for your area. If none of the definitions of higher level MUC classes match your site, reconsider your choice of MUC level 1 class in Step 2.

How to Classify Land Cover Sample to MUC levels 2, 3, and 4

Step 1: Determine the MUC level 2 class.

- ❑ Review the level 2 definitions that apply to the MUC level 1 class of your site.
- ❑ Select the MUC level 2 class that applies to your site.
- ❑ If necessary, make measurements of the vegetation on your site to resolve quantitative distinctions between different level 2 classes using the procedures given in Using Field Observations to Determine MUC Class.

Step 2: Determine the MUC level 3 class.

- ❑ Review the level 3 definitions that apply to the MUC level 2 class of your site. If there are none, record your MUC level 2 class (two digits); you have completed this protocol.
- ❑ Select the MUC level 3 class that applies to your site.
- ❑ If necessary, make additional measurements of the vegetation on your site to resolve quantitative distinctions between different level 3 classes using the procedures given in *Using Field Observations to Determine MUC Class.*

Step 3: Determine the MUC level 4 class.

- ❑ Review the level 4 definitions that apply to the MUC level 3 class of your site. If there are none, record your MUC level 3 class (three digits); you have completed this protocol.
- ❑ Select the MUC level 4 class that applies to your site.
- ❑ If necessary, make additional measurements of the vegetation on your site to resolve quantitative distinctions between different level 4 classes using the procedures given in *Using Field Observations to Determine MUC Class.*
- ❑ Record your MUC level 4 class.

Using Field Observations to Determine MUC Class

Distinguishing among some MUC classes requires quantitative measurements of the percentage of your site that is covered by different types of vegetation. This can be accomplished using modified versions of the Canopy and Ground Cover measurement procedures of the *Biometry* Protocol. You can identify the appropriate MUC class by calculating the percentages of the vegetation types observed at the Land Cover Sample Site. Use the *Dominant/Co-Dominant Vegetation Data Work Sheet* to add up your canopy and/or ground cover observations. You can calculate percentages of deciduous and evergreen canopy cover, and graminoid and forb ground cover in addition to the total canopy cover and green, brown, and total ground cover measurements presented in the Biometry Protocol.

Determining the Percentage of Tree Cover That is Evergreen or Deciduous

Step 1: Make a modified canopy cover measurement.

- ❑ Repeat the canopy cover measurement from the Biometry Protocol but at each location note "E" if the canopy touching the crosshairs is part of an evergreen tree and "D" if the canopy touching the crosshairs is part of a deciduous tree.

Step 2: Calculate the percentage of the canopy that is evergreen or deciduous.

- ❑ Divide the number of E observations (or D observations) by the sum of the E's and the D's and multiply by 100. If the percentage of evergreen species is greater than 50%, then the site is considered mainly evergreen.

Determining the Composition of Herbaceous Coverage:

Step 1: Make a modified measurement of ground cover.

- ❑ Repeat the ground cover measurement from the Biometry Protocol, but instead of noting whether vegetation is green or brown, note whether it is graminoid (grass) or forb (broad leafed) and record a "GD" if the vegetation under foot or touching the ankle or leg below the knee is a graminoid and an "FB" if it is a forb.

Step 2: Calculate the percentage of ground cover that is graminoid or forb.

- ❑ Divide the number of GD measurements (or FB measurements) by the sum of the GD's and FB's and multiply by 100 to obtain a percentage. If the percentage of graminoid species is greater than 50%, then the sample is considered graminoid. Conversely, if the percentage of forb is greater than 50%, then the sample is considered forb.

$$\% \text{ Evergreen} = \frac{\#\text{ of E's (evergreen observations)}}{\#\text{ of E's} + \#\text{ of D's (total canopy cover observations)}} \times 100$$

$$\% \text{ Graminoid} = \frac{\#\text{ of GD's (Graminoid Observations)}}{\#\text{ of GD's} + \#\text{ of FB's (Total \# of Herbaceous Ground Observations)}} \times 100$$

Determining Total Shrub Canopy Cover

If your site or area is one where the dominant land cover types is naturally occurring shrubland or dwarf shrubland (ornamental and cultivated shrubs do not count), you should slightly modify one of the preceding procedures. The equations for canopy cover percentage can be adapted to determine the total shrub canopy cover as well as the percentage of evergreen and deciduous shrubs.

Step 1: Determining the Amount of Shrub Cover

- ❑ If the canopy of the shrub cover is over head, carry out the canopy cover measurement from the Biometry Protocol. If the canopy cover touching the crosshairs is shrub record "SB", if it is a deciduous tree record "D", and if it is an evergreen tree record "E". If the shrubs are too short to make true canopy observations (i.e. they are too short to walk under), treat the shrubs as an additional ground cover category along with graminoid and forb. Carry out the ground cover measurement from the Biometry Protocol, recording "GD" if the vegetation touching the observer's body at any height is a graminoid, "FB" if the vegetation is a forb, and "SB" if it is a shrub.

Step 2: Calculate the Percentage of Shrub Cover

- ❑ If the shrub cover is over head, divide the number of SB measurements by the sum of the SB, D, and E measurements. If the shrubs are not overhead, divide the number of SB measurements by the sum of the SB, GD, and FB measurements. Multiply by 100 to obtain a percentage.

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. Prof. Pap., 1976.

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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.

$$\% \text{ Shrub} = \frac{\#\text{ of SB's (Shrub Observations)}}{\#\text{ of SB's} + \#\text{ of E's} + \#\text{ of O's (Total canopy cover observations)}} \times 100$$

OR

$$\% \text{ Shrub} = \frac{\#\text{ of SB's (Shrub Observations)}}{\#\text{ of SB's} + \#\text{ of GD's} + \#\text{ of FB's (Total ground cover observations)}} \times 100$$