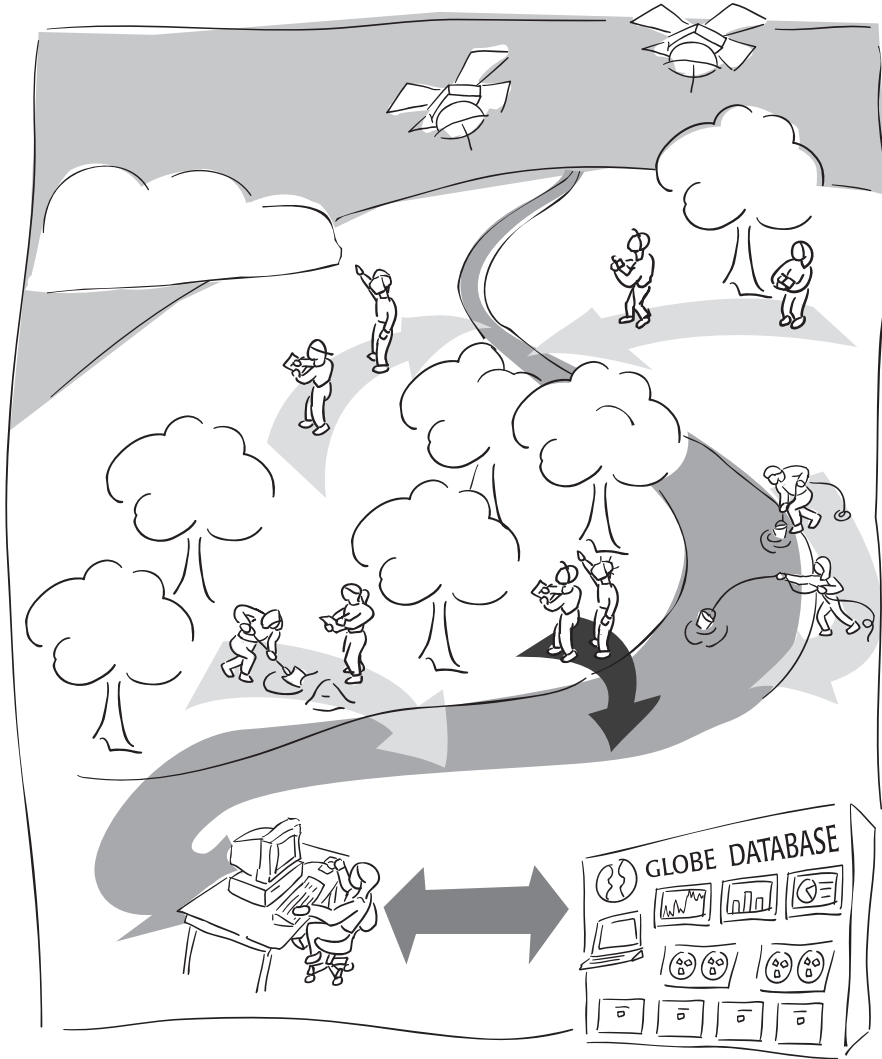


Biosphere Investigation



A GLOBE[®] Learning Investigation



Biosphere Investigation at a Glance



Protocols

Daily and Bi-Weekly, Seasonal Measurements

[Cloned and Common Lilacs](#) (daily, Seasonal)

[Green-Up](#) (bi-weekly, seasonal)

[Green-Down](#) (bi-weekly, seasonal)

[Ruby-Throated Hummingbirds](#) (daily or bi-weekly, seasonal)

[Phenological Gardens](#) (daily or bi-weekly, seasonal)

[Arctic Bird Migration](#) (every other day from 2 weeks prior to expected arrival)

Monthly

[Seaweed Receptacle Reproductive Stages](#) (four months in a row)

Once Per Site (or when land cover type has changed)

[Land Cover Sample Site Protocol](#) (Data collected once for each site: GPS location, photographs, land cover classification)

[Biometry Protocol](#) (Data collected once to determine land cover class of Land Cover Sample Sites or more often to study changes in biomass over time: canopy cover and ground cover, tree, shrub and/or graminoid height, tree circumference, graminoid biomass, dominant and co-dominant vegetation)

[Carbon Cycle Site Selection](#)

[Carbon Cycle Standard Site Set-up](#)

[Carbon Cycle Non-Standard Site Set-up](#)

[Carbon Cycle Standard Site Tree Mapping](#)

[Carbon Cycle Non-Standard Site Tree Mapping](#)

Yearly

[Carbon Cycle Standard Site Tree Circumference](#)

[Carbon Cycle Non-Standard Site Tree Circumference](#)

[Carbon Cycle Standard Site Shrub/Sapling](#)

[Carbon Cycle Non-Standard Site Shrub/Sapling](#)

[Carbon Cycle Standard Site Herbaceous](#)

[Carbon Cycle Non-Standard Site Herbaceous](#)

Suggested Activities

Note: Certain Learning Activities are desirable prior to implementing Protocols. Read the Introduction to become familiar with concepts of the biosphere, land cover and phenology.

Land Cover

Read the *Measurement Logistics and Suggested Methodology in the Introduction*.

Perform [Getting to Know Your Satellite Imagery and GLOBE Study Site Learning Activity](#).

Make a [densiometer](#) and [clinometer](#) (see *Investigation Instruments*).

Review how to pace and use a compass, densiometer, clinometer and tape measure (see *Investigation Instruments*).

Practice the *GPS Protocol* (see GPS Chapter) and the [Biometry Protocol](#).

Choose appropriate Land Cover Sample Sites within your Study Site (review *Sample Site Selection and Set-up*).

Perform the *Site Seeing Learning Activity* ([Beginner](#), or [Intermediate](#)) - introduces systems concepts.

Perform the [Leaf Classification Learning Activity](#) - introduces the concepts of classification.

Practice using the [MUC System](#) to classify land cover.

Perform [Land Cover Sample Site Protocol](#) at each Sample Site.

Perform the *Odyssey of the Eyes Learning Activity* ([Beginning](#), [Intermediate](#), or [Advanced](#)) - introduces remote sensing.

Perform either the [Manual Mapping: A Tutorial for the Beverly, MA Image](#) (from the Appendix) if you will be doing a manual map or the Unsupervised Clustering Tutorial if you will be doing a computer-aided map.

Perform either [Manual](#) or [Computer-aided Land Cover Mapping Learning Activity](#) using a Landsat satellite image.

Perform the [Bird Beak Accuracy Assessment Learning Activity](#) to introduce accuracy assessment.

Perform the [Accuracy Assessment Tutorial](#) from the Appendix to analyze the accuracy of your land cover type map.

Perform the [Land Cover Change Detection Learning Activity](#).

Perform the [Discovery Area Learning Activity](#) - uses the satellite images and maps students create.

[Using GLOBE Data to Analyze Land Cover Learning Activity](#) - relates land cover data to other GLOBE investigation measurements

Phenology

If you intend on doing the [Phenological Gardens Protocol](#), the best time to plant your garden is in the spring or autumn. Also, you must wait a year before collecting data.

[Green-Up Cards](#), [A Sneak Preview to Budburst](#), and a [First Look at Phenology learning activities](#) set the stage for taking plant phenology measurements.

Choose one of the Phenology Protocols to start ([Green Down](#) or [Hummingbirds](#) in the fall; [Green Up](#), or [Hummingbirds](#) in the spring); [Phenological Gardens](#) throughout the year).

[A Beginning Look at Photosynthesis](#) and [Investigating Leaf Pigments](#) learning activities help students better understand the process of photosynthesis.

[Global Patterns in Green-Up and Green-Down](#) and [Limiting Factors in Ecosystems](#) help students to explore global trends in green-up and green-down and to explore why these patterns occur in different ecosystems.

Carbon Cycle

Read the [Introduction to the Global Carbon Cycle](#).

Perform Carbon Cycle Learning Activities to gain understanding in systems thinking, carbon and the global carbon cycle. Use the [Flowchart for Carbon Cycle and Systems Introductory Materials](#) to choose the appropriate activities for your students.

Determine if your site is Standard or Non-Standard with the [Site Selection Protocol](#).

Perform [Biomass Units](#) activity to learn the concept of biomass.

Standard Sites Only: practice estimating percent cover with the [Percent Cover](#) activity.

Perform the [Allometry](#) activity to understand how circumference of trees can be used to estimate biomass.

Practice pacing and using a compass with the guides in the [Standard Site Set-up Protocol](#) or [Non-Standard Site Set-up Protocol](#).

For sites with trees: learn and practice the correct way to measure tree circumference with the [How to Measure Trees Supporting Protocol](#).

Table of Contents

Introduction

The Big Picture	Introduction 1
Why Investigate components of the biosphere?	Introduction 2
Scientists Need GLOBE Data	Introduction 5
Educational Objectives	Introduction 5
Measurement Logistics	Introduction 10
Protocols at a Glance	Introduction 13
Suggested Methodology	Introduction 14
Implementation Considerations	Introduction 19

Protocols

Land Cover

- [Sample Site Selection and Set-Up](#)
- [Investigation Instruments: The MUC System](#)
- [Investigation Instruments: Clinometer](#)
- [Investigation Instruments: Densimeter](#)
- [Investigation Instruments: Compass](#)
- [Investigation Instruments: Tape Measure](#)
- [Land Cover Sample Site Protocol](#)
- [Biometry Protocol](#)
- [Fire Fuel Ecology Protocol](#)

Phenology

- [Green-Up Protocol](#)
- [Green-Down Protocol](#)
- [Ruby-throated Hummingbird Protocol](#)
- [Lilac Phenology Protocol](#)
- [Phenological Gardens Protocol](#)
- [Seaweed Reproduction Phenology Protocol](#)
- [Arctic Bird Migration Monitoring Protocol](#)

Carbon Cycle

- [Carbon Cycle Site Selection](#)
- [Carbon Cycle Standard Site Set-up](#)
- [Carbon Cycle Non-Standard Site Set-up](#)
- [Carbon Cycle Standard Site Tree Mapping](#)
- [Carbon Cycle Non-Standard Site Tree Mapping](#)
- [Carbon Cycle Standard Site Tree Circumference](#)

[Carbon Cycle Non-Standard Site Tree Circumference](#)

[Carbon Cycle Standard Site Shrub/Sapling](#)

[Carbon Cycle Non-Standard Site Shrub/Sapling](#)

[Carbon Cycle Standard Site Herbaceous](#)

[Carbon Cycle Non-Standard Site Herbaceous](#)

Learning Activities

Land Cover

[Getting to Know Your Satellite Imagery and GLOBE Study Site](#)

Site Seeing ([Beginner](#), and [Intermediate](#) versions)

[Leaf Classification](#)

Odyssey of the Eyes ([Beginning](#), [Intermediate](#), and [Advanced](#) versions)

[Bird Beak Accuracy Assessment](#)

[Discovery Area](#)

[Using GLOBE Data to Analyze Land Cover](#)

[Manual Land Cover Mapping](#)

[Manual Mapping: A Tutorial for the Beverly, MA, Image](#)

[Computer-aided Land Cover Mapping](#)

[Accuracy Assessment Tutorial](#)

[Land Cover Change Detection](#)

[Change Detection Tutorial](#)

[Do You Know Your MUC?](#)

Phenology

[Green-up Cards](#)

[A Sneak Preview of Budburst](#)

[A First Look at Phenology](#)

[A Beginning Look at Photosynthesis](#)

[Investigating Leaf Pigments](#)

Carbon Cycle

[Flowchart for Carbon Cycle and Systems Introductory Materials](#)

[Paperclip Simulation and Model-Introduction to Systems Thinking](#)

[Carbon Cycle Adventure Story](#)

[Carbon Travels Game](#)

[Getting to Know the Global Carbon Cycle](#)

[Biomass Units](#)

[Percent Cover](#)

[Allometry](#)

[Biomass Accumulation Model](#)

[Simple Global Carbon Cycle Model Teacher](#)

[Global Carbon Cycle Model with Feedbacks Teacher Guide](#)

Appendix

Site Definition Sheet	Appendix 3
Land Cover	
Land Cover Sample Site Data Sheet	Appendix 9
Tree and/or Shrub Canopy and Ground Cover Data Sheet	Appendix 10
Measure Tree Height on Level Ground Data Sheet	Appendix 12
Measure Tree Height on Level Ground: Simplified Clinometer Technique Data Sheet	Appendix 13
Measure Tree Height on a Slope: Stand by Tree Data Sheet	Appendix 14
Measure Tree Height on a Slope: Two-Triangle with Eyes Higher or Lower than Tree Base Technique Data Sheet	Appendix 15
Tree Circumference Data Sheet	Appendix 17
Graminoid Biomass Data Sheet	Appendix 18
Land Cover Summary Data Sheet	Appendix 19
Fire Fuel Protocol: Center Plot Data Sheet	Appendix 20
Fire Fuel Protocol: Transect Measurements Data Sheet	Appendix 21
Clinometer Sheet	Appendix 22
Table of Tangents	Appendix 23
Table of Cosines	Appendix 24
Phenology	
Tree and Shrub Green-Up Data Sheet	Appendix 25
Grass Green-Up Data Sheet	Appendix 26
Tree, Shrub, and Grass Green-Down Data Sheet	Appendix 27
Cloned and Common Lilac Data Sheet	Appendix 28
Phenological Gardens Data Sheet	Appendix 29
Seaweed Reproductive Phenology Site Definition Sheet	Appendix 31
Seaweed Reproduction Phenology Data Sheet	Appendix 32
Ruby-throated Hummingbird (RTHB) Site Definition Sheet	Appendix 33
Ruby-throated Hummingbird (RTHB) Hummingbird Sighting Data Sheet	Appendix 35
Ruby-throated Hummingbird (RTHB) Feeder Visit Data Sheet	Appendix 37
Ruby-throated Hummingbird (RTHB) Flower Visit Data Sheet	Appendix 39
Ruby-throated Hummingbird (RTHB) Feeder vs. Flower Visit	

<u>Data Sheet</u>	Appendix 41
<u>Ruby-throated Hummingbird (RTHB) Flower Species Visit Data Sheet</u>	Appendix 43
<u>Ruby-throated Hummingbird (RTHB) Nesting Report Data Sheet (U.S. and Canada)</u>	Appendix 45
<u>Arctic Bird Migration Monitoring Site Definition Sheet</u>	Appendix 46
<u>Arctic Bird Migration Monitoring Data Sheet</u>	Appendix 47
<u>Non-Standard Carbon Site Set-Up Data Sheets</u>	Appendix 48
<u>Non-Standard Herbaceous Data Sheet</u>	Appendix 50
<u>Non-Standard Shrub&Sapling Data Sheet</u>	Appendix 51
<u>Non-Standard Tree Data Sheet</u>	Appendix 53
<u>Standard Carbon Site Set-Up Data Sheets</u>	Appendix 56
<u>Standard Herbaceous Data Sheet</u>	Appendix 58
<u>Standard Shrub&Sapling Data Sheet</u>	Appendix 59
<u>Standard Tree Data Sheet</u>	Appendix 61