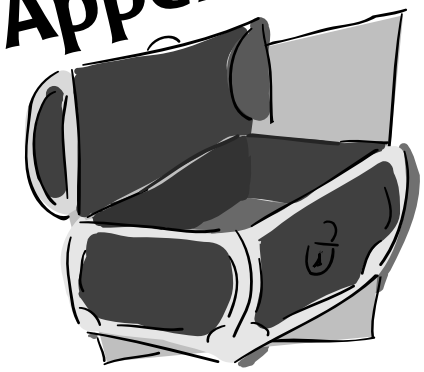
Appendix



Earth System Science Investigation

Budburst Site Definition Sheet

School Name: _____Class or Group Name:_____

Name(s) of student(s) filling in Data Sheet: _____

_____

Date: _____

Site name (give your site a unique name):_____

Coordinates: Latitude: _____ ❒ N or ❒ S (check one)
Longitude: _____ ❒ E or ❒ W (check one)
Elevation: _____ meters

Source of Location Data (check one): ❒ GPS ❒ Other

If other, describe:_____

Tree or shrub Label	Genus	Species

Comments (metadata):

1. Are the trees or shrubs in the understory?
2. At this site, are there more than one dominant species?

Other comments: _____

_____

_____

_____

Earth System Science Investigation

Green-Up and Green-Down Site Definition Sheet

School Name: _____

Observer Names: _____

_____

Date: _____ Check one: ❒ New Site ❒ Metadata Update

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

Coordinates: Latitude: _____ ❒ N or ❒ S (check one)
Longitude: _____ ❒ E or ❒ W (check one)
Elevation: _____ meters

Source of Location Data (check one): ❒ GPS ❒ Other

If other, describe:_____

Nearest Atmosphere Site: ATM-_____

Distance to Site: ____ meters; Direction to Site: ❒ N ❒ NE ❒ E ❒ SE ❒ S ❒ SW ❒ W ❒ NW

Type of site: ❒ Atmosphere Study Site ❒ Land Cover Sample Site ❒ Other

If other, describe: _____

_____

For each tree, shrub or grass plot, provide the following information.
Species is NOT required for grasses.

Tree, Shrub, or Grass Label	
Genus	
Species	
Common Name	

Comments:

_____

_____

_____

_____

_____

_____

_____

Budburst Protocol

Data Sheet

School Name: _____Class or Group Name:_____

Name(s) of student(s) filling in Data Sheet: _____

_____

Date: _____

Site name (give your site a unique name):_____

	Tree Label: _____		Tree Label: _____	
Date	**Are tiny leaves emerging? Yes or No**	**Can budburst be seen on 3 locations on the tree? Yes or No**	**Are tiny leaves emerging? Yes or No**	**Can budburst be seen on 3 locations on the tree? Yes or No**

Comments: _____

_____

_____

_____

Earth System Science

Tree and Shrub Green-Up Data Sheet

School Name: _____ Study Site: PHN-_____

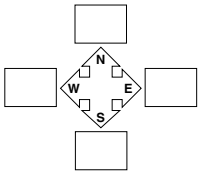
Observer Names:_____

Plant Scientific Name: Genus_____ Species: _____

Plant Common Name: _____

Green-Up Cycle:_____ Year:_____

Photo Number and Orientation



Tree and Shrub Green-Up

Date (day and month)	**Leaf 1** (dormant, swelling, budburst, length (mm), lost)	**Leaf 2** (dormant, swelling, budburst, length (mm), lost)	**Leaf 3** (dormant, swelling, budburst, length (mm), lost)	**Leaf 4** (dormant, swelling, budburst, length (mm), lost)	**Reported to GLOBE**
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑

Check the last column on the green-up table when you report your data to GLOBE.

Comments *(date each comment):*

_____

_____

Earth System Science

Grass Green-Up Data Sheet

School Name: _____ Study Site: PHN-_____

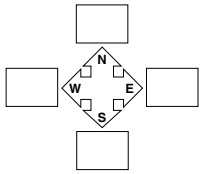
Observer Names:_____

Plant Scientific Name: Genus_____

Plant Common Name: _____

Green-Up Cycle:_____ Year:_____

Photo Number and Orientation



Grass Green-Up

Date (day and month)	**Leaf 1** (No shoot length (mm), or lost)	**Leaf 2** (No shoot length (mm), or lost)	**Leaf 3** (No shoot length (mm), or lost)	**Leaf 4** (No shoot length (mm), or lost)	**Reported to GLOBE**
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑

Check the last column on the green-up table when you report your observations to GLOBE.

Comments *(date each comment):*

_____

_____

_____

Earth System Science

Tree, Shrub, and Grass Green-Down Data Sheet

School Name: _____ Study Site: PHN-_____

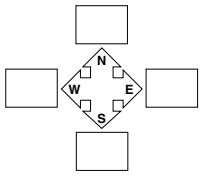
Observer Names:_____

Plant Scientific Name: Genus_____ Species: _____

Plant Common Name: _____

Green-Down Cycle:_____ Year:_____

Photo Number and Orientation



Tree, Shrub, and Grass Green-Down

Date (day and month)	**Leaf 1** (Color, fallen, snow covered)	**Leaf 2** (Color, fallen, snow covered)	**Leaf 3** (Color, fallen, snow covered)	**Leaf 4** (Color, fallen, snow covered)	**Reported to GLOBE**
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑
					❑

Check the last column on the green-up table when you report your observations to GLOBE.

Comments *(date each comment):*

_____

_____

_____

Ruby-throated Hummingbird (RTHU)

Site Definition Data Sheet

School Name: _____ Class or Group Name:_____

Name(s) of student(s) filling in *Data Sheet:*_____

_____

Date:_____

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

Coordinates: Latitude:_____ ❑ N or ❑ S Longitude:_____ ❑ E or ❑ W

Elevation:____ meters

Source of Location Data (check one): ❑ GPS ❑ Other _____

Nearest Atmosphere Site: ATM-_____

Distance to ATM Site:_____meters;

Direction to Site: ❑ N ❑ NE ❑ E ❑ SE ❑ S ❑ SW ❑ W ❑ NW

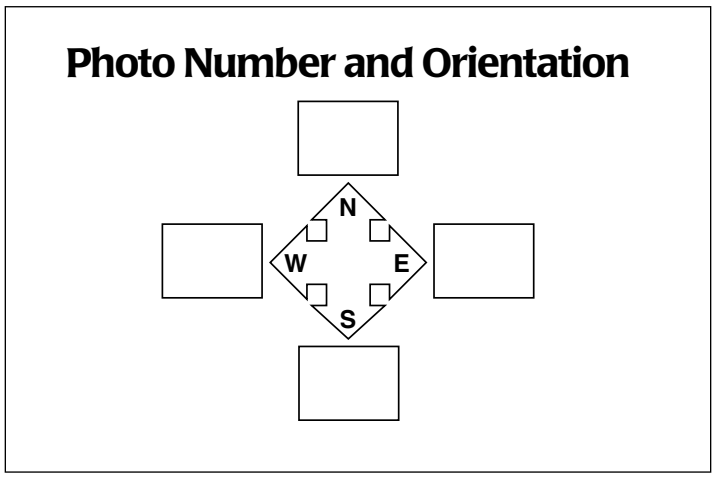
Elevation Difference (Soil Moisture Site – Hummingbird Site):_____meters
(this value may be positive or negative)

Check If Present At Site: ❑ Hummingbird Feeder ❑ Flowers

If flowers are present, record the following (use additional sheets if needed):

Genus	Species	Common Name

Photo Number and Orientation



Comments (Metadata): _____

Ruby-throated Hummingbird (RTHU)

Hummingbird Sighting Protocol Data Sheet

School Name: _____Class or Group Name: _____

Name(s) of Student(s) Filling in *Data Sheet:* _____

_____

Site Name: _____

	NUMBER OF HUMMINGBIRDS OBSERVED					
Date						
Observation Start Time: (local time)						
Observation End Time: (local time)						
Observation Start Time: (UT)						
Observation End Time: (UT)						
Adult Male *full red throat* February-October (U.S., Canada) January-September ONLY (Mexico, Central America, Caribbean)						
Adult Male (probable adult, but may be an advanced juvenile) *full red throat* October-December (Mexico, Central America, Caribbean)						
Adult Female *white throat* February-April ONLY (U.S., Canada) January-May (Mexico, Central America, Caribbean)						
Undetermined Sex and Age (could be female or young male) *white throat* May-October (U.S., Canada) August-December ONLY (Mexico, Central America, Caribbean)						
Undetermined Sex and Age *throat not observed* Any time of the year (all locations)						
Young Male *throat streaked in green or black and/or one or more red throat feathers* May-October (U.S., Canada) August-April (Mexico, Central America, Caribbean)						

If no hummingbirds are seen, record "0" on the Data Sheet above and enter "0" on the data entry page on the GLOBE Web site.

For any "unusual" RTHU (i.e., one with "abnormal" plumage or one that is color-marked) record in the Data Entry page's Comments section the color of the bird's forehead, crown, throat, breast, belly, flanks, back, tail, bill, and eyes, and the location of other distinct markings. Describe the bird's activity (including feeding behavior). Take a photo if possible. Also follow this procedure for any "vagrant" hummingbirds other than RTHUs from 15 October through 15 March. Please be sure to report any of these "unusual" and "vagrant" hummingbirds directly to research@hiltonpond.org as soon as possible after sighting.

Comments:

Ruby-throated Hummingbird (RTHU)

Feeder Visit Protocol Data Sheet

School Name: _____Class or Group Name: _____

Name(s) of Student(s) Filling in *Data Sheet:* _____

_____

Site Name: _____

	NUMBER OF FEEDER VISITS					
Date						
Observation Start Time: (local time)						
Observation End Time: (local time)						
Observation Start Time: (UT)						
Observation End Time: (UT)						
Adult Male *full red throat* February-October (U.S., Canada) January-September ONLY (Mexico, Central America, Caribbean)						
Adult Male (probable adult, but may be an advanced juvenile) *full red throat* October-December (Mexico, Central America, Caribbean)						
Adult Female *white throat* February-April ONLY (U.S., Canada) January-May (Mexico, Central America, Caribbean)						
Undetermined Sex and Age (could be female or young male) *white throat* May-October (U.S., Canada) August-December ONLY (Mexico, Central America, Caribbean)						
Undetermined Sex and Age *throat not observed* Any time of the year (all locations)						
Young Male *throat streaked in green or black and/or one or more red throat feathers* May-October (U.S., Canada) August-April (Mexico, Central America, Caribbean)						

Observations are made in 45-minute time blocks. If no hummingbirds are seen, record "0" on the Data Sheet above and enter "0" on the data entry page on the GLOBE Web site.

For any "unusual" RTHU (i.e., one with "abnormal" plumage or one that is color-marked) record in the Data Entry page's Comments section the color of the bird's forehead, crown, throat, breast, belly, flanks, back, tail, bill, and eyes, and the location of other distinct markings. Describe the bird's activity (including feeding behavior). Take a photo if possible. Also follow this procedure for any "vagrant" hummingbirds other than RTHUs from 15 October through 15 March. Please be sure to report any of these "unusual" and "vagrant" hummingbirds directly to research@hiltonpond.org as soon as possible after sighting.

Comments:

Ruby-throated Hummingbird (RTHU)

Flower Visit Protocol Data Sheet

School Name: _____Class or Group Name: _____

Name(s) of Student(s) Filling in *Data Sheet:* _____

_____

Site Name: _____

	NUMBER OF FLOWER VISITS					
Date						
Observation Start Time: (local time)						
Observation End Time: (local time)						
Observation Start Time: (UT)						
Observation End Time: (UT)						
Adult Male *full red throat* February-October (U.S., Canada) January-September ONLY (Mexico, Central America, Caribbean)						
Adult Male (probable adult, but may be an advanced juvenile) *full red throat* October-December (Mexico, Central America, Caribbean)						
Adult Female *white throat* February-April ONLY (U.S., Canada) January-May (Mexico, Central America, Caribbean)						
Undetermined Sex and Age (could be female or young male) *white throat* May-October (U.S., Canada) August-December ONLY (Mexico, Central America, Caribbean)						
Undetermined Sex and Age *throat not observed* Any time of the year (all locations)						
Young Male *throat streaked in green or black and/or one or more red throat feathers* May-October (U.S., Canada) August-April (Mexico, Central America, Caribbean)						

Observations are made in 45-minute time blocks. If no hummingbirds are seen, record "0" on the Data Sheet above and enter "0" on the data entry page on the GLOBE Web site.

For any "unusual" RTHU (i.e., one with "abnormal" plumage or one that is color-marked) record in the Data Entry page's Comments section the color of the bird's forehead, crown, throat, breast, belly, flanks, back, tail, bill, and eyes, and the location of other distinct markings. Describe the bird's activity (including feeding behavior). Take a photo if possible. Also follow this procedure for any "vagrant" hummingbirds other than RTHUs from 15 October through 15 March. Please be sure to report any of these "unusual" and "vagrant" hummingbirds directly to research@hiltonpond.org as soon as possible after sighting.

Comments:

Ruby-throated Hummingbird (RTHU)

Feeder vs. Flower Visit Protocol Data Sheet

School Name: _____Class or Group Name: _____

Name(s) of Student(s) Filling in *Data Sheet:* _____

_____

Site Name: _____

		NUMBER OF VISITS					
Date							
Observation Start Time: (local time)							
Observation End Time: (local time)							
Observation Start Time: (UT)							
Observation End Time: (UT)							
Adult Male *full red throat* February-October (U.S., Canada) January-September ONLY (Mexico, Central America, Caribbean)	Feeder:						
	Flower:						
Adult Male (probable adult, but may be an advanced juvenile) *full red throat* October-December (Mexico, Central America, Caribbean)	Feeder:						
	Flower:						
Adult Female *white throat* February-April ONLY (U.S., Canada) January-May (Mexico, Central America, Caribbean)	Feeder:						
	Flower:						
Undetermined Sex and Age (could be female or young male) *white throat* May-October (U.S., Canada) August-December ONLY (Mexico, Central America, Caribbean)	Feeder:						
	Flower:						
Undetermined Sex and Age *throat not observed* Any time of the year (all locations)	Feeder:						
	Flower:						
Young Male *throat streaked in green or black and/or one or more red throat feathers* May-October (U.S., Canada) August-April (Mexico, Central America, Caribbean)	Feeder:						
	Flower:						

Observations are made in 45-minute time blocks. If no hummingbirds are seen, record "0" on the Data Sheet above and enter "0" on the data entry page on the GLOBE Web site.

For any "unusual" RTHU (i.e., one with "abnormal" plumage or one that is color-marked) record in the Data Entry page's Comments section the color of the bird's forehead, crown, throat, breast, belly, flanks, back, tail, bill, and eyes, and the location of other distinct markings. Describe the bird's activity (including feeding behavior). Take a photo if possible. Also follow this procedure for any "vagrant" hummingbirds other than RTHUs from 15 October through 15 March. Please be sure to report any of these "unusual" and "vagrant" hummingbirds directly to research@hiltonpond.org as soon as possible after sighting.

Comments:

Ruby-throated Hummingbird (RTHU)

Flower Species Visit Protocol Data Sheet

School Name: _____Class or Group Name: _____

Name(s) of Student(s) Filling in *Data Sheet:* _____

_____

Site Name: _____

Date						
Observation Start Time: (local time)						
Observation End Time: (local time)						
Observation Start Time: (UT)						
Observation End Time: (UT)						
FLOWER NAME	**NUMBER OF FLOWER VISITS, by Species**					
Genus:						
Species:						
Adult Male *full red throat* February-October (U.S., Canada) January-September ONLY (Mexico, Central America, Caribbean)						
Adult Male (probable adult, but may be an advanced juvenile) *full red throat* October-December (Mexico, Central America, Caribbean)						
Adult Female *white throat* February-April ONLY (U.S., Canada) January-May (Mexico, Central America, Caribbean)						
Undetermined Sex and Age (could be female or young male) *white throat* May-October (U.S., Canada) August-December ONLY (Mexico, Central America, Caribbean)						
Undetermined Sex and Age *throat not observed* Any time of the year (all locations)						
Young Male *throat streaked in green or black and/or one or more red throat feathers* May-October (U.S., Canada) August-April (Mexico, Central America, Caribbean)						

Observations are made in 45-minute time blocks. If no hummingbirds are seen, record "0" on the Data Sheet above and enter "0" on the data entry page on the GLOBE Web site.

For any "unusual" RTHU (i.e., one with "abnormal" plumage or one that is color-marked) record in the Data Entry page's Comments section the color of the bird's forehead, crown, throat, breast, belly, flanks, back, tail, bill, and eyes, and the location of other distinct markings. Describe the bird's activity (including feeding behavior). Take a photo if possible. Also follow this procedure for any "vagrant" hummingbirds other than RTHUs from 15 October through 15 March. Please be sure to report any of these "unusual" and "vagrant" hummingbirds directly to research@hiltonpond.org as soon as possible after sighting.

Comments:

Ruby-throated Hummingbird (RTHU)

Nesting Report Protocol Data Sheet (U.S. and Canada)

School Name: _____

Class or Group Name: _____

Name(s) of Student(s) Filling in *Data Sheet:* _____

_____

Site Name: _____

Date Nest Was Found: _____

Check One: ☐ 1st set of eggs at this nest

☐ 2nd set of eggs at this nest

☐ 3rd set of eggs at this nest

Record dates for the following observations. It is possible you will not observe all activities listed.

Observation	Date
Start of Nest Construction	
End of Nest Construction	
First Sighting of Adult Female on Nest	
Laying of First Egg	
Laying of Second Egg	
First Egg Hatched	
Second Egg Hatched	
When First Nestling Leaves the Nest	
When Second Nestling Leaves the Nest	
Last Sighting of Adult Female on Nest	

Number of eggs laid: _____

Number of eggs that did not hatch: _____

Number of nestlings that survived: _____

Record dates and observations of adult male RTHU behavior at the nest:_____

_____

_____

_____

Comments: _____

_____

_____

_____

Clonal and Common Lilac

Site Definition Sheet

School Name: _____Class or Group Name:_____

Name(s) of student(s) filling in Data Sheet: _____

_____

Date: _____

Site name (give your site a unique name):_____

Coordinates: Latitude: _____ ❒ N or ❒ S (check one)
Longitude: _____ ❒ E or ❒ W (check one)
Elevation: _____ meters

Source of Location Data (check one): ❒ GPS ❒ Other

If other, describe:_____

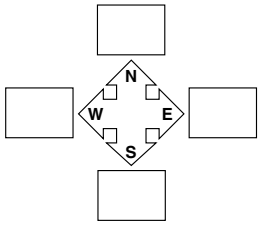
Nearest Atmosphere Site: ATM-_____

Distance to Site: _____ meters; Direction to Site: ❒ N ❒ NE ❒ E ❒ SE ❒ S ❒ SW ❒ W ❒ NW

Elevation Difference (Atmosphere Site – this site):_____ meters (this value may be positive or negative)

Lilac shrub label	Clonal or common	Date planted OR indicate if planted before 1997	Height (cm)

Photo Number and Orientation



Comments:_____

_____

_____

_____

_____

_____

Common and Clonal Lilac

Data Sheet

School Name: _____Class or Group Name:_____

Name(s) of student(s) filling in Data Sheet:_____

_____

Site Name:_____

Lilac shrub label	Clonal or common	Date of first leaf observed (YYYY/MM/DD)	Date of last observation immediately before first leaf (YYYY/MM/DD)	Date of full or 95% leafed (YYYY/MM/DD)	Date of last observation immediately before full leaf (YYYY/MM/DD)

Lilac shrub label	Clonal or common	Date of first bloom observed (YYYY/MM/DD)	Date of last observation immediately before first bloom(YYYY/MM/DD)	Date of full bloom (YYYY/MM/DD)	Date of last observation immediately before full bloom (YYYY/MM/DD)

Lilac shrub label	Clonal or common	Date of fend of bloom (YYYY/MM/DD)	Date of last observation immediately before end of bloom(YYYY/MM/DD)	Height (cm) Measured once only in autumn

Comments:_____

_____

_____

_____

_____

_____

_____

Phenological Gardens

Site Definition Data Sheet

School Name: _____Class or Group Name:_____

Name(s) of student(s) filling in Data Sheet: _____

_____

Date: _____

Site name (give your site a unique name):_____

Coordinates: Latitude: _____ ❒ N or ❒ S (check one)
Longitude: _____ ❒ E or ❒ W (check one)
Elevation: _____ meters

Source of Location Data (check one): ❒ GPS ❒ Other

If other, describe:_____

Nearest Atmosphere Site: ATM-_____

Distance to ATM Site: _____ meters;
Direction to Site: ❒ N ❒ NE ❒ E ❒ SE ❒ S ❒ SW ❒ W ❒ NW

Elevation Difference (Atmosphere Site – this site):_____ meters (this value may be positive or negative)

Nearest Soil Moisture Site: SMS-_____

Distance to Soil Moisture Site:_____(meters);
Direction to Site: ❑ N ❑ NE ❑ E ❑ SE ❑ S ❑ SW ❑ W ❑ NW

Elevation Difference (Atmosphere Site – this site):_____ meters (this value may be positive or negative)

Plants in Garden

Shrub	Planted in Garden? Yes or No	Date planted
Witch Hazel 'Jelena'		
Witch Hazel 'Genuine'		
Lilac		
Mock-Orange		
Forsythia		
Heather 'Allegro'		
Heather 'Long White'		
Snowdrops		

Soil Texture in the top 10 cm (from *Soil Characterization Field Measurement Protocol*): _____Soil pH in the top 10 cm (from *Soil Characterization Lab Analysis Protocol*): _____

Soil pH method (check one): ❑ paper ❑ meter

Photo Number and Orientation

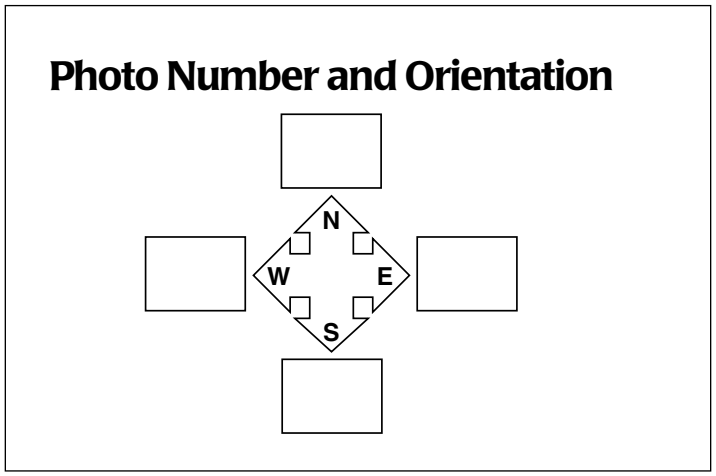


Photo of Garden

Comments (Metadata): _____

Phenological Gardens

Data Sheet

School Name: _____Class or Group Name:_____

Name(s) of student(s) filling in Data Sheet:_____

_____

Site Name:_____

For witch hazel, mock-orange, heather and snowdrops, record the dates for the following flowering stages:

	Flowering Stage		
Shrub	**BF**	**GF**	**EF**
Witch Hazel 'Jelena'			
Snowdrops			
Mock-Orange			
Heather 'Allegro'			
Heather 'Long White'			
Witch Hazel 'Genuine'			

BF = Beginning of flowering

GF = General flowering

EF = End of flowering

For lilac and forsythia, record the dates for the following flowering and leaf growth stages:

	Flowering Stage			Leaf Stage	
Shrub	**BF**	**GF**	**EF**	**LU**	**FL**
Lilac					
Forsythia					

LU = Beginning of leaf unfolding

FL = Full leafs

Height and health of each plant. Measure in the Autumn.

Shrub	**Height (cm)**	**Health of Shrub Healthy = H Unhealthy = U Dead = D**	**If shrub died, did you replace it with another shrub? (yes or no)**
Witch Hazel 'Jelena'			
Snowdrops	not necessary to measure the height		
Mock-Orange			
Heather 'Allegro'			
Heather 'LongWhite'			
Lilac			
Forsythia			

Was fertilizer used on the plants this year?_____ If yes, date of application: _____

Type of fertilizer _____

Record dates plant(s) were watered:_____

If plants are pruned, record date(s):_____

Comments (Metadata): _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Seaweed Reproductive Phenology

Site Definition Data Sheet

School Name: _____Class or Group Name:_____

Name(s) of student(s) filling in *Data Sheet:* _____

_____

Date: _____

Site name (give your site a unique name):_____

Coordinates: Latitude: _____ ❒ N or ❒ S (check one)
Longitude: _____ ❒ E or ❒ W (check one)
Elevation: _____ meters

Source of Location Data (check one): ❒ GPS ❒ Other

If other, describe:_____

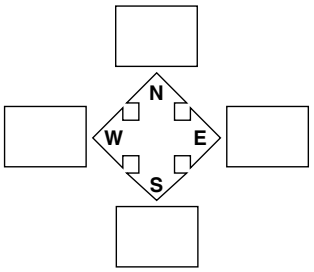
Tidal Range: _____ meters

Beach Aspect:_____°

Beach Slope:_____°

Dominant Rock size (check one): ❑ large boulders ❑ medium boulders
❑ small boulders ❑ cobbles ❑ pebbles ❑ gravel

Photo Number and Orientation



Comments (Metadata): _____

_____

_____

_____

_____

_____

Seaweed Reproduction Phenology Protocol

Data Sheet

School Name: _____Class or Group Name:_____

Name(s) of student(s) filling in *Data Sheet:*_____

_____

Site Name:_____

Date: _____

Time:_____(local) _____(UT)

Time of low tide:_____(local) _____(UT)

Species (check one): ❑ *Fucus vesiculosus* ❑ *Asophyllum nodosum*
❑ *Fucus distichus* ❑ *Fucus spiralis* ❑ *Fucus serratus*
❑ *Pelvetia canaliculata*

Stage	1	2	3	4	5	Total
Number of receptacles in Stage						
Percentage of receptacles in stage [(number in stage/total number of receptacles observed)*100]						100

Comments: _____

_____

_____

_____

_____

Arctic Bird Migration Monitoring

Site Definition Data Sheet

School Name: _____Class or Group Name:_____

Name(s) of student(s) filling in Data Sheet: _____

_____

Date: _____

Site name (give your site a unique name):_____

Coordinates: Latitude: _____ ❒ N or ❒ S (check one)
Longitude: _____ ❒ E or ❒ W (check one)
Elevation: _____ meters

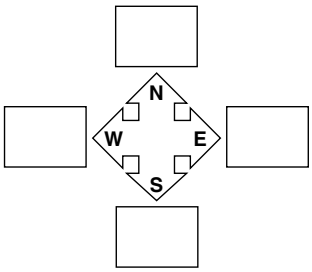
Source of Location Data (check one): ❒ GPS ❒ Other

If other, describe:_____

Nearest Atmosphere Site: ATM-_____

Distance to ATM Site: ____ meters;
Direction to Site: ❒ N ❒ NE ❒ E ❒ SE ❒ S ❒ SW ❒ W ❒ NW

Photo Number and Orientation



Type of Site (select one): ❒ Field ❒ Estuary/shore ❒ Lake or Pond ❒ Ocean/shore
❒ Forest or Woodland ❒ Other

If other, describe: _____

Comments (Metadata): _____

_____

_____

_____

_____

_____

_____

_____

Arctic Bird Migration Monitoring Protocol

Data Sheet

School Name: _____Class or Group Name:_____

Name(s) of student(s) filling in Data Sheet: _____

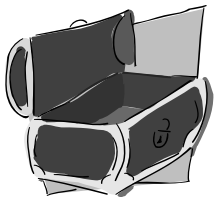
Site name:_____

Bird Genus:_____ Species:_____ Bird species common name:_____

Bird Observations

Date	Local Start Time	Local End Time	Start Time (UT)	End Time (UT)	If by ocean, UT time of low tide	Number of birds	Comments

Glossary



Abscission
Separation of leaves or other structures from an axis by the formation of an layer that reduces and then cuts off the flow of water and nutrients between leaf and tree

Acclimation
Process by which plants become increasingly resistant to subfreezing temperature without sustaining injury.

Adhesion
Molecular attraction that holds the surfaces of two substances together e.g. attraction of water molecules to other kinds of molecules

Aerosols
Particles of solid and liquid suspended in the atmosphere

Almost Closed System
A system in which almost no matter enters or leaves; the Earth system is considered an almost closed system because only a small amount of gases and particles enter or leave the system at the top of the atmosphere. In studying the Earth as a whole you use

Annotate
To label

Anthocyanin
Pigment in leaves that is bright red and purple

Aquifer
A body of permeable rock or gravel capable of storing water underground

Atmospheric Carbon
Carbon that is in gaseous form (combined with other atoms like oxygen) that make up part of the Earth's atmosphere such as carbon dioxide and carbon monoxide

Average Surface Temperature
The surface temperature of the Earth averaged over a wide region and over a long period of time

AVHRR Satellite
Satellite that carries the Advanced Very High Resolution Radiometer instrument

Axis
The invisible straight line between the North and South poles

Biogeochemical Cycles
Movement of chemical elements from organisms to physical environment back to organisms in a circular cycle

Biomass
Total mass of all the organisms of a given type or in an area or region

Biome
A major ecological community type (e.g., rain forest, grassland, desert)

Biota
All of the organisms living in a particular region, including plants, animals, and microorganisms

Boreal
Of or relating to northern regions or the Northern Hemisphere

Boundary
A line or a plane that divides two different areas or regions

Broad-leafed Trees
Trees that have wide and flat leaves rather than needlelike leaves

Budburst
The opening or breaking of buds which are hard protective covers containing miniature leaves. It is a seasonal event that signals the start of leaf growth or green-up

Canopy
The uppermost layer of plant leaves that are detected by satellite remote sensing

Capillary Action
Attraction of the surface of a liquid to the surface of a solid which is expressed as the readiness of a liquid such as water, to flow through a solid such as paper

Carbon Cycle
The movement of carbon through the surface, interior, and atmosphere of the Earth, which may involve organisms

Carbon Fixation
The process by which carbon taken from the carbon dioxide in the air is incorporated in the cells of a plant or microorganism, such as in photosynthesis

Carotene
Pigment in leaves that is orange

Celestial Sphere
An imaginary sphere of infinite extent with the Earth at its center on which the stars, planets, and other heavenly bodies appear to be located

Chemical Cycle
The movement of various chemicals through the surface, interior, and atmosphere of the Earth and the chemical reactions that impact the form of those chemicals

Chemical Energy
The energy produced or absorbed in the process of a chemical reaction

Chlorophyll
A pigment which gives plants their green color and traps light energy for plants, algae, and some bacteria to use in making food

Chromatography
The separation of substances in a mixture by placing the mixture in a mobile phase (water or other solvent) that is placed over a stationary phase (e.g. paper)

Climate
The statistical collective of the weather conditions of a specified area during a specified time period

Climate Cycles
Alternating episodic climate events that recur with some regularity, but are not strictly periodic

Climatic Island
An area of uniform climate, such as a mountain top, that is isolated from other areas similar to it

Climatogram
A graph showing the long term average of temperature and precipitation totals for a region (a year or longer)

Climatograph
See climatogram

Closed System
A system in which no matter enters or leaves

Cohesion
Force holding a solid or liquid together due to the attraction of like molecules, for example the attraction of water molecules to each other

Components
Parts of a whole

Conifers/Coniferous
Any cone-bearing trees, chiefly evergreen trees of the class Coniferinae, including pine, fir, and spruce that have needle-like leaves

Connections
Links between one component of the Earth system and another

Consumers
Living things that use resources in their environment to survive

Continental Climate
Climate characteristic of the interior of a large land mass, generally marked by large annual and daily ranges of temperature, low relative humidity and generally moderate or small amounts of rainfall.

Contrast
The ratio between maximum and minimum values

Control
An experimental set up and result against which other experiments that incorporate modifications or changes and the results of those experiments are compared

Crown
The leafy portion of a tree or shrub. Even the lowest branches of a tree or shrub are part of the crown

Cryosphere
Part of the Earth that is frozen, comprising ice sheets, glaciers, and sea areas covered by ice

Dew Point
The temperature to which air must be cooled to reach saturation of water vapor to occur

Diagram
A visual representation of a system used to communicate information about that system to others

Diurnal
Daily, as in diurnal rotation of the Earth

Dormancy
State of suspended growth and metabolism

Earth System
The components that comprise the environment of the Earth, including the atmosphere, hydrosphere, lithosphere, pedosphere (soils), cryosphere (ice), and biosphere, and the processes that cause them to interact

Earth System Science
An area of scientific investigation that focuses on the processes which take place in the atmosphere, hydrosphere, lithosphere, pedosphere (soils), cryosphere (ice), and biosphere and the processes that allow them to interact.

Ecliptic
Where the Earth's orbit intersects the celestial sphere

Ecologist
A scientist who studies the relations between organisms and their environment

Ecology
The study of the relations between organisms and their environment

Ecosystem
A local biological community and its pattern of interaction with its environment

Elevation
The vertical distance above mean sea level

Energy Cycle
The movement of energy through the surface, interior, and atmosphere of the Earth in all of its forms

Environment
The surrounding conditions that affect the quality of life of plants and animals

Environmental variables
Physical properties that describe the state of the environment

Equator
An invisible circle that divides the Earth into two hemispheres

Equatorial
Located at the equator or in the plane of the equator

Equinox
(equal night) when the sun crosses the equator, causing the length of day and night to be equal in both hemispheres

Estuary
Semi-inclosed coastal body of water which has a free connection with the open sea

Flux
The amount of material flowing through a specified surface or system per unit time

Fluxes
The rate of flow of some quantity (such as water, energy or carbon for example) from one place or reservoir to another

Frazzle Ice
Known also as frazil ice, flowing water ice that forms platelets rather than continuous sheets on rivers and other moving bodies of water

GIS
Geographic Information System

Grassland
An area of natural vegetation dominated by grasses (areas are called steppes or prairies in temperate regions and savannahs in tropical regions)

Green-down
When plants start changing colors and/or lose their leaves at the end of the growing season

Green-up
When plants sprout new growth

Grey-scale
A range of tones from white to black that indicate on a map or other visualization the relative amounts of the quantity being described

Growing Season
That part of the yearly plant growth cycle when vegetation comes out of winter dormancy, grows, and reproduces.

Hemisphere
Half of a spherical or roughly spherical body (such as the Earth)

Icosahedron
20-sided polyhedron

Insolation
The energy that comes to the Earth from the Sun (INcoming SOLar radiATION)

Interconnections
The processes by which the different components of the Earth system interact with each other

Kinetic Energy
The energy an object has because of its motion

Land Cover
Usually vegetation but in the absence of vegetation an indication of what is on the land surface

Landmark Value
The point on a color scale where the representative value undergoes a distinctive change

Latent Heat
The energy stored or used by a substance to produce a change in phase, either between solid and liquid, liquid and gas, or solid and gas

Latitude
The angular distance of a part of the Earth that is north or south of the Earth's equator; a region of the Earth considered in relation to its distance from the equator

Lichen
A combination of an alga (or a cyanobacterium) and a fungus, living in symbiotic relationship characteristically forming a crustlike, scaly or branching growth on rocks or tree trunks

Limiting Factor
An ecosystem variable whose presence or absence limits the growth of the ecosystem elements

Lithosphere
The solid portion of the Earth

Liverwort
Moss-like plants that grow and help decay rocks or tree trunks on damp ground

Longitude
Distance measurement that goes from one pole to another pole around the outside of the Earth

Map Projection
The systematic arrangement of latitudes and longitudes (and associated surface features) that shows a curved surface on a flat plane

Marine Climate
Climate of a region that is affected by the sea. Generally characterized by mild winters, cool summers, and an even distribution of rainfall through the year

Maxima
(Plural of maximum) the greatest possible amount or degree

Maximum Greenness
When vegetation vigor peaks

Mercator Projection
A map projection of the Earth in which the latitude lines are drawn as straight lines the same length as the equator and cross the longitude lines at right angles. The biggest disadvantage is the distortion of the land near the poles

Meridian
An imaginary circle on the Earth's surface that passes through the North and South poles

Mid-latitude
The latitude range generally between 30 degrees to 60 degrees

NDVI
Normalized Difference Vegetation Index

Nitrogen Cycle
A series of chemical processes, mostly occurring in organisms, in which nitrogen atoms are circulated in the Earth systems

NOAA
National Oceanographic and Atmospheric Administration

Northern Hemisphere
The half of the Earth that lies north of the equator

Ocean Currents
The movement of ocean water in a regular way along a defined path that can either be cyclic or continuous

Open System
A system in which mass and energy enter and leave

Ozone
One of the allotropes of oxygen (O3), sometimes referred to as tri-oxygen

Perpendicular
A line at right angles to a line or plane (for example, when you watch a sunset, you are standing perpendicular to the horizon)

Petiole
Slender stem that supports the leaf or leaf stalk

pH
A measure of acidity on a scale of 0 to 14, 0 being all hydrogen ion (highly acidic), 14 being no hydrogen, all hydroxyl ions (highly basic)

Phenology
The study of natural response of living organisms to seasonal and climatic changes in their environment. Examples of phenological events include migration of birds and butterflies, flowering, salmon spawning, etc. Plant phenology includes green-up and green-down

Photosynthesis
The process used by green plants, algae and photosynthetic bacteria to use the energy of sunlight to convert carbon dioxide and water into carbohydrates, through the green pigment chlorophyll; this process releases oxygen and is the chief source of atmosphere

Polar
Regions on the Earth poleward of 60 degrees latitude

Polyhedron
A solid formed or bounded by planes or faces

Potential Energy
The energy an object has or the objects' stored capacity to do work because of its configuration and position

Potential Growing Season
That part of the yearly temperature cycle when the temperature is above freezing, thus enabling plant growth to occur.

Processes
The progression of physical interactions between different components of the Earth system and between sub-components of the Earth system

Producers
Living things that as a result of their biologic processes release material into their environment that may be used by other living things

Protractor
A measuring device used to measure angles

Region
An area defined by a common feature or features

Relationships
Processes by which different components of the Earth system, or parts of the components of the Earth system interact and affect each other

Remote Sensing
A method of obtaining information about something without coming into physical contact with it

Reservoirs
A space to store a substance, or a supply of a substance

Resolution
The smallest area that can be identified individually in a map or satellite picture, or the smallest measurable change in a quantity

Respiration
A process by organisms that converts the energy in organic materials into energy for use by cells

Rural
An area with very little man made structures

Satellite
Any natural or man made object that orbits an body in space, man made satellites usually carry instruments for measuring various things about the Earth

Scale
The regular markings on an instrument that permit the readings of a measured quantity, or the relative size of an object or area used to help define the processes that affect that object or area

Seasonal Cycle
The regular progression through the year through winter, spring, summer, and fall

Senescence
The changes that occur in an organism between maturity and death; in a plant this is equivalent to "green-down" and is associated with a reduction and/or halt of plant photosynthesis

Sensible Heat
The energy involved in heating (or cooling in the case of a loss of sensible heat) of a surface or object

Solar Energy
Energy coming from the sun

Solstice
(Stand still) when the sun is at its greatest distance from the equator, resulting in the longest day in one hemisphere and the shortest day in the other hemisphere; the sun appears to "stand still" when it reaches its highest point on this day

Southern Hemisphere
The half of the Earth that lies south of the equator

Spatial Relationship
Where bodies are located in regards to each other (e.g., the Sun and the Earth)

Sub Polar
A climate zone lying between the temperate and polar zones

Sub Tropical
A climate zone lying between the tropic and temperature zones

Suburban
An land area in which there is a mixture of man-made structures and open spaces

Surface Temperature
The temperature of the surface or the air next to the surface of the Earth

System
A group of components that interact to produce a whole (in the case of the Earth system) or a specific results (in the case of a machine)

Tannin
Bitter waste product in leaves that is brown; common name for tannic acid or similar compounds

Temperature
A measure of the energy in an object or gas, measured with a thermometer

Thermal inertia
A material body's resistance to a change in temperature

Time Scales
The time period over which different processes occur ranging from seconds and minutes for the formation of clouds to billions of years for the formation of the Earth

Transpiration
Loss of water by plants mainly through the stomata to the atmosphere

Tropic of Cancer
The parallel of latitude 23° 27' north of the equator; the most northerly latitude at which the sun can shine directly overhead

Tropic of Capricorn
The parallel of latitude 23° 27' south of the equator; the most southerly latitude at which the sun can shine directly overhead

Tropical
Of, occurring in, or characteristic of the tropics

Tundra
Treeless plains that lie poleward of the tree line in the Arctic. Tundra lies mostly over permafrost and is not permanently covered with snow

Urban
Area mostly covered with man made structures

Variables
A characteristic that can be measured and can assume different values

Vegetation Vigor
Amount of plant growth

Visualization
Display of information graphically or on a map using color or grey-scales, and/or lines and symbols

Water Cycle
The cycle by which water is moved between the different components of the Earth system (atmosphere, hydrosphere, lithosphere, pedosphere, cryosphere, and biosphere) in its various states (solid, liquid, and gas)

Watershed
The total area from which water is drained by a river and its tributaries

Weather
The day to day state of the atmosphere, mainly with respect to its affect on life and human activities

Winds
The movement of air relative to the surface of the Earth

Xanthrophyll
Pigment in leaves that is yellow