PCNP

Partners for Colorado Native Plants

Rare Plant Monitoring Steward Handbook

Denver Botanic Gardens
Grow your mind

Colorado Natural Areas Program

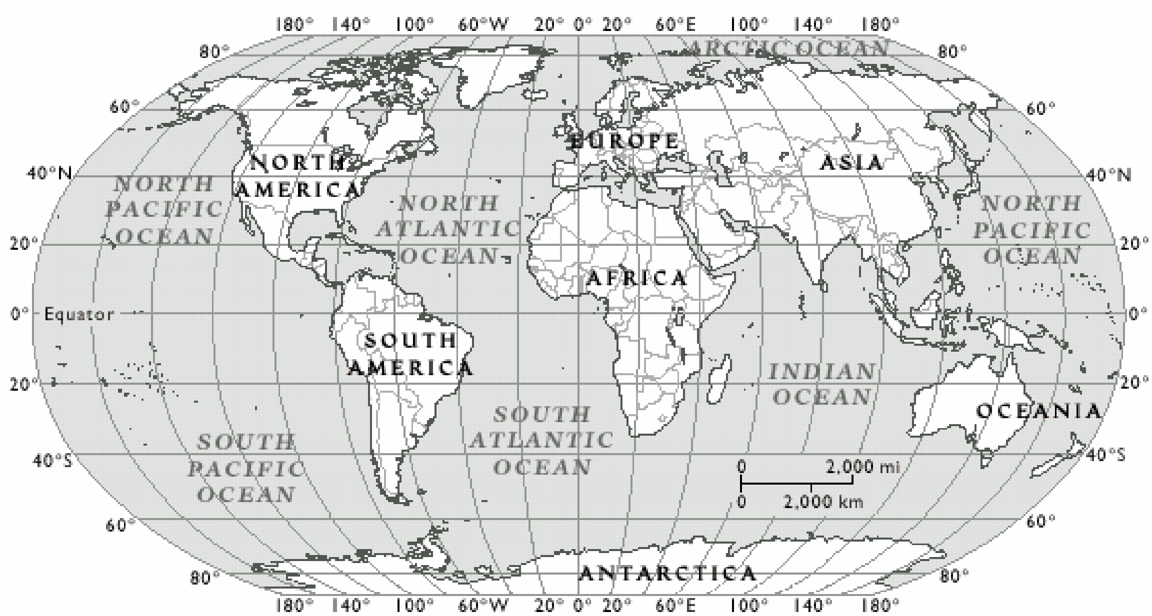
THE GLOBAL POSITIONING SYSTEM

Bill Eichelberger 4/21/2004

With additional information about UTM coordinates by Brian Kurzel 6/14/2007

The Global Positioning System (GPS) is a group of satellites built and maintained by the United States to provide accurate positioning information at any point on the earth. The GPS Constellation consists of 24 satellites that orbit the earth at an altitude of 11,000 nautical miles, taking 12 hours per revolution. This constellation provides the user with between five and eight satellites visible at all times from any point on the earth.

A GPS receiver picks up the signal from the satellites and performs some complex calculations to determine the latitude and longitude of the location of the receiver. The following map shows the earth with imaginary lines of latitude and longitude drawn on it. You will note that zero latitude is the equator and zero longitude is the Prime Meridian that passes through Greenwich, England. Another grid that is often used to locate features on the earth is Universal Transverse Mercator (see UTM handout).



The basic thing the receiver does is to display coordinates of locations on the earth (including latitude/longitude or UTM coordinates), although all GPS receivers can use this information to provide many other functions. The following are summaries of GPS coordinates in the two main systems.

<u>Latitude and Longitude</u>

The receiver displays degrees, minutes, and decimal fractions of minutes. Look at the coordinates showing on your GPS. This will be shown in this format:

N 39° 43.933'

W104° 57.628'

On the map above, that would be roughly on the E in North America.

A minute of latitude or longitude is roughly a mile*. The right-hand digit of the GPS reading is one thousandth of a minute, and since there are roughly 5,000 feet in a mile then the last digit gives you about five foot accuracy. Actually, a GPS has an error of a few feet, and the reading will change a little as you watch it, even if you are not moving, but at least you know you are pretty close to your objective.

To use a GPS to find a location, when you are given the latitude and longitude, you turn on the GPS and wait until it picks up enough satellites to be able to compute its location. (You can toggle between Lat/Long and UTM display, or some units will show both on the same screen.) This usually takes a couple of minutes and may take longer if you have moved quite a distance since the GPS was last turned on. Then you look at the GPS reading and compare it with the coordinates of the location you want to go to. Since "a minute is a mile" and a degree is therefore 60 miles*, you can get a rough idea of how far you are from your objective by subtracting the coordinates of your location from those of your objective. You can then tell which way to go and how far to go.

As an example, the location of the orchid site for *Spiranthes diluvialis*, in the Boulder Open Space near South Boulder Creek, is given as

```
N   39  58.51
W 105 13.34
```

We can subtract the coordinates of the Botanic Gardens as follows:

```
Orchid site: N  39  58.51
Gardens:     N  39  43.933
                  ---------------
                      14.577  so the site is about 14.5 miles north of the Gardens

Orchid site: W  105    13.34  which is   104  73.34
Gardens:                                 104  57.628
                                       ----------------
                                             15.712 so the site is about 15.7 miles west
```

Note that many EOR's only have two decimal places. Thus the closest we can actually come to the plant site using the GPS is about 50 feet. This still should be close enough.

All these calculations give only rough answers. However, the closer you get to the objective, the less difference this will make. When the GPS reads the exact numbers of the site you are really within 50 feet of the objective.

*It is true that a minute of latitude or longitude is one nautical mile (1.15 statute miles) at the equator. Since the lines of longitude are all the same length, this is true anywhere on the earth for the North-South readings. The lines of latitude get shorter the farther you are from the equator, so using the assumption that a minute is a mile for the East-West readings will give you a result that is actually too large. However, this error will matter less and less the closer you get to your objective.

UTM Coordinates

The receiver displays Easting (X-axis)) and Northing (Y-axis) coordinates. Look at the coordinates showing on your GPS. They will be shown in this format:

N 4513750 (7-digits)
E 489250 (6-digits)

The numbers show the number of meters you are north of the equator and east (or west) of a center meridian in a certain UTM Zone (see UTM handout). A good reminder is that in Colorado we are always further north of the equator than we are east or west of a Zone meridian*, so the Northing will always have more digits (7-digits vs. 6-digits for Easting).

To use a GPS to find a location, when you are given UTM coordinates, you turn on the GPS and wait until it picks up enough satellites to be able to compute its location. (You can toggle between Lat/Long and UTM display, or some units will show both on the same screen.) This usually takes a couple of minutes and may take longer if you have moved quite a distance since the GPS was last turned on. Then you look at the GPS reading and compare it with the coordinates of the location you want to go to. Since UTM coordinates are in meters, you can figure out how many meters (or thousands of meters = kilometers) you are from your objective by determining the difference between the coordinates of your location from those of your objective. You can then tell which way to go and how far to go.

Below is a summary that will help you use UTM's to figure out how to reach a destination:

NORTHING

If the Northing of your destination is ***larger*** than your current location, you are south of your destination and need to ***go north***.

If the Northing of your destination is ***smaller*** than your current location, you are north of your destination and need to ***go south***.

EASTING

If the Easting of your destination is ***larger*** than your current location, you are west of your destination and need to **go east**.

If the Easting of your destination is ***smaller*** than your current location, you are east of your destination and need to ***go west***.

As an example, the location of the *Physaria bellii* site in Larimer County is given as:

N 4513750
E 489250

The coordinates of the Denver Botanic Gardens are:

N 4398038

E 503227

We can determine the difference in coordinates for the Northing and Easting as follows:

Northing

Plant site: N 4513750

Gardens: N 4398038

115712 meters (115.7 kilometers)

Destination is a larger number, so we need to travel 115.7 kilometers (~72 miles) north from the Gardens

Easting

Plant site: E 489250

Gardens: E 503227

- 13977 meters (13.9 kilometers)

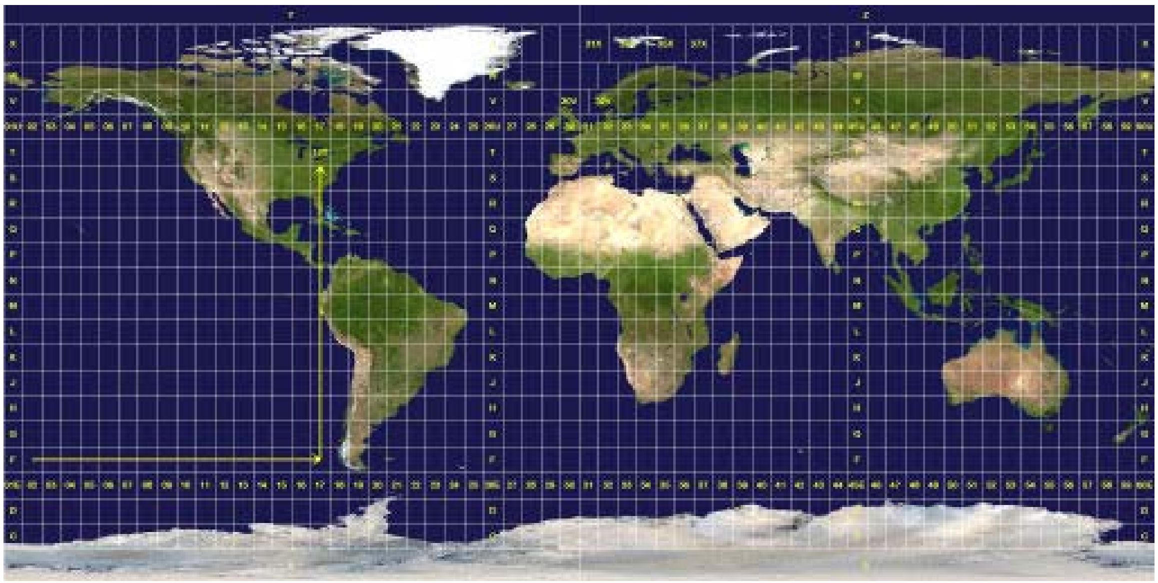
Destination is a smaller number, so we need to travel 13.9 kilometers west (8.7 miles) from the Gardens.

All these calculations give only rough answers. However, the closer you get to the objective, the less difference this will make. When the GPS reads the exact numbers of the site you are really within 50 feet of the objective. Be careful not to pay such close attention to your GPS numbers as not to notice that you are stepping on a rare plant!

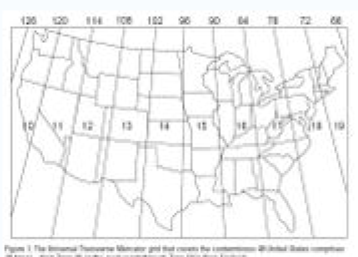
* Be very clear about what PROJECTION and ZONE the plant location is found in. The UTM projection should always be in NAD1983 (CONUS). Zone 13 is used for all parts of Colorado east of a meridian that roughly passes through Meeker, Durango and Montrose. Zone 12 is found to the west of that meridian.

The **Universal Transverse Mercator** (**UTM**) coordinate system is a grid-based method of specifying locations on the surface of the Earth. It is used to identify locations on the earth, but differs from the traditional method of latitude and longitude in several respects.

The UTM system is not a single map projection. The system instead employs a series of sixty zones, each of which is based on a specifically defined Transverse Mercator projection.



UTM longitude zone



Simplified view of US UTM longitude zones.

The UTM system divides the surface of the Earth between 80° S latitude and 84° N latitude into 60 zones, each 6° of longitude in width and centered over a meridian of longitude. Zones are numbered from 1 to 60. Zone 1 is bounded by longitude 180° to 174° W and is centered on the 177th West meridian. Zone numbering increases in an easterly direction.

UTM latitude zone

The UTM system segments each longitude zone into 20 latitude zones. Each latitude zone is 8 degrees high, and is lettered starting from "C" at 80° S, increasing up the English alphabet until "X", omitting the letters "I" and "O" (because of their similarity to the digits one and zero). The last latitude zone, "X", is extended an extra 4 degrees, so it ends at 84° N latitude, thus covering the northern most land on Earth. Latitude zones "A" and "B" do exist, as do zones "Y" and Z". They cover the western and eastern sides of the Antarctic and Arctic regions respectively. A convenient trick to remember is that the letter "N" is the first letter in the northern hemisphere, so any letter coming before "N" in the alphabet is in the southern hemisphere, and any letter "N" or after is in the northern hemisphere.

Notation

Each grid square is referred to by the longitude zone number and the latitude zone character. The longitude zone is always written first, followed by the latitude zone. For example (see image, top right), a position in Toronto, Canada, would find itself in longitude zone 17 and latitude zone "T", thus the full reference is "17T".

Locating a position using UTM coordinates

A position on the Earth is referenced in the UTM system by the UTM longitude zone, and the easting and northing coordinate pair. The easting is the projected distance of the position from the central meridian, while the northing is the projected distance of the point from the equator. The point of origin of each UTM zone is the intersection of the equator and the zone's central meridian. In order to avoid dealing with negative numbers, the central meridian of each zone is given a "false easting" value of 500,000 meters. Thus, anything west of the central meridian will have an easting less than 500,000 meters. For example, UTM eastings range from 167,000 meters to 833,000 meters at the equator (these ranges narrow towards the poles). In the northern hemisphere, positions are measured northward from the equator, which has an initial "northing" value of 0 meters and a maximum "northing" value of approximately 9,328,000 meters at the 84th parallel -- the maximum northern extent of the UTM zones. In the southern hemisphere, northings decrease as you go southward from the equator, which is given a "false northing" of 10,000,000 meters so that no point within the zone has a negative northing value.

As an example, the CN Tower is located at the geographic position 43°38′33.24″N, 79°23′13.7″W. This is in longitude zone 17, and the grid position is 630084m east, 4833438m north.

The latitude zone is unnecessary if the full distance from the equator is given (as above) and the hemisphere is known. It does, however, become important when further sub-division of the UTM grid is undertaken, such as in the military grid reference system.

FINDING PLANTS
Revised from Bill Eichelberger May 7, 2004

Example: If the GPS coordinates that we have on the Element Occurrence Record are in the form:

LAT: 401843N
LONG: 1053853W

These numbers are crunched together but they actually are degrees, minutes, and seconds. So in the format of most GPS units the location would be:

N 40° 18'43" (40 degrees 18 minutes 43 seconds North)
W 105° 38'53" (105 degrees 38 minutes 53 seconds West)

EOR gives the lat/long in the Form DDMMSS. For greater accuracy- 3 digits instead of two- we will convert this to the Form DDMM.MMM. Do this by taking the last two digits 43/60 = .717 for latitude. For longitude, the last two digits are 53/60=.883

So converted to DDMM.MMM: LAT: 40 18.717 LONG: 105 38.883

Referring to the Global Positioning System handout you will see that your GPS actually shows three digits to the right of the decimal point, and that the third digit is about one one-thousandth of a mile or five feet. The coordinates of the location you are trying to find only have two digits to the right of the decimal point and thus that last digit is about fifty feet instead of five feet. When the GPS reading is right on the coordinates you were given, you are within about 50 feet of the site. Furthermore, the coordinates you are given may not have been obtained with a GPS but might have come from measurements on a USGS quad or some other map. Thus you cannot expect the GPS to take you exactly to the location of the plants you are looking for. You will have to know the habitat that you are looking for, and the description of the plant, as well.

Note that you have to know which way is north in order to know which direction you have to go to get to your site. Thus you should take a magnetic compass.

When you get close to the coordinates of your plant site you should be very careful. You have to be looking all the time, as the coordinates you were given may be inaccurate and you could step on some plants.

When you find the plants you are looking for, you must write down the actual coordinates as shown on your GPS. This will provide better accuracy the next time someone checks on this site. You must write down the altitude as given by the GPS. You must also write down the accuracy shown on your GPS. This will be a number, usually about 20 feet.

If the group of plants is larger than you can measure with your tape, you should take two or more GPS readings to show the extent of the group.

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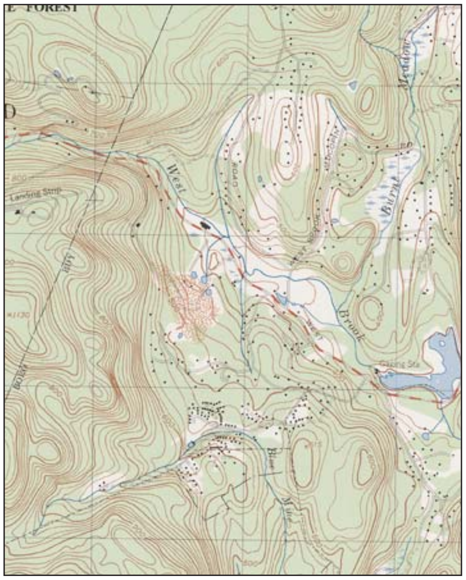
Finding Your Way with Map and Compass



Part of a 7.5-minute topographic map at 1:24,000 scale.

A topographic map tells you where things are and how to get to them, whether you're hiking, biking, hunting, fishing, or just interested in the world around you. These maps describe the shape of the land. They define and locate natural and manmade features like woodlands, waterways, important buildings, and bridges. They show the distance between any two places, and they also show the direction from one point to another.

Distances and directions take a bit of figuring, but the topography and features of the land are easy to determine. The topography is shown by contours. These are imaginary lines that follow the ground surface at a constant elevation; they are usually printed in brown, in two thicknesses. The heavier lines are called index contours, and they are usually marked with numbers that give the height in feet or meters. The contour interval, a set difference in elevation between the brown lines, varies from map to map; its value is given in the margin of each map. Contour lines that are close together represent steep slopes.

Natural and manmade features are represented by colored areas and by a set of standard symbols on all U.S. Geological Survey (USGS) topographic maps. Woodlands, for instance, are shown in a green tint; waterways, in blue. Buildings may be shown on the map as black squares or outlines. Recent changes in an area may be shown by a purple overprint. A road may be printed in red or black solid or dashed lines, depending on its size and surface. A list of symbols is available from the Earth Science Information Center (ESIC).

From Near to Far: Distance

Maps are made to scale; that is, there is a direct relationship, a ratio, between a unit of measurement on the map and the actual distance that same unit of measurement represents on the ground. If, for instance, 1 inch on the map represents 1 mile (which converts to 63,360 inches) on the ground, the map's scale is 1:63,360. Below is a listing of the scales at which some of the more popular USGS maps are compiled.

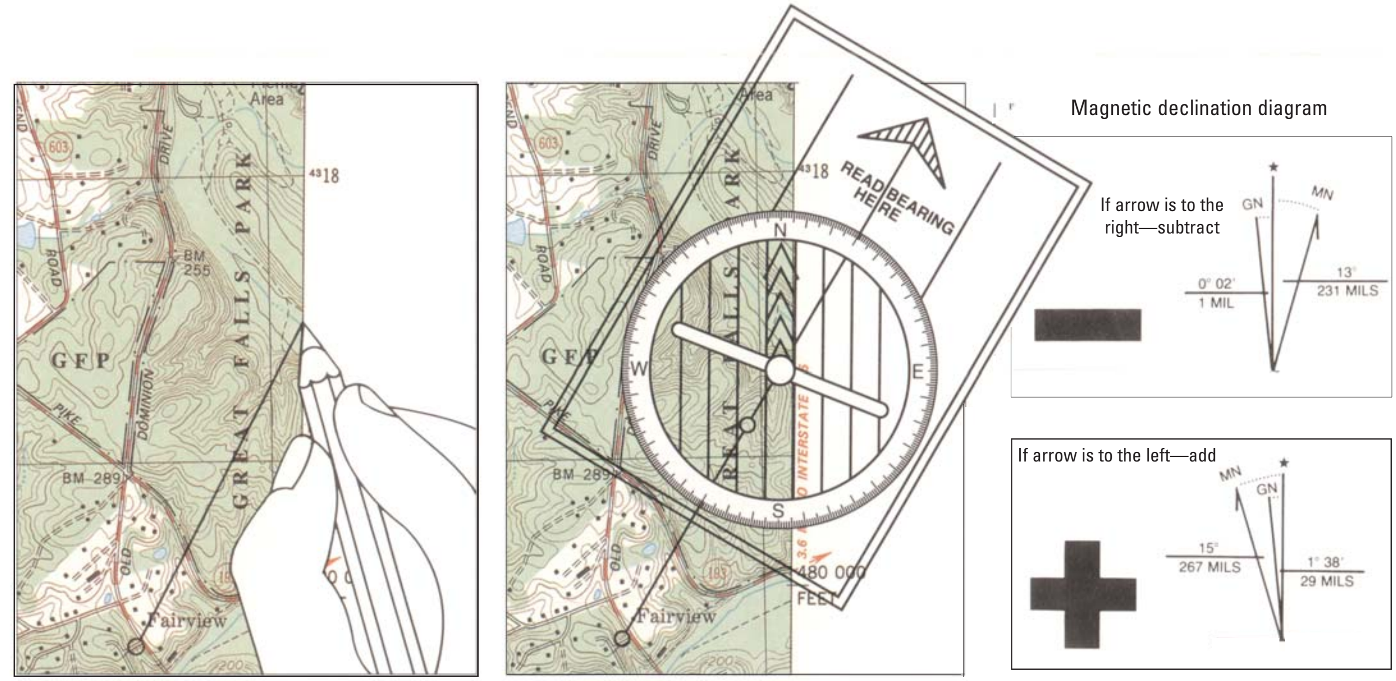
A convenient way of representing map distance is by the use of a graphic scale bar. Most USGS topographic maps have scale bars in the map margin that represent distances on the map in miles, feet, and kilometers. The table below shows the corresponding area of coverage for each scale and the linear distance that each scale represents in inches and centimeters.

From Here to There: Determining Direction

To determine the direction, or bearing, from one point to another, you need a compass as well as a map. Most compasses are marked with the four cardinal points—north, east, south, and west—but some are marked additionally with the number of degrees in a circle (360: north is 0 or 360, east is 90, south is 180, and west is 270). Both kinds are easy to use with a little practice. The illustrations on the reverse side show how to read direction on the map.

One thing to remember is that a compass does not really point to true north, except by coincidence in some areas. The compass needle is attracted by magnetic force, which varies in different parts of the world and is constantly changing. When you read north on a compass, you're really reading the direction of the magnetic north pole. A diagram in the map margin will show the difference (declination) at the center of the map between compass north (magnetic north indicated by the MN symbol) and true north (polar north indicated by the "star" symbol). This diagram also provides the declination between true north and the orientation of the Universal Transverse Mercator (UTM) grid north (indicated by the GN symbol). The declination diagram is only representational, and true values of the angles of declination should be taken from the

Map Series Name	Scale	1 inch represents	1 centimeter represents	Map area (approximate square miles)
Puerto Rico 7.5-minute	1:20,000	1,667 feet	200 meters	71
7.5-minute	1:24,000	2,000 feet	240 meters	49 to 70
7.5- by 15-minute	1:25,000	2,083	250 meters (about)	98 to 140
Alaska	1:63,360	1 mile	634 meters (about)	207 to 281
Intermediate	1:50,000	0.8 mile	500 meters (about)	County
Intermediate	1:100,000	1.6 miles	1 kilometer (about)	1,568 to 2,240
United States	1:250,000	4 miles	2.5 kilometers (about)	4,580 to 8,669



(1) Drawing a straight line over the map edge.

(2) Reading the compass on the map.

(3) Using the magnetic declination diagrams.

numbers provided rather than from the directional lines. Because the magnetic declination is computed at the time the map is made, and because the position of magnetic north is constantly changing, the declination factor provided on any given map may not be current. To obtain current and historical magnetic declination information for any place in the United States, contact:

National Geomagnetic Information Center
Phone: 303-273-8486
E-mail: jcaldwell@usgs.gov
Web site: geomag.usgs.gov

or

National Geophysical Data Center
Phone: 303-497-6826
E-mail: info@ngdc.noaa.gov
Web site: www.ngdc.noaa.gov/ or www.ngdc.noaa.gov/seg/potfld/geomag.shtml

Taking a compass bearing from a map:

(1) Draw a straight line on the map passing through your location and your destination and extending across any one of the map borders.

(2) Center the compass where your drawn line intersects the map border, align the compass axis N-S or E-W with the border line, and read on the compass circle the true bearing of your drawn line. Be careful to get the bearing in the correct sense because a straight line will have two values 180° apart. Remember north is 0, east is 90, and so on.

(3) To use this bearing, you must compensate for magnetic declination. If the MN arrow on the map magnetic declination diagram is to the right of the true north line, subtract the MN value. If the arrow is to the left of the line, add the value. Then, standing on your location on the ground, set the compass so that “zero degrees or North” aligns with the magnetic north needle, read the magnetic bearing that you have determined by this procedure, and head off in the direction of this bearing to reach your destination.

A Word of Caution

Compass readings are also affected by the presence of iron and steel objects. Be sure to look out for—and stay away from—pocket knives, belt buckles, railroad tracks, trucks, electrical lines, and so forth when using a compass in the field.

Information

For information on these and other USGS products and services, call 1-888-ASK-USGS, or visit the general interest publications Web site on mapping, geography, and related topics at erg.usgs.gov/isb/pubs/publists/.

For additional information, visit the ask.usgs.gov Web site or the USGS home page at www.usgs.gov.

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The Universal Transverse Mercator (UTM) Grid

Map Projections

The most convenient way to identify points on the curved surface of the Earth is with a system of reference lines called parallels of latitude and meridians of longitude. On some maps, the meridians and parallels appear as straight lines. On most modern maps, however, the meridians and parallels appear as curved lines. These differences are due to the mathematical treatment required to portray a curved surface on a flat surface so that important properties of the map (such as distance and areal accuracy) are shown with minimum distortion. The system used to portray a part of the round Earth on a flat surface is called a map projection.

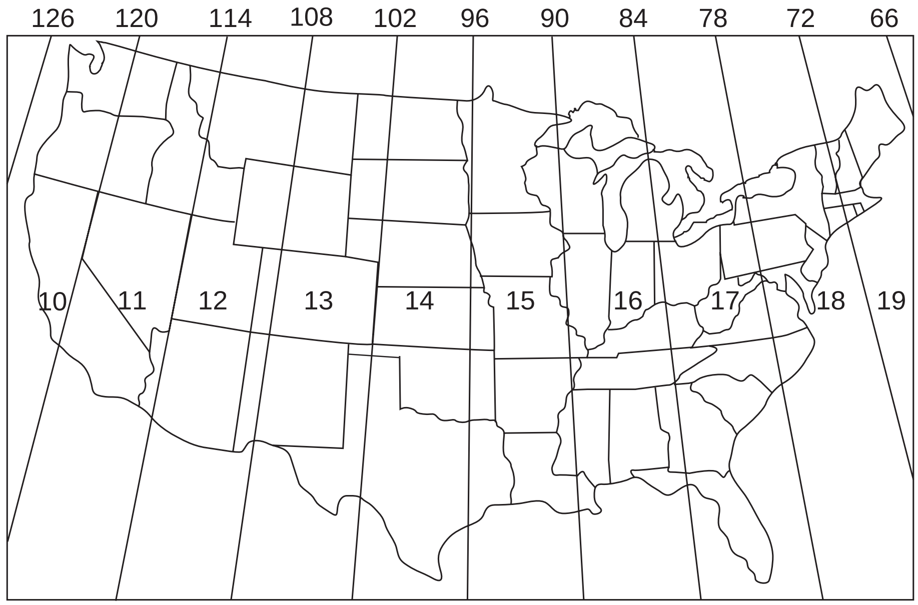


Figure 1. The Universal Transverse Mercator grid that covers the conterminous 48 United States comprises 10 zones—from Zone 10 on the west coast through Zone 19 in New England.

Grids

To simplify the use of maps and to avoid the inconvenience of pinpointing locations on curved reference lines, cartographers superimpose on the map a rectangular grid consisting of two sets of straight, parallel lines, uniformly spaced, each set perpendicular to the other. This grid is designed so that any point on the map can be designated by its latitude and longitude or by its grid coordinates, and a reference in one system can be converted into a reference in another system. Such grids are usually identified by the name of the particular projection for which they are designed.

The Universal Transverse Mercator Grid

The National Imagery and Mapping Agency (NIMA) (formerly the Defense Mapping Agency) adopted a special grid for military use throughout the world called the Universal Transverse Mercator (UTM) grid. In this grid, the world is divided into 60 north-south zones, each covering a strip 6° wide in longitude. These zones are numbered consecutively beginning with Zone 1, between 180° and 174° west longitude, and progressing eastward to Zone 60, between 174° and 180° east longitude. Thus, the conterminous 48 States are covered by 10 zones, from Zone 10 on the west coast through Zone 19 in New England (fig. 1). In each zone, coordinates are measured north and east in meters. (One meter equals 39.37 inches, or slightly more than 1 yard.) The northing values are measured continuously from zero at the Equator, in a northerly direction. To avoid negative numbers for locations south of the Equator, NIMA's cartographers assigned the Equator an arbitrary false northing value of 10,000,000 meters. A central meridian through the middle of each 6° zone is assigned an easting value of 500,000 meters. Grid values to the west of this central meridian are less than 500,000; to the east, more than 500,000.

Virtually all NIMA-produced topographic maps and many aeronautical charts show the UTM grid lines.

Determining a UTM Grid Value for a Map Point

The UTM grid is shown on all quadrangle maps prepared by the U.S. Geological Survey (USGS). On 7.5-minute quadrangle maps (1:24,000 and 1:25,000 scale) and 15-minute quadrangle maps (1:50,000, 1:62,500, and standard-edition 1:63,360 scales), the UTM grid lines are indicated at intervals of 1,000 meters, either by blue ticks in the margins of the map or with full grid lines. The 1,000-meter value of the ticks is shown for every tick or grid line. In addition, the actual meter value is shown for ticks nearest the southeast and northwest corners of the map. Provisional maps at 1:63,360 scale show full UTM grids at 5,000-meter intervals.

To use the UTM grid, you can place a transparent grid overlay on the map to subdivide the grid, or you can draw lines on the map connecting corresponding ticks on opposite edges. The distances can be measured in meters at the map scale between any map point and the nearest grid lines to the south and west. The northing of the point is the value of the nearest grid line south of it plus its distance north of that line; its easting is the value of the nearest grid line west of it plus its distance east of that line (see fig. 2).

On maps at 1:100,000 and 1:250,000 scale, a full UTM grid is shown at intervals of 10,000 meters and is numbered and used in the same way.

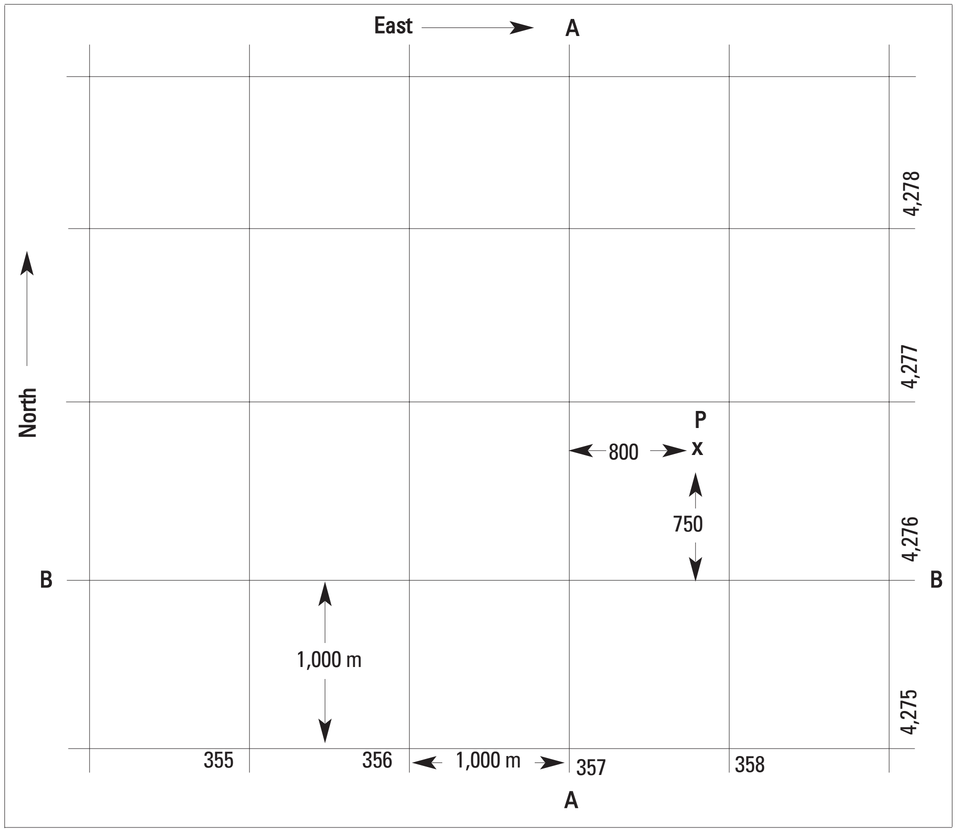


Figure 2. The grid value of line A-A is 357,000 meters east. The grid value of line B-B is 4,276,000 meters north. Point P is 800 meters east and 750 meters north of the grid lines; therefore, the grid coordinates of point P are north 4,276,750 and east 357,800.

Information

Detailed UTM grid information is included in several NIMA-produced technical publications that are available for public sale from the USGS. Publication descriptions are available in the online "NIMA Catalog of Public Sale Topographic Maps, Publications and Digital Products." The Web site is mac.usgs.gov/mac/nimamaps/index.html. After locating the catalog, click on "Digital Products" to reach the "DoD and NIMA Publications and Digital Products" section.

For information on these and other USGS products and services, call 1-888-ASK-USGS, or visit the general interest publications Web site on mapping, geography, and related topics at erg.usgs.gov/isb/pubs/pubslists/.

For additional information, visit the ask.usgs.gov Web site or the USGS home page at www.usgs.gov.

Rare Plant Surveys and Element Occurrence Forms

Or…

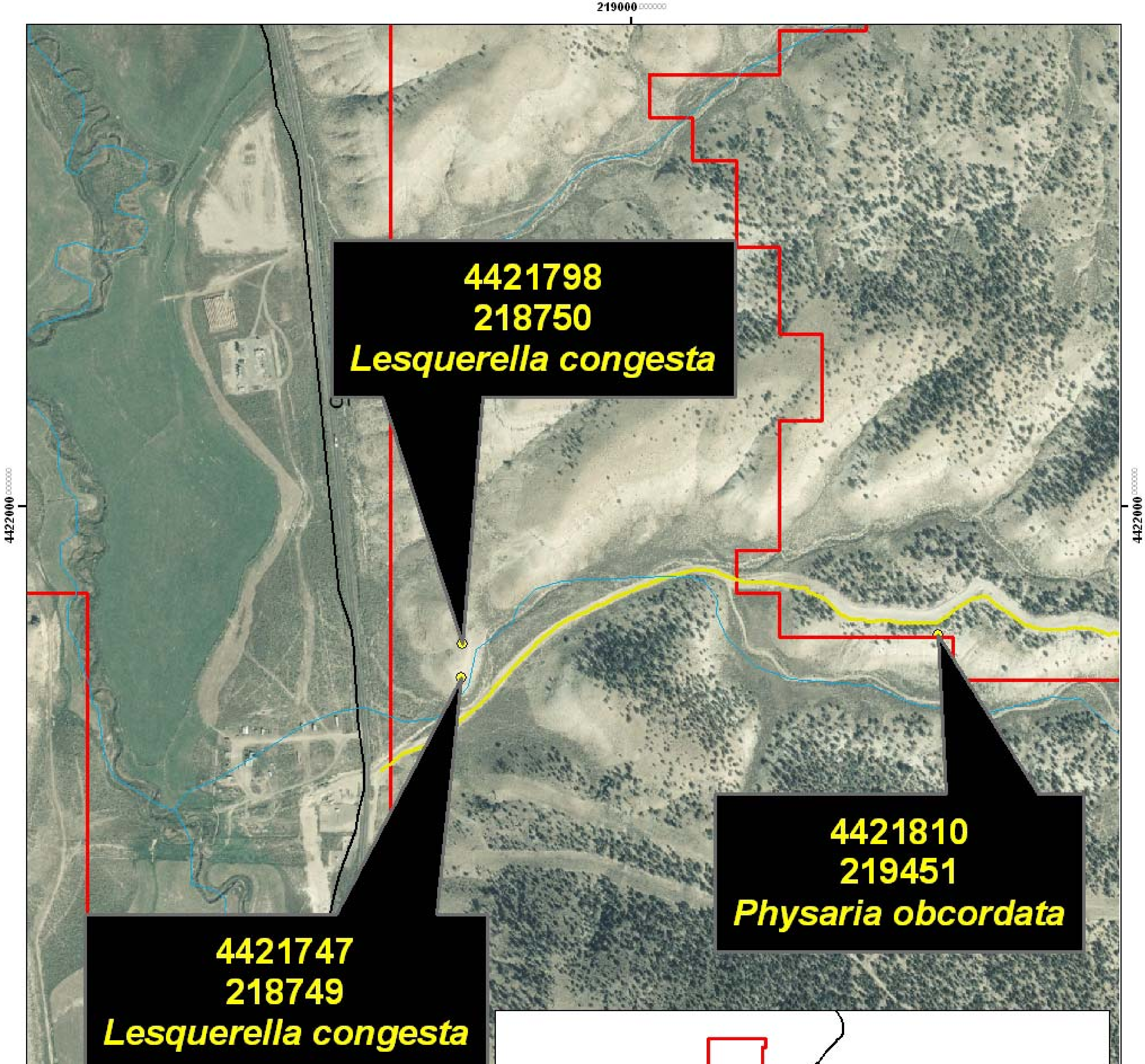
"How do I find those tiny plants, and what do I do when I find them??"

“How do I find these tiny plants??”

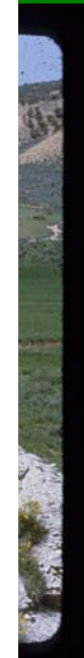
"How do I find these tiny plants??"

Two main types of Projects for
Rare Plant Monitoring Stewards:

1. ***Monitoring on known sites*** of rare plants
   – We already know where they are, you need to re-locate them…



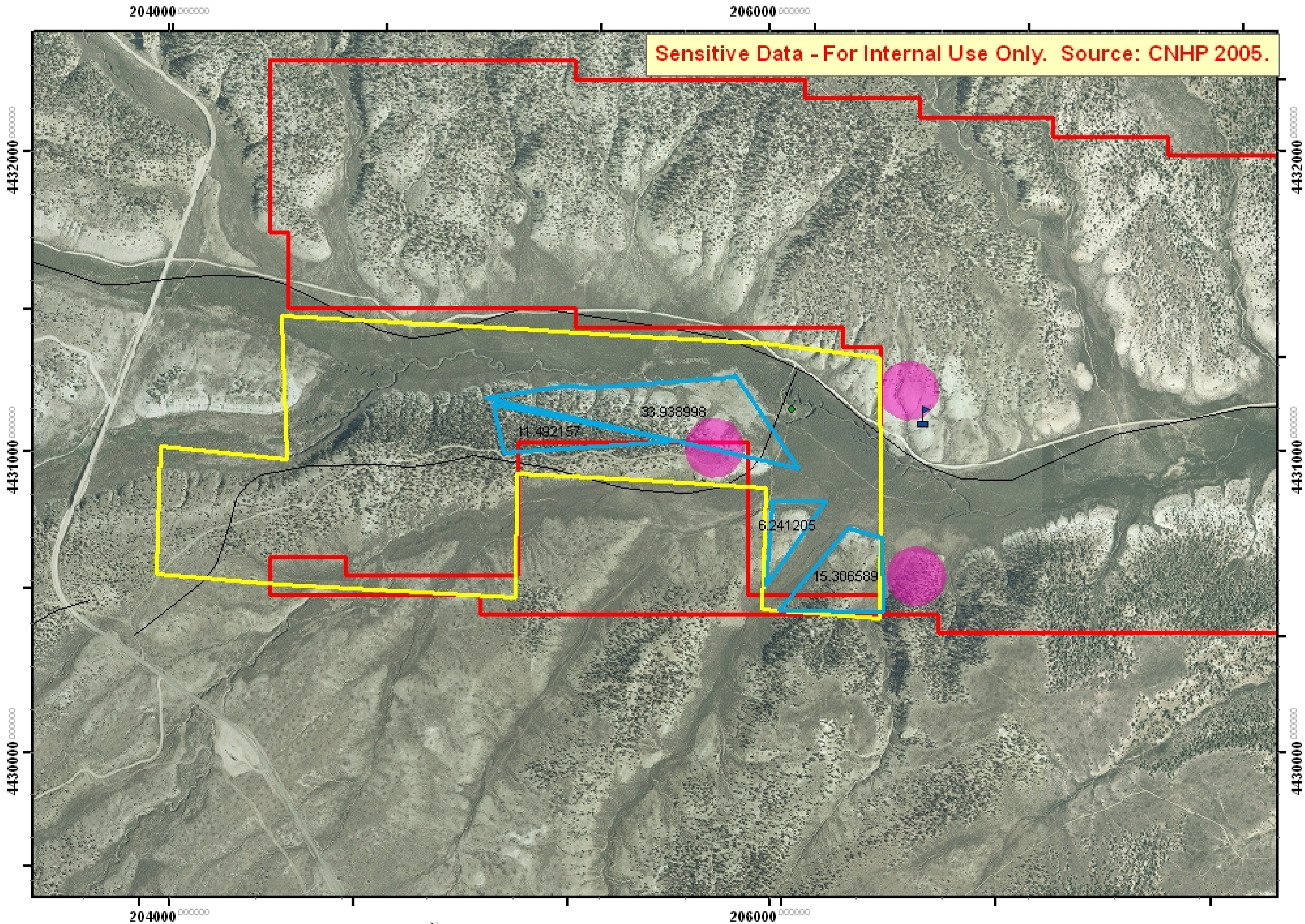
219000
4422000
4422000
4421798
218750
Lesquerella congesta
4421810
219451
Physaria obcordata
4421747
218749
Lesquerella congesta



"How do I find these tiny plants??"

Two main types of Projects for
Rare Plant Monitoring Stewards:

2. ***Survey of potential habitat*** to map new plant locations
   - We think they might be there, but you're the one to find and map them…



Duck Creek Natural Area

0 0.15 0.3 0.6
Kilometers

Windmill/Well
Lescon Macroplot
CNHP Lesquerella congesta occurences
Duck Creek Natural Area
SWA_Boundaries_0126
DOW_lescon_potential_habitat2007

“How do I find these tiny plants??”

- Locate potential habitat
  - Use habitat characteristics such as:
    - geologic formations (light colored? Shale?)
    - plant associations (Pinyon-juniper? Barrens?)
    - microhabitat requirements (north-facing? Drainages?)
    - Other?
- Survey systematically

“What do I do when I find the tiny plants?”

“What do I do when I find the tiny plants?”

- If monitoring plot and protocol already established… collect data!

- No matter what, fill out information about the plant you have located (or re-located)
  - Element Occurrence Record

COMPLETING FIELD SURVEY FORMS FOR ELEMENT OCCURRENCE RECORDS

Colorado Natural Heritage Program
Providing Comprehensive and Reliable Biological Information For Colorado

WHAT IS AN ELEMENT OCCURRENCE?

- An Element Occurrence (EO) is an area of land and/or water in which a species or natural community is, or was present.

- An EO should have practical conservation value for the species.

WHAT IS AN ELEMENT OCCURRENCE RECORD (EOR)?

- a data management tool

- which has both spatial and tabular components including a mappable feature and associated data

DATA PROCESSING

- Mapping each location accurately and entering data from a variety of sources can be challenging.

GETTING STARTED

DATE OF SURVEY: June 6, 2005

OBSERVERS NAME/AFFILIATION: Jane Doe/CNAP volunteer steward

OBSERVERS ADDRESS: PO Box 123, Denver, CO 80215 303/123-4567

TAXONOMY

SPECIES SCIENTIFIC NAME: Penstemon harringtonii

LOCATION

SURVEY SITE NAME: Jimmy Creek

COUNTY: Eagle   USGS QUADRANGLE: State Bridge

TOWNSHIP: 82W RANGE: 7S

SECTION: 6   1/4 SECTION: NE

ADDITIONAL TRS OR 1/4 SEC: S5 NW4

UTM ZONE & COORDINATES: Zone 13, 1234567N/123456E

DATUM: NAD 27

LOCATION continued

ELEVATION: 7250 ft.

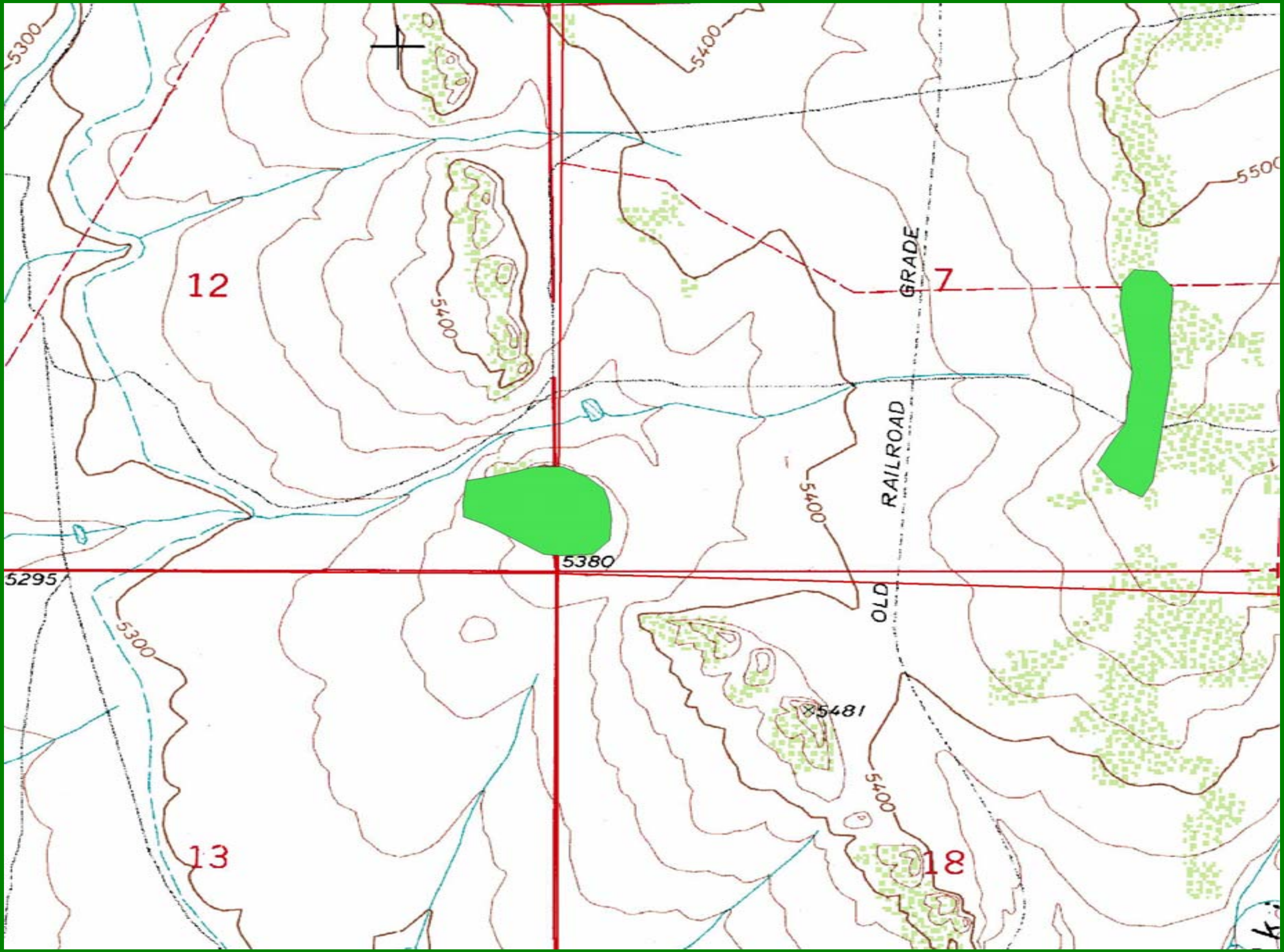
NATIONAL FOREST/BLM DISTRICT: NA

LAND OWNERSHIP/MANAGEMENT: CNAP/Jones Ranch Natural Area, Bill Jones owner

LOCATIONAL ACCURACY/MAPPING INSTRUCTIONS

- Attach a copy of the appropriate part of the USGS 7.5’ topo
- Delinate the population(s) on the map
  - With a point if the area is 40 ft. or less in diameter
  - With a polygon if larger than 40 ft. in diameter

MAPPED LOCATION



DIRECTIONS TO SITE

From I-70 take the Edwards exit and go west on frontage road to Jimmy Creek Road. Go north on Jimmy Creek Road for 1.2 miles. Park at Jimmy Creek trailhead and hike up trail approximately 0.5 mile. The plants will be on your left in the open sagebrush.

POPULATION BIOLOGY

ESTIMATED NUMBER OF INDIVIDUALS: 300 counted, estimate 500 total

NUMBER OF SUBPOPULATIONS: NA

SIZE OF AREA COVERED BY POPULATION: 2 acres

PHENOLOGY: 70% flowering, 20% in fruit, 10% vegetative

SYMBIOTIC OR PARASITIC RELATIONSHIPS: Bees observed visiting flowers

EVIDENCE OF DISEASE, PREDATION OR INJURY: Some individuals appear to have been browsed by deer

REPRODUCTIVE SUCCESS: Mature fruits and seedlings observed

HABITAT

ASSOCIATED PLANT COMMUNITY: Artemisia tridentata, Festuca thurberi

HABITAT TYPE: Sagebrush shrublands

ADDITIONAL ASSOCIATED PLANT SPECIES: Erigeron sp., Stipa comata, Phlox sp.

APSECT: SE SLOPE: 5%

SLOPE SHAPE: concave LIGHT EXPOSURE: open

MOISTURE: dry SOIL TEXTURE: sandy loam

GEOMORPHIC LANDFORM: Colorado River alluvium

EVIDENCE OF THREATS AND DISTURBANCE

Evidence of past grazing, some plants have been browsed. Area is heavily used by hikers, but they do not seem to impact the Penstemon.

DOCUMENTATION

PHOTOGRAPH TAKEN: Jane Doe personal collection, copy provided to CNHP

SPECIMEN TAKEN: no

IDENTIFICATION: Colorado Flora, West Slope

COMMENTS

Owner is very interested in the conservation of the plants at this site. He spent two hours in the field with us.

SUBMIT SURVEY FORMS TO:

COLORADO STATE UNIVERSITY-COLLEGE OF NATURAL RESOURCES

Mailing Address: 8002 Campus Delivery, Fort Collins, CO 80523-8002

Physical Address: 259 General Services Bldg., Fort Collins, CO 80523

Attn: Jill Handwerk/Botany

Jeremy Siemers/Zoology

Jodie Bell/Ecology

Tips for Leading Rare Plant Monitoring Field Trips

The main thing to remember is that Volunteers are giving their time to help us out… so we want to make sure things run as smoothly as possible, and that they are happy and healthy.

Review the following tips when preparing to lead a field trip:

Be Prepared… organization goes a long way to making the experience a good one.

- ❖ If possible, visit the site before the volunteers to familiarize yourself with the plant, the habitat and the transect location.
  - Know the CNHP ranking and federal status of the plant (BLM sensitive species?)
  - Know the history of the monitoring transect and the area.
  - If you don't have enough information, contact Brian, Michelle, Jenny or Denise.
  - Read up on the plant as much as possible so you are well-informed. Check out the following websites where you can get information on the plant:
    - www.natureserve.org/explorer
    - www.centerforplantconservation.org/ASP/CPC_NCList_fine.asp
    - http://plants.usda.gov
- ❖ Review the monitoring protocol and give it a 'dry-run' if possible to familiarize yourself with the details.
- ❖ E-mail driving directions, meeting times and places, equipment lists and any other information that volunteers may need a week ahead of time.
- ❖ Bring enough materials for all volunteers, including:
  - maps
  - survey protocols
  - data sheets
- ❖ Bring extras of everything just in case.
- ❖ Have extra pencils and clipboards.

Be Safety-Conscious… nobody can have fun when they are not feeling healthy & safe.

- ❖ Send an equipment list to volunteers so there are no surprises (see example below).
- ❖ Check with participants ahead of time to see if there are any specific needs and/or limitations. Try to accommodate these.
- ❖ Give constant reminders to apply sunscreen, drink water, and eat food.
  - Take care of yourself! If you are sunburned and dehydrated, your day will be much harder.
- ❖ Purchase water and snacks for everyone (you will be reimbursed for this!). Hand these out before you hike so you don't have to carry everything.

Tips for Leading Rare Plant Monitoring Field Trips

- Take at least two defined food/water breaks and a lunch break.
- If lightning is approaching, use common sense to move to a safe location quickly. In general, if you count 10 seconds or less between lightning and the associated thunder, gather belongings and move downhill to a safe location!

Be Informative & Friendly… give context and information to motivate volunteers.

- Before leaving the car, give some background information and review what you know about the plants, plant habitat, and location of monitoring transect.
- Before setting up monitoring, review the protocol verbally so everyone knows what they will be doing.
- If feasible, divide monitoring duties between volunteers, and allow people to switch jobs if interested. HOWEVER, if certain jobs have more potential for human error, try to keep people in same positions.
- Always be kind and courteous to set a positive mood.

Remember…

- *Something will NOT go smoothly.* If you can't re-locate the plant population right away or if you forgot something important, don't let it dominate the day. Volunteers know you are human and are willing to help (that's why they volunteered!). More often than not, sharing the difficulty will de-escalate the problem and help a solution arise.
- *Have fun!* By being relaxed and focused, everyone will have a better time and get work done more efficiently.
- *Provide closure.* Before people part ways, 'circle-up' and thank people for the important work they have done. Also ask for highlights or improvements so you learn something for the next time.

Materials (to bring)

- Clip-boards (if you have one)
- GPS unit
- Compass
- Notebook
- Pencils
- Hand lens
- Colorado Flora: Western Slope; Weber & Whitman (if you have it)
- Plant Identification Terminology by Harris & Harris (if you have it)
- Sun hat, sunscreen, sunglasses
- 2 1-Liter Water bottles (or Hydration system)
- Hiking boots
- Long pants
- Insect repellent
- NO DOGS

Survey Field Kit

Here’s a list of what you need in your daypack when you are out monitoring rare plants:

REQUIRED EQUIPMENT:

GPS – at least one for your group
Extra batteries for it
Magnetic compass (not the one in the GPS)
Metric retractable tape measure (@ Home Depot 5m tape for under $10)
CNHP field form (the blank form from CNHP* which you must fill out)
EOR (the original report from CNHP)
USGS map of section of quad that you are in
Your workbook w/ pictures of native orchids, including their leaves & lips
Flowers/plant field guide book (for IDing the associated plants)
3 pencils (I always lose one)
Water- lots
Food (a meal, not just snacks)
Sunscreen
Sunglasses
Plastic flagging tape or kite string (this is for marking the boundaries of your population, remove when finished)
Good hiking shoes
Camera & film
Rain slicker
Allergy tablets (if you are prone to allergies)

Some of the above items can be distributed between packs.

In addition, these are nice to have:

OPTIONAL:

Clipboard
Bug repellant
Walking stick
Cell phone
Emergency space blanket
Long pants
Lupe (10x magnification works well)

* Colorado Natural Heritage

Rare Plant Monitoring Steward Protocol: Point-in-time Methodology
Prepared by Jennifer Neale, Denver Botanic Gardens
April 8, 2008
Adapted from the BLM handbook: Measuring and Monitoring Plant Populations pgs. 346-348

Objectives:

(1) To use temporary sampling units to robustly estimate population size with confidence. Ex: obtain estimates of the mean density and population size with 90% confidence intervals that are within 20% of the estimated true value. (This will be the focus of this protocol)

(2) THIS OBJECTIVE WILL BE THE FOCUS OF SUBSEQUENT TRAINING AND WILL NOT BE ADDRESSED IN THIS DOCUMENT. To use temporary sampling units to detect differences between two sample estimated population sizes. Ex.: detect a 20% change in population size from one year to the next with 80% confidence.

Methods:

- Record all your decisions and reasoning throughout this methodology.
- Where feasible, flag all individuals of the rare plant population that you are interested in studying. Spend no more than 2 hours flagging and record the number of people flagging and the amount of time spent. If flagging will cause undo harm to the plant population (ex. causing excessive erosion), then skip this step.
- Set up a macroplot that encompasses the majority of the population you are interested in counting. The size of the population will dictate the size of the macroplot.
    - If the population is estimated to be less than 100 individuals, count all individuals in the population.
    - If the population is likely >100 individuals, place a *rectangular or square* macroplot around a majority of the individuals. This macroplot will be subjectively placed to include the most plants and should be at a minimum 20m x 30m. The macroplot can be very large (~50m x 100m), but anything larger than 40m x 60m may result in more difficulty in completing a count efficiently. In general, a larger, skinnier plot seems to work better.
    - If you must use a very large macroplot (~50m x 100m or greater), make sure in the next step you include larger quadrats.
    - Do not put permanent markers at the corners of the plot. Use stakes/posts to anchor the four corners temporarily and GPS all four corners. Run meter tapes on all four sides with parallel sides having tapes oriented in the same direction.
- Designate quadrats within the macroplot. The number and size of quadrats will depend on the density and clumpiness of the plants. The goal is to have a 'reasonable' number of quadrats (at least 30) with a minimum number of quadrats having zero plant counts. Quadrats should also be relatively easy to count plants within, therefore longer & skinnier rectangle quadrats are preferred. For example, in a 20 X 30 plot, if plants are dense throughout the macroplot, you can use a smaller quadrat (60 2 X 5 m) because each quadrat would likely include a fair number of plants. If plants are sparse or clumpy in the macroplot, larger quadrats would decrease the variability between quads of number of individuals within a quad (e.g. 30 2m x 10m) and have less quadrats with zero plants.

- Once quadrats are set, use the data sheet (p. 116 from MMPP) to draw the macroplot and quadrats as they appear on the ground. Number each of the quadrats sequentially starting with #1.
    - Determine the number of quadrats that will be read initially (20%): Y= Total # of quadrats x 0.2 (e.g. 30 total quadrats x 0.2 = 6 initial quadrats).
    - Use a random number selector to pick random numbers that will determine which quadrats will be included in the initial data collection (e.g. pick 6 random numbers between 1 and 30 to select the included quadrats).
        1. Random numbers can be selected using an Excel Spreadsheet RAND() function; a random number chart taken from the MMPP; or by telling a partner to run their stopwatch, stop randomly and select the appropriate numbers.
- Read the selected quadrats.
    - Pre-determine what the counting unit will be (e.g. individuals, rosettes, stems, etc.)
    - Make sure to determine ahead of time if you will be noting reproduction or other demographic traits.
    - Make sure you decide ahead of time how to count individuals spanning the edge of the quadrat. Implement a rule that will exclude plants that touch 2 sides of each quadrat and include plants that touch the 2 other sides (e.g. if quadrats are oriented north-south, include all plants that touch the north and west side of a quadrat and exclude all plants touching the south and east sides). Apply this rule consistently to all quadrats.
    - Use flagging tape and meter tapes to lay out sides of the quadrats and count all individuals in the selected quadrats.
    - Record all counts on the data sheet (p. 116 from MMPP) and enter the numbers into the Excel spreadsheet to determine the mean and standard deviation for inclusion in the appropriate equations.

Statistics: Follow methods pgs 346-348 of MMPP.

- Using the Equation provided in the Excel spreadsheet, you will determine the actual number of quadrats to count to get the most accurate information. You should not have to count more than 50% of all quadrats in your macroplot. You can enter different Zα-values and B-values to bring down the number of required quadrats.
    - Start with a Confidence Level of 90% and a B-value of 0.1.
        - If this results in an unreasonable number of quadrats, drop the Confidence Level to 80% and run through the Equation again.
        - If you still have an unreasonable number of quadrats, drop your B-value to 0.2 and run through the Equation again. You may drop your B-value to 0.3 if you still get an unreasonable number of quadrats.

- If, with a Confidence Level of 80% and a B-value of 0.3, you still get an unreasonable number of quadrats, increase the size of your quadrats and start over. .

- Calculate the uncorrected sample size estimate using **sample size equation 1**: see attached doc (p.346-347).

- Consult the sample size **correction table for single parameter estimates** (see attached table) to determine the corrected sample size estimate (p.349).
- If more than 5% of the population is being counted (likely in our case) multiply the corrected sample size estimate by the finite population correction factor. See **Step 3 of Sample size equation 1** on attached document (p. 347).
- If the actual number of quadrats to count is greater than the number of quadrats you have already counted, then you're done. If it is less, then count the quadrats needed to bring the number up to the actual number of quadrats from your statistics.
- Multiply your mean by the total number of quadrats in your macroplot to receive the estimate of population size with the desired level of confidence.

"What's the difference between $Z\alpha$ and B?"

Think of it this way: After performing this analysis using a Confidence Level of 80% and a B-value of 0.2, you can say "We are 80% confident that our population estimate is within 20% of the true value."

Sample size equation #1: Determining the necessary sample size for estimating a single population mean or a population total with a specified level of precision.

Estimating a sample *mean vs. total population size*. The sample size needed to estimate confidence intervals that are within a given percentage of the estimated *total population size* is the same as the sample size needed to estimate confidence intervals that are within that percentage of the estimated *mean value*. The instructions below assume you are working with a sample mean.

Determining sample size for a single population mean or a single population total is a two- or three-step process.

(1) The first step is to use the equation provided below to calculate an uncorrected sample size estimate.

(2) The second step is to consult the Sample Size Correction Table (Table 1) appearing on pages 349-350 of these instructions to come up with the corrected sample size estimate. The use of the correction table is necessary because the equation below under-estimates the number of sampling units that will be needed to meet the specified level of precision. The use of the table to correct the underestimated sample size is simpler than using a more complex equation that does not require correction.

(3) The third step is to multiply the corrected sample size estimate by the finite population correction factor if more than 5% of the population area is being sampled.

1. Calculate an initial sample size using the following equation:

$$n = \frac{(Z_\alpha)^2 (s)^2}{(B)^2}$$

Where:

n = The uncorrected sample size estimate.

Z_α = The standard normal coefficient from the table below.

s = The standard deviation.

B = The desired precision level expressed as half of the maximum acceptable confidence interval width. This needs to be specified in absolute terms rather than as a percentage. For example, if you wanted your confidence interval width to be within 30% of your sample mean (i.e., $\bar{x} \pm 30\% * \bar{\chi}$) and your sample mean = 10 plants/quadrat then B = (0.30 x 10) = 3.0.

Table of standard normal deviates (Z_α) for various confidence levels

Confidence level	Alpha (α) level	(Z_α)
80%	0.20	1.28
90%	0.10	1.64
95%	0.05	1.96
99%	0.01	2.58

2. To obtain the adjusted sample size estimate, consult Table 1 on page 349-350 of these instructions.

n = the uncorrected sample size value from the sample size equation.

n* = the corrected sample size value.

3. Additional correction for sampling finite populations.

The above formula assumes that the population is very large compared to the proportion of the population that is sampled. If you are sampling more than 5% of the whole population then you should apply a correction to the sample size estimate that incorporates the finite population correction (FPC) factor. This will reduce the sample size.

The formula for correcting the sample size estimate with the FPC for confidence intervals is:

$$n' = \frac{n^*}{(1 + (n^*/N))}$$

Where:
- n' = The new FPC-corrected sample size.
- n* = The corrected sample size from the sample size correction table (Table 1).
- N = The total number of possible quadrat locations in the population. To calculate N, determine the total area of the population and divide by the size of one quadrat.

Example:
Management objective:
Restore the population of species Y in population Z to a density of at least 30 plants/quadrat by the year 2001.

Sampling objective:
Obtain estimates of the mean density and population size with 95% confidence intervals that are within 20% of the estimated true value.

Results of pilot sampling:
Mean ($\bar{x}$) = 25 plants/quadrat.
Standard deviation (s) = 7 plants.

Given:
The desired **confidence level** is 95% so the appropriate Z_α from the table above = 1.96.
The desired **confidence interval width** is 20% (0.20) of the estimated true value. Since the estimated true value is 25 plants/quadrat, the desired confidence interval (**B**) = 25 x 0.20 = 5 plants/quadrat.

Calculate an unadjusted estimate of the sample size needed by using the sample size formula:

$$n = \frac{(Z_\alpha)^2(s)^2}{(B)^2} \quad n = \frac{(1.96)^2(7)^2}{(5)^2} = 7.5$$

Round 7.5 plots up to 8 plots for the unadjusted sample size.

To adjust this preliminary estimate, go to Table 1 on pages 349-350 of these instructions and find n = 8 and the corresponding n* value in the 95% confidence level portion of the table. For n = 8, the corresponding n* value = 15.

The corrected estimated sample size needed to be 95% confident that the estimate of the population mean is within 20% (+/- 5 plants) of the true mean = **15 quadrats**.

If the pilot data described above was gathered using a 1m x 10m (10 m^2) quadrat and the total population being sampled was located within a 20m x 50m macroplot (1000 m^2) then N = $1000m^2/10m^2$ = 100. The corrected sample size would then be:

$$n' = \frac{n^*}{(1 + (n^*/N))} \qquad n' = \frac{15}{(1 + (15/100))} = 13.0$$

The new, FPC-corrected, estimated sample size to be 95% confident that the estimate of the population mean is within 20% (+/- 5 plants) of the true mean = **13 quadrats**.

Sample size correction table for single parameter estimates, Part 1

80% confidence level						90% confidence level					
n	n*	n	n*	n	n*	n	n*	n	n*	n	n*
1	5	51	65	101	120	1	5	51	65	101	120
2	6	52	66	102	121	2	6	52	66	102	122
3	7	53	67	103	122	3	8	53	67	103	123
4	9	54	68	104	123	4	9	54	69	104	124
5	10	55	69	105	124	5	11	55	70	105	125
6	11	56	70	106	125	6	12	56	71	106	126
7	13	57	71	107	126	7	13	57	72	107	127
8	14	58	73	108	128	8	15	58	73	108	128
9	15	59	74	109	129	9	16	59	74	109	129
10	17	60	75	110	130	10	17	60	75	110	130
11	18	61	76	111	131	11	18	61	76	111	131
12	19	62	77	112	132	12	20	62	78	112	132
13	20	63	78	113	133	13	21	63	79	113	134
14	22	64	79	114	134	14	22	64	80	114	135
15	23	65	80	115	135	15	23	65	81	115	136
16	24	66	82	116	136	16	25	66	82	116	137
17	25	67	83	117	137	17	26	67	83	117	138
18	27	68	84	118	138	18	27	68	84	118	139
19	28	69	85	119	140	19	28	69	85	119	140
20	29	70	86	120	141	20	29	70	86	120	141
21	30	71	87	121	142	21	31	71	88	121	142
22	31	72	88	122	143	22	32	72	89	122	143
23	33	73	89	123	144	23	33	73	90	123	144
24	34	74	90	124	145	24	34	74	91	124	145
25	35	75	91	125	146	25	35	75	92	125	147
26	36	76	93	126	147	26	37	76	93	126	148
27	37	77	94	127	148	27	38	77	94	127	149
28	38	78	95	128	149	28	39	78	95	128	150
29	40	79	96	129	150	29	40	79	96	129	151
30	41	80	97	130	151	30	41	80	97	130	152
31	42	81	98	131	152	31	42	81	99	131	153
32	43	82	99	132	154	32	44	82	100	132	154
33	44	83	100	133	155	33	45	83	101	133	155
34	45	84	101	134	156	34	46	84	102	134	156
35	47	85	102	135	157	35	47	85	103	135	157
36	48	86	104	136	158	36	48	86	104	136	158
37	49	87	105	137	159	37	49	87	105	137	159
38	50	88	106	138	160	38	50	88	106	138	161
39	51	89	107	139	161	39	52	89	107	139	162
40	52	90	108	140	162	40	53	90	108	140	163
41	53	91	109	141	163	41	54	91	110	141	164
42	55	92	110	142	164	42	55	92	111	142	165
43	56	93	111	143	165	43	56	93	112	143	166
44	57	94	112	144	166	44	57	94	113	144	167
45	58	95	113	145	168	45	58	95	114	145	168
46	59	96	115	146	169	46	60	96	115	146	169
47	60	97	116	147	170	47	61	97	116	147	170
48	61	98	117	148	171	48	62	98	117	148	171
49	62	99	118	149	172	49	63	99	118	149	172
50	64	100	119	150	173	50	64	100	119	150	173

APPENDIX 7—TABLE 1. Sample size correction table for adjusting "point-in-time" parameter estimates. n = the uncorrected sample size value from the sample size equation. n* = the corrected sample size value. This table was created using the algorithm reported by Kupper and Hafner (1989) for a one-sample tolerance probability of 0.90. For more information consult Kupper and Hafner (1989).

Sample size correction table for single parameters, Part 2

95% confidence level						99% confidence level					
n	n*	n	n*	n	n*	n	n*	n	n*	n	n*
1	5	51	66	101	121	1	6	51	67	101	122
2	7	52	67	102	122	2	8	52	68	102	123
3	8	53	68	103	123	3	9	53	69	103	124
4	10	54	69	104	124	4	11	54	70	104	126
5	11	55	70	105	125	5	12	55	72	105	127
6	12	56	71	106	126	6	14	56	73	106	128
7	14	57	72	107	128	7	15	57	74	107	129
8	15	58	74	108	129	8	16	58	75	108	130
9	16	59	75	109	130	9	18	59	76	109	131
10	18	60	76	110	131	10	19	60	77	110	132
11	19	61	77	111	132	11	20	61	78	111	133
12	20	62	78	112	133	12	21	62	79	112	134
13	21	63	79	113	134	13	23	63	80	113	135
14	23	64	80	114	135	14	24	64	82	114	136
15	24	65	81	115	136	15	25	65	83	115	138
16	25	66	83	116	137	16	26	66	84	116	139
17	26	67	84	117	138	17	28	67	85	117	140
18	28	68	85	118	139	18	29	68	86	118	141
19	29	69	86	119	141	19	30	69	87	119	142
20	30	70	87	120	142	20	31	70	88	120	143
21	31	71	88	121	143	21	32	71	89	121	144
22	32	72	89	122	144	22	34	72	90	122	145
23	34	73	90	123	145	23	35	73	92	123	146
24	35	74	91	124	146	24	36	74	93	124	147
25	36	75	92	125	147	25	37	75	94	125	148
26	37	76	94	126	148	26	38	76	95	126	149
27	38	77	95	127	149	27	39	77	96	127	150
28	39	78	96	128	150	28	41	78	97	128	152
29	41	79	97	129	151	29	42	79	98	129	153
30	42	80	98	130	152	30	43	80	99	130	154
31	43	81	99	131	154	31	44	81	100	131	155
32	44	82	100	132	155	32	45	82	101	132	156
33	45	83	101	133	156	33	46	83	103	133	157
34	46	84	102	134	157	34	48	84	104	134	158
35	48	85	103	135	158	35	49	85	105	135	159
36	49	86	105	136	159	36	50	86	106	136	160
37	50	87	106	137	160	37	51	87	107	137	161
38	51	88	107	138	161	38	52	88	108	138	162
39	52	89	108	139	162	39	53	89	109	139	163
40	53	90	109	140	163	40	55	90	110	140	165
41	54	91	110	141	164	41	56	91	111	141	166
42	56	92	111	142	165	42	57	92	112	142	167
43	57	93	112	143	166	43	58	93	114	143	168
44	58	94	113	144	168	44	59	94	115	144	169
45	59	95	114	145	169	45	60	95	116	145	170
46	60	96	116	146	170	46	61	96	117	146	171
47	61	97	117	147	171	47	62	97	118	147	172
48	62	98	118	148	172	48	64	98	119	148	173
49	63	99	119	149	173	49	65	99	120	149	174
50	65	100	120	150	174	50	66	100	121	150	175

APPENDIX 7—TABLE 1. (continued) Sample size correction table for adjusting "point-in-time" parameter estimates. n = the uncorrected sample size value from the sample size equation. n* = the corrected sample size value. This table was created using the algorithm reported by Kupper and Hafner (1989) for a one-sample tolerance probability of 0.90. For more information consult Kupper and Hafner (1989).

Contact Information

In case of an emergency or if you have additional questions regarding this project, you may contact any of the following:

Brian Kurzel
Natural Areas Coordinator
Colorado Natural Areas Program
303-866-3203 ext. 4301
303-548-8180 - cell
Brian.Kurzel@state.co.us

Jennifer Ramp Neale
Manager of Research Programs
Denver Botanic Gardens
720-865-3562 - office
303-961-2247 – DBG cell
nealejr@botanicgardens.org

Michelle DePrenger-Levin
Research Associate
Denver Botanic Gardens
720-865-3630
deprengm@botanicgardens.org

Denise Wilson
Denver Botanic Gardens Volunteers
PCNP Coordinator (orchid trips)
303-642-0510 – home
303-588-6442 - cell
denisewil@aol.com

Jill Handwerk
Botany Information Manager
Colorado Natural Heritage Program
970-491-5857
www.cnhp.colostate.edu