

NPP Field Protocol *for distribution*

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GENERAL INFORMATION

Synopsis. We read the NPP sites in spring (May), when shrubs and spring annuals have reached peak biomass; fall (Sept-Oct), when summer perennials and annuals have reached peak biomass but before killing frosts; and winter (February), before shrubs begin spring growth. The plant standing biomass, as expressed by volume, is what we are interested in, not simply the dimensions of the plant. We measure this "volume" in the field by measuring the "cover" and "height" of all separate vegetative units in the permanent one square meter measurement quads at each of 15 sites (3 in each of 5 dominant vegetation types). We identify canopy systems and height classes to determine "units" that should be read as separate observations. The protocol for cover and height measurements must follow exactly the protocol used during the five-year period when reference harvests were made. Otherwise, data from regressions will not be valid.

Analysis. From the dimensional measurements of "height" and "cover," volume can be calculated for each species in each quadrat. A regression of biomass against volume is constructed by harvesting plants near but outside the grid of permanent quadrats. All species were harvested each season for five years. Based on the developed regressions from these data, only two species continue to be harvested each season if they are green – PAOB (*Panicum obtusum*) and PLMU (*Pleuraphis mutica*). Twenty samples of each species should be harvested that represent the range of covers measured by all readers during the current season. If a new species is encountered for which no regression exists, a decision needs to be made on the necessity of harvesting it, or whether an existing regression would be representative for that species. If the decision is made to harvest a new species, the number of samples to harvest of a particular species is 15 for dominants and 10 for most other species. Range of cover values to be harvested is based on the range of cover values recorded from the permanent quadrats. Plants representative of those measured on the quads are harvested outside the NPP sites, and their cover and height values measured as for the quadrats. Samples are returned to the laboratory, refrigerated (4 degrees C) until sorted (dead material discarded, unless obviously from the current season of growth), dried for 72 hours (60 degrees C), and weighed (2 decimal places).

Harvest data are used to build regressions of biomass against volume. Quadrat data are used to estimate plant volume by species by quadrat, and then total biomass on a quadrat; positive increments in biomass over a time interval provide estimates of productivity for that quadrat.

Frame placement. Quad boundaries are delineated by the inside corners of the 1-m² PVC frame (see "Equipment"), which fits over 2 nails marking opposite corners of the permanent quad. (Rebar are used in place of nails at some locations because of active soil surfaces that may cause loss of nails. Legs slide onto the rebar during frame placement.) The legs of this frame should be adjusted to the appropriate heights before placing onto the nails to avoid excess strain on the legs and to avoid damage to vegetation caused by the frame being too low. Legs should not be bowed in or out of the quad but straight up and down because it will distort the frame otherwise. The frame should be as close to vegetation as possible and perpendicular to the center of gravity, not parallel to the ground if the ground is sloped. The legs should be attached to the frame so that the 2 pipes that make up the leg are oriented diagonally away from the corners of the frame, not parallel to either side of the frame.

Measurement guideline. Cover and height are based on any vegetative part of a plant that falls within an infinite vertical column whose walls are defined by the inside edge of the frame. This includes the vegetative part of a plant that extends into the area defined above but which is rooted outside the quadrat. Do not include what is not within the area defined by the frame. Every quad should be measured as you find it naturally. Do not change any aspect of the vegetation or litter on a quad; i.e., do not release snagged branches when snagging was caused naturally. Do not remove spider webs that may be binding vegetation in an otherwise unnatural position. Do not move dead branches on the ground or remove litter in order to see a plant better. Do your best to not move branches or bunches of grass around to see something else better. If you must, then try to measure what you have to move first so it is measured in the most natural position possible.

Calibration. Before beginning to read the quads at any site, all field members who will be reading cover should calibrate by measuring the same plant off the plot. Each person reads the cover (keeping their answers to themselves) and measurements are compared **after all** have read. As necessary, readings are discussed and adjustments made to bring cover measurements into agreement. This is repeated with other examples of the same species until all readers are in agreement within 10%. Extremes of plant structure for a species are read and calibrated to represent the range of reading difficulty that might be encountered.

SITE ETIQUETTE

1. **Layout.** Each site except for P-COLL is arranged in a grid of 8 rows by 8 rows of rebar at intervals of 10 meters. There is a 5 meter buffer zone around each site designated by tall, 3/8" rebar at each of the 4 corners. The 4 corners of the actual grid have 1/2 rebar. The rebar marking the locations of the quad stations are 3/8", so the outside corner of the site is recognizable by the diameter difference of the rebar. The southernmost and westernmost rows are buffer rows. All other rows are quad rows. Each rebar marks one quad, which is located 2 meters south and 2 meters west of the labeled rebar. The near nail is located 2 meters perpendicular from the north-south line of rebar. The "far" nail is located 151 cm from the near nail continuing on the perpendicular. The nails are painted white. Sometimes these are difficult to see and so there might be flags near the nails as well. In the playas there are short pieces of rebar instead of nails. Numbering of quads begins at the northeast corner, proceeds to the south, and continues in a snake-like fashion. Rows run alternately north-south or south-north. There are 49 quads except for P-COLL, which has 48 quads. The grid at P-COLL is 3 rows by 18 rows and no buffer rebar.
2. **Walking.** When walking on a site from quad to quad or row to row, always walk just to the east of the line of rebar running north-south. If detouring around vegetation encountered along the line, detour to the east, follow near the vegetation, and return immediately to the north-south line. This will help ensure that, over the years, everyone is walking the same path and will minimize disturbance to a larger area. The only time walking is allowed across the site in the east-west direction is to help another team or check the i.d. of a species. When walking east-west, the same guidelines above apply, except that you walk along the north edge of the rebar line running east-west. Always orient yourself before moving to the next quad; the view of the rebar going diagonally across the site (wrong way!) will look very similar to the line running north-south. Whenever possible, if not making measurements (ie, walking to and from a site) walk outside of the site.
3. **Approaching quad.** When approaching a quad from a row of rebar, walk the 2 meters up along the north-south rebar line from the tagged rebar and then on the perpendicular cut in the 2 meters over to the near nail. Do not walk in at an angle to the quad. This ensures that all personnel walk in the same paths and minimizes the compaction impact.
4. **Plant collection.** Specimens should only be collected off the site and outside the 5 meter buffer zone.
5. **Reader row assignment.** Each reader should read an entire row of quads at a time. Having one person on each row reduces the risk of confusion as to which quads were read and therefore reduces the risk of missing a quad. On the last row, 2 readers may "leap frog" and finish a row together by moving in the same direction and measuring alternating quads. These readers should check with each other to clarify which quads have been read and which still need to be read.
6. **Check quad numbers.** Check quad numbers on the aluminum tags on each rebar **every time** you approach a quad to make sure that the row is numbered in the direction you think, you did not miss a quad, or confuse the quad number.
7. **Missing nail?** If a nail or rebar appears to be missing, do a thorough search with the help of others before considering replacement. When searching, make careful measurements to where it should be; compare perpendicularity of nails to the reference grid line with adjacent quads. The missing nail or rebar will be found in a very large percentage of cases; it is quite rare to have been pulled out and carried off by animal or water. It is often buried in the soil or under detritus or plant part.
 - a. When searching for a missing nail, check the perpendicularity of other quad nails nearby. The perpendicular alignment of the missing nail will likely match that of its neighbors; that is, if the far nail appears to be off the perpendicular, the missing nail was likely placed in a similar alignment.
 - b. During the search, minimize disturbance by carefully feeling in the soil or, if digging is necessary, work in toward the location from outside the quad
 - c. It is very important that a replacement nail be put in the same spot as the original to ensure future measurements are from the same area as past measurements. Documentation should state whether nail was replaced in existing hole from which it was pulled or replacement location was based on new measurements.
 - d. If any nail is replaced because it is missing or found laying on the ground, **DOCUMENT** exactly what is done. Describe in detail the situation of how it was found, how it was rectified, and include measured distances from grid line to near nail to far nail, etc. Do not leave it to the reader of your notes to make assumptions. This is important so one can tell if or how much error may be introduced in reestablishing nail location.
 - e. The near nail is 200 cm on the perpendicular from the grid line (rebars with quad i.d. tags). The 2 nails marking the corners of the permanent, 1x1 m² measurement quad are 151 cm apart. The far nail is 351 cm on the perpendicular from the grid line.

RECORDER ETIQUETTE

1. **Voice recorder specs.** Data must be recorded using a Sony digital voice recorder (e.g., ICD-P320) and headset. The Sony model used must have USB download capability, VOC (voice activation), and low/high microphone sensitivity. The headset must have an inline pause switch, foam windscreen for mic, and designed to be worn behind-the-head (to allow wearing of head cover).
2. **Voice files.** Each site must have its own unique voice file for each reader for each day. For example, if it takes a reader 2 days to read a site, there will be 2 voice files for that reader for that site.
3. **Begin & end voice file.** At the beginning and end of each voice file, the following information should be read in the given order: the reader's name, state "these are NPP quad measurements for 'season year', the current date, the zone and site. If a quad or site needs to be continued on another voice file, at the end of the recording state give the information listed in the previous sentence, but also state that the site measurements will be continued on a following day. At the beginning of the next recording that is a continuation of these site measurements, state that it is a continuation for the site, what quads were done previously and by whom. Then provide the required information listed at the beginning of this paragraph (who, what, when, where).
4. **Reading order.** For each observation data fields should be read in the following order: "species code", "cover", "height", "count" (for all readings, including counts of 1), "phenology" flower/veg, "comment" (include comment if there is one), "end comment." If there is no comment don't say anything; phenology ends the reading in this case. For the species code, spell it the first few times the code is used in each quad or if it is a lone observation stuck in between observations of other species. If in doubt, spell the code so there can be no confusion as to what species you mean.)

Example of reading PRGL on a quad:

First reading: "Begin PRGL, cover 14.5, height 46, count 1, veg"

subsequent reading: "PRGL, cover 7, height 32, count 1, flowering"

Last reading: "PRGL, cover 0.25, height 14, count 1, Veg, End PRGL"

5. **Begin & End species.** Do your best to read all observations of a given species together in a row. This will eliminate confusion as to what species is being read and greatly facilitate the efficiency of data entry. At the beginning of a group of observations for a given species, always state "Begin xxxx", where xxxx is the species code. At the end of the group of observations for a given species always state "End xxxx" where xxxx is the species code. If you miss a plant and have to return to a species later on, do so. Simply make another observation; do not try to add to a "count" given previously. Be sure to spell the species code again for clarification, though. State that it is another reading of a previously read species so it is clear to data entry that it is an additional reading for that species.
6. **Begin & End quad.** At the beginning of each quad say "begin Quad #." At the end of each quad say "end quad #." State when beginning and ending a row on the site.
7. **Spell codes at new site.** When beginning measurements at a new site, spell each species code (as you read them) a few times to allow the data entry person to become accustomed to your pronunciation. Species that occur infrequently should always be spelled.
8. **Spell similar codes.** Always spell anything that might be misheard; e.g., EUAL vs. YUEL; ERAB vs. ARAD, etc. DO NOT MUMBLE!! Enunciate clearly, especially when reading the numbers 13, 14, 15 and 16. They can sound very similar during data entry when mumbled. There are often background noises that can easily interfere with your readings. Speak as clearly as possible at all times.
9. **Make a mistake?** If you make a mistake, a) state the correction on the voice file but do not attempt to correct the actual recording (don't delete, insert, etc.—too dangerous in the field). b) Write the correction on paper or notebook including all relevant information for later transfer to the field notes Word document upon return from the field (include date, zone, site, plot, spp, relevant measurements, and the correction).
10. **Document quads done.** Each reader must keep a written log of all quads read for each site **as they are completed or at the beginning and end of each row.** Record the quad immediately after completing it if you are leapfrogging other readers on the same row. This is essential to avoid missing or duplicating quads. Do not postpone this.
 - a. At the end of measurements for a given site and at end of the day, all readers will read out the quads they have done ("count off") to ensure that all quads were read (none missed or read twice). Read them in the order they were done (e.g., quads 14-8, 15-21, 6-7).
 - b. One person records this information in the field before leaving the site upon completion of the site or completion of the day's readings, whichever comes first. Associate the reader's initials or name with quads they read in case there are questions later. Verify that there are no missing or duplicated quads. List rows separately even if read consecutively; e.g., 22-28, 29-35. Follow example below for field notes.

9/8/16	NPP
C-CALI	
JA	Q1-7, 49-43, 42-41
KJ	Q14-8, 36-39
RC	Q15-21, 22-28, 29-35, 40

- c. Back in the office this person uses this list to verify that the digital voice filenames of all readers for that day accurately match the quads read in the field by each reader. When reviewing the day's voice files for all readers, verify that there are no missing or duplicated quads (1-49 or 1-48 for P-COLL). This person also uses this field list each day to cross check the entries in the Excel quad check list as made by each reader upon return from the field.
11. **Consistent speaking speed.** Maintain a constant speed of speech while recording and minimize the amount of dead air on the file. If it takes more than 2-3 seconds to take a particular measurement, use the *pause* switch on the headset.
12. **Check batteries.** Once in a while check that the batteries are still good.

MEASUREMENTS

Cover

1. Cover is quantified by determining what percent of the frame's 100 10 cm x 10 cm squares (see "Equipment") are intercepted by each vegetative unit. Because of the overlap of vegetative units (especially in shrubs and succulents), it is possible to end up with a total percent cover of over 100%.
2. The smallest acceptable cover is 0.01; the largest acceptable cover varies by species. For perennials, cover measurement should not exceed reference harvests on which biomass regressions are based if at all possible. See the "NPP Reference Harvest Maximum Cover by Species for Period 1990-1995" for values. If an individual is larger than the max cover allowed, then try to find a natural break (a difference in height class, a dead area, etc.) to divide the individual up into portions that do not exceed the maximum cover. Only divide up as much as you have to (not more) in order to not exceed the max cover. For mat grasses such as MUPO and PLMU if no natural break can be found, then create an arbitrary break using one of the strings on the frame and divide the mat roughly in half. This will help account for edge effects that would occur in a naturally occurring break. For other perennials, if no natural break can be found then read the cover as is, even if it exceeds the Max Cover values from the regressions. Annuals are always read as whole individual plants, regardless of Max Cover values from the regressions. Do not break them up for any reason.
3. All annual plants that grew during the current season should be measured even if they are dead. If an annual is dead, however, read it **only** if you are **sure** that it is the current season's growth and that it still retains the same dimensions as when it was alive. In this case, make a general comment at the beginning of each site that all the individuals for Species X at Site Y are dead but being read anyway since they are from the current season.
4. Acceptable cover sizes: If <0.25 use 0.01, 0.05, 0.1, 0.25; if >0.25 use multiplies of 0.25.
5. For perennial plants, cover is based only on the vegetative portion. For annual plants, cover includes both the vegetation and inflorescence.
6. When reading plant cover, it is important to stay centered over material being measured so parallax (angle of view) doesn't cause you to over (or under) measure cover. When height of shrubs (or density of plants around frame) prohibit you from leaning over plants, use a tape measure to drop vertical lines from the frame to delineate vertical column of intercept. A niner and plastic (see "Equipment") can be used to help measure canopy systems or low growing plants below the frame. The niner is used to reach in under the frame to measure low-lying vegetation that is too far from the frame for accurate measurement. The plastic should be used to measure covers $<0.5\%$ and may be used for up to 0.5% covers.
7. Different types of species are measured using different protocols as follows:

Grasses

- a. Grasses as a group are measured in several ways depending on the species. They are read as either clumps, mats or balls. Clumps (*Sporobolus*, *Aristida*) are measured approximately midway between basal area and a perimeter drawn around the outside at a point that includes the densest part of the clump but not the more open top. Mats (BOER) are read by drawing a perimeter line around the central mass of grass except for wispy ends. Balls (MUPO, PLMU) are read by drawing a circle around the perimeter of the plant that includes all but individual outliers.
- b. Live grass is frequently mixed with dead. In general, read solid cover without attempting to read "around" dead. This is the method regressions are based on. However, if green is very sparse and patchy in its occurrence in the dead material, only green cover is read.
- c. Measure only grass that is green, except for MUPO and BOER. Live MUPO vegetation may be green, buff or purple; BOER vegetation may be green, buff or straw colored. Dead grass vegetation (indicated by gray or black) should not be measured unless it is evenly mixed with live material. With the exception of MUPO and BOER, if no green is visible, the plant should be considered dormant and not measured. It is by this definition that reference harvests were made for five years and biomass regressions developed. However, under drought stress conditions in the spring it has been noted that some grass species have greened up under the sheath to a varying degree (usually small). If the green under the sheath only extends up 5 or 6 centimeters, consider it dormant and do not measure as the amount of live biomass is very small. A reference harvest of this will result in a very poor regression because of the great variability of live-to-dead in the harvest. If more than about 6 cm, use good judgment as to whether measurement and subsequent

harvest will result in meaningful values. If measurements are made, it is necessary to do a reference harvest of 20 samples at each site where this is done.

- d. The condition of mat-formers and PLMU are assessed in areas outside the plot before starting to take measurements to determine if plant color in some way corresponds to new green growth that may not be obvious without tearing apart the plant.
- e. DAPU - read height in densest part of main plant, not including outliers; measure to top of green, not the fluff (old seed heads); when very dry, only read live parts; stoloniferous outliers are read as individual readings if they are rooted or show any green.

BOBA - if inflorescence sticks out 180 degrees, measure conservatively rather than to end points.

BOER - read actual cover as a mat not just basal clump; read as solid cover unless there are large dead areas; height may vary significantly within the clump, if so then break into height classes and measure cover accordingly; reference harvests did not include very fine scale height classes. A good example of a valid height class are stolons or leaf masses that lay across open space or dead vegetation and are rooted elsewhere.

BOERS, PAOBS - used for runners (stolons) across bare ground or dead vegetation. Every 10 cm = 0.5%, height = 1 cm. Tufts on stolons are read separately.

Sporobolus species- check for green at base and read only green for height; if plant is a mix of gray and golden with green blades in between, measure entire clump with height to top of green blades.

SCBR and MUAR – Do not read if there is no green visible; include tawny colored grass with the green blades if the green blades are interspersed throughout, do not read gray colored material, if there is green localized within a clump then read just that part of the clump; read height to top of green foliage only. If a clump is growing from stolons hanging in mid-air, read the height from the bottom of the green to the top of the green, not from the ground.

SPAI - do not measure curly leaves that hang over the main plant mass; read green vegetation only, not the dead in between; if there is some visible green within the clump, then read all straw colored grass for cover and measure to top of green only for height. If the green is limited to isolated spots and not distributed throughout the straw colored portion, only the green areas should be measured.

PLMU - measure to top of leaf mass; measure conservatively around perimeter of clump; if plant is not green without tearing it apart, or without visible green, consider it dead or dormant (don't measure).

PAOB (P-SMAL) - if examination off the plot indicates that there is consistent green beneath the dry mats, measure total cover of the straw-colored vegetation and take the height of an average green blade found within the mat (in this condition, only one or two blades may be visible above the mat); if examination off the plot indicates that there are only scattered clumps of green within the mats, measure these clumps rather than assuming all straw colored vegetation is alive; small plants of one to three blades spread out are read by drawing a perimeter around the majority of the foliage.

MUPO - read as ball when well-defined, ignore individual outliers; break into height classes if possible; maximum cover is 12 (not 24 as listed in the old Max Cover sheet).

Shrubs and Sub-shrubs

- a. Shrubs (e.g., PRGL, FLCE, LATR, ATCA) are measured by separating foliage into branches or canopy systems and measuring each separately. Bare stem connecting foliage to the ground (or edge of vertical column defined by inside edge of quadrat frame) is included as part of the cover using the formula below.
- b. Vertical height includes only green foliage, from lowest green leaf to highest.
- c. Perennial shrubs that are deciduous are measured as alive even if dormant; i.e., mesquite in winter. Dead branches are not measured. Scratch bark to check for green cambium if in doubt.
- d. Always include all live stem in readings of a shrub/subshrub. Do not double-count stem areas. Measure the stem connecting the foliage to the ground to a logical junction; i.e., measure the bare stem to the ground, where it intersects the frame, or a logical branch junction and include it with the foliage section that makes the straightest line to the ground. If not following the stem to the ground, stop measurements at a joint or edge of frame.
- e. Bare stem is defined as 0.5% if crossing entire 10 cm square, 0.25% if only partly crossing square; 2 stems crossing 10 cm square is 1% (so is 3, 4, or more). Trunk or stem more than 2 inches (5 cm) in diameter is defined as a whole 1% cover for each 10 cm crossed. Only if there is no foliage associated with a bare branch is a height measurement made of the branch; otherwise, while cover is a combination of foliage and bare branch, height is from lowest green leaf to highest. If a bare branch has no foliage associated with it, measure height from low end of branch to high end; be sure to make a comment of "bare branch" if the entire observation consists of only bare branch. NOTE: It is the vertical, 2-dimensional view that is considered when measuring cover. There is no added value with increasing cover density within a vertical column being considered. Do not measure separately a "bare" branch that is over or under foliage cover that is part of the same reading. Think two dimensional when measuring three dimensional cover in the context of this vertical view.

- f. Don't measure dead bare stem or areas of dead foliage. Scrape branch with fingernail to check for live cambium if in doubt.
- g. LATR - draw a line around perimeter of branch and ignore small open areas (generally less than 10 cm); exposed root crowns (common at C-CALI) are not measured as they are not aboveground (standing) biomass.
 PRGL - in winter measure bare branches by canopy systems and take vertical height from lowest point of bare branch to top of branch whether vertical or at an angle; when foliage is present, draw circle around perimeter of green vegetation and measure by branch system including any bare branch as part of the reading; height is from bottom to top of green foliage only.
 FLCE - when leafless, read densely overlapping branches like LATR, not like dormant PRGL; if a single branch has dead or no leaves, then read as bare stem; measure height from finer branches with obvious potential to produce leaves, not from ground; FLCE canopy systems are more lumped than for LATR and PRGL.
 XAMI, XASA - measure to top of green foliage from lowest green foliage; ignore inflorescence.
 EPTR - draw perimeter around needles by branch system, ignore spaces within branch system.
 LYBE - measure as solid cover (not by canopy system) unless a branch is distinct from the mass.
 PAIN - break into general canopy systems as you would for FLCE.

Forbs

Annual forbs are measured by drawing a circle around the outside of the plant including the inflorescence. Do not include the inflorescence or reproductive structures in cover or height for perennial forbs.

- BOIN - draw circle around plant including inflorescence.
- LEGO - measure stems individually if spindly and old with no, or few, leaves.
- PSTA - measure like a subshrub and don't read outliers, draw a circle around perimeter.
- LIVE - draw a peripheral line around it for cover even if stems are at 90 degree angles.
- SILE - if thick, read as cover rather than as individual plants.
- DEPI - if cover thick, read each individual plant separately, do not read as mat; if plants are the same size, read cover and height with a multiple count.
- BAMU - Be careful in the winter as some old, dead plants often appear to be alive; do not read dead plants. Only read new, live plants.
- ERTR - measure perimeter; treat long outliers like bare branches (0.5 or 0.25%).
- AMCH, ALIN, KAPA - measure large plants as actual cover (not perimeter); treat outliers as bare branch and read according to formula described in section on shrubs, use perimeter measure for small plants.

Succulents

- YUBA - leaf, stem, and inflorescence are not measured separately
- Yucca elata - leaf, stem, and inflorescence are each measured separately
 YUELL - draw a circle around perimeter of leaf blades and count entire cover; if 2 leaf balls overlap, measure each separately as if the other is not there; regressions are based on a one time harvest of entire cover.
 YUELC - measure cover and height of caudex
 YUELI - measure cover and height of inflorescence including flowering stem
- OPVI, OPPH - measure each pad as longest length by width (in place of cover and height); use counts for same size class; do not include spines or glochids in measurements. Any reproductive structure (flower or fruit with supporting base) is a separate measurement from the pad; if an open or closed flower is present, include the entire flower as part of the reading along with the supporting base of the reproductive structure.
- OPLE - measure like a shrub
- OPIM - measure each stem segment as length between joints and segment width (in place of cover and height); use counts for same size class. Measure reproductive structure (bud, flower, fruit) separate from vegetative stem segments.
- OTHER cactus species - read as solid cover and measure height from the ground; do not include inflorescence or spines in cover or height.

Height

1. Height is recorded as a whole number in centimeters.
2. All heights are vertical heights which are defined as a line parallel to the pull of gravity (and not necessarily perpendicular to the ground, which may be sloping).
3. Heights of all annual plants are measured from base or lowest part of plant to highest point of plant (inflorescence or vegetative part).

4. Perennial forb heights are measured from base or lowest part of plant to highest green foliage; do not include inflorescence.
5. To measure the heights of perennial grasses measure to the top of the main leaf mass (do not include reproductive structures or extreme outliers).
6. Perennial shrub and sub-shrub heights are measured from lowest green foliage to highest green foliage. They are not necessarily measured from the base to the top of the plant. No reproductive structures included in height
7. Height of a plant extending into the air space defined by the one square meter quadrat is based only on that part of the plant within the quadrat (and not from the ground).

Phenology

1. If there is one bud, flower, seed, or fruit on an observation (individual measurement), the observation is recorded as Flowering (F). If no reproductive structure is present then the observation is Vegetative (V).
2. The phenology of succulents is determined differently depending on the species.
YUEL - the inflorescence is measured separately from the caudex (trunk or stalk) and rosette (leaves). The inflorescence would be given an F while the caudex and rosette will always be assigned a V.
OPPH, OPVI, and OPIM - the fruits and flowers are also measured separately from the pads; the reproductive structures' measurements are given an F while the pads are given a V.
OPLE - cover is measured like a shrub and so each separate observation will be given its own phenological state regardless of the phenological state of the rest of the plant. For other cactus species, each plant is measured as a whole and so will be given one phenological distinction.
3. Each separate observation of shrub or subshrub is assigned it's own phenological distinction regardless of the condition of the rest of the plant. In other words, if you are measuring a small portion of a branch and there are no reproductive structures on it, it is given a V, even if the rest of the branch has flowers.
4. If a plant has obvious floral structures (such as the flowering stalks in *Eriogonum* species) but the flowers themselves have been grazed, still call it flowering as we are interested in reproductive status for each season, and we know that individual did grow reproductive structures. If it is unclear whether a plant had flowered before it was grazed, call it vegetative.
5. If viable seeds are present in a season after the fruits initially emerged, identify as F and comment " old fruit." If old flowers or fruits are still present but no viable seeds are present, identify as V.
6. If all or most individuals of an annual species are dead at a given site, but you are sure that they were this season's growth, and they show evidence of reproductive parts, then each individual reading would be assigned an "F" for phenology and a comment should be made after the first reading of the species that "All plants of XXXX at this site are dead and post-fruit unless otherwise noted." Be sure to repeat this comment for each site if it holds true.

Count

This is the number of individuals of a specific species with the same % cover and height. This is essentially a multiplier that is applied when the biomass is calculated so that each individual of that species does not have to be recorded separately.

Miscellaneous

1. **NONE code.** A quad with no living vegetation is recorded as NONE 1 0 0 1 V in the data book or simply read as NONE (and spell it) on the digital voice recorder.
2. **Grass/Shrub seedling comment.** For any seedling of a perennial grass species or perennial shrub species, make a comment of "seedling". Perennial grass seedling is identified as having established since the previous NPP season. Presence of cotyledons qualifies the shrub individual as a seedling.
3. **Starting species.** Start each quad at a site reading the dominant species for that zone (if present) as a way to double check the quad id number in case of data recording errors. For example, if reading vegetation at a creosotebush site, always start with LATR, even if there is only 0.01% present in quad.
4. **Maintenance notes.** Maintain a written list of maintenance needed as you read the quads. Be sure to include the zone, site, and quad number in addition to what is wrong. If you did maintenance on the quad while you were there, write down what you did, the zone, site, quad number, and date. If you need to refer to a nail missing, the nail closest to the row of numbered rebar is the "near nail", and the nail farthest from the line created by the rebar is the "far nail."
5. **Other notes.** Maintain a written list of any corrections, unknown species descriptions, data problems, etc. as you read the quads. Notes from all readers should be compiled at the end of the NPP season by the team leader and submitted as a WORD document for archiving and use by the data entry person. It is extremely helpful to the data entry person to know of problems or changes to the data before he/she enters it; it saves time and reduces errors.

EQUIPMENT

1. Digital Voice Recorders – one per person plus an extra for the group. See Digital Recorder Etiquette section for more information.
2. Extra AAA Batteries – two per person, for the digital recorders
3. Data Sheets – as a backup if digital recorders break or an extra person is present to record. Record for each observation: date, zone, site, quadrat #, species¹, observation #², cover³, height⁴, count⁵, phenological state⁵, comments.
¹4-5 letter acronym ²Sequential number beginning with “1” for each measurement of all species in that quadrat
[Used only when data is recorded in field data books, not during voice recordings of data because it cannot be accurately tracked.] ³Percentage of quadrat covered by canopy of that individual or species. ⁴Vertical extent of that individual or species. ⁵Number of individuals present with the same dimensions. ⁶Flowering or Vegetative.
4. Frames:
 - a. The frame is constructed of 1/2 inch PVC. The interior dimensions of the corners of the square are 1 meter on each side. Each corner coupling is a female threaded right-angle T (threads are for attachment of the adjustable legs). The 1m² area of the frame is divided into 100 squares (10 cm X 10 cm) by nylon string passed through small holes drilled into the PVC. Each square equals 1 % cover.
 - b. Each adjustable leg is constructed of 2 pieces of 1/2 inch PVC. One piece is about 45 cm long, with a male coupling at one end (to screw into the female corner of the frame), and a female end at the other (to match the diameter of the other end to maintain leg stability). The second piece of PVC for each leg is typically about 125 cm long; the most appropriate length for the legs will depend on the maximum height of vegetation to be measured. This sliding piece of PVC is connected to the other through galvanized electrical conduit fittings. These fittings remain attached to the shorter PVC with hose clamps wrapped around the couplings at each end. The adjustment nut for these hose clamps should be along the flattest side of the loop around the legs, not on the round ends. The tension on the sliding lengths of PVC can be adjusted by loosening and tightening the conduit fittings -- it is important that a pair of rings (with the extra flanges cut off) be inside the fittings to provide this tension (these rings need to be replaced periodically to maintain tension). Because of the additional space taken up by the materials of the adjustable legs, the 2 nails marking the corners of the permanent measurement quad are exactly 151 cm apart.
5. Niner - The niner is also made of 1/2 inch PVC and nylon string, but it has no legs. The interior dimensions of the square are 30 cm on a side, and the enclosed area divided into 9 10 cm X 10 cm squares with nylon string. Corner couplings are simple right angle pieces. The niner is used to reach in under the frame to measure low-lying vegetation that is too far from the frame for accurate measurement.
6. Plastic - The plastic is used for measuring covers less than or equal to 0.5%. It is made of a small square of clear 1/4 inch plexiglass, 7.1 cm on a side (the entire plastic equals 0.5% cover). Within that area, squares are etched with dimensions of 0.1, 0.22, 0.32, and 0.5 cm on a side. These squares delineate the covers of 0.01%, 0.05%, 0.10% and 0.25% respectively. To help relocate a plastic dropped into vegetation, tie brightly colored surveyor's tape to a small hole drilled into one corner of it
7. Measuring Tape - Retractable 3-m metric tapes for both measuring the height of vegetation and dropping vertical lines from the frame.
8. Hammer And Extra Quad Nails And Washers – to replace missing nails or replace pulled nails.
9. Plant Presses And Ziplock Bags With Wet Paper Towels – to collect vouchers for unidentified species. (Always collect from off of the site or quad!)