BASELINE MONITORING

Regenerative Stewardship Curriculum: Develop

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REGENERATIVE STEWARD COURSE PLAN

Discover & Define

1
Introductions & Determining Value Alignment

2
Share or Review System of Change

3
Articulate a Vision

4
Identify Opportunities & Barriers

5
Understand Steward Energy Levels

Develop

6
Understand the Land

7
Understand the Business

8
Understand the Management

9
Identify the Lever

Deliver

Overview

PURPOSE

This tool is used to do in-field soil evaluations as well as collect samples for lab analysis for physical, chemical, and biological responses relevant for monitoring soil health.

PREP ITEMS

See subsequent slides.

TIMING

Ideally during peak growing season; otherwise, at some other part of the production cycle, and at the same time of year thereafter.

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Overview

DELIVERY

Add test results to a spreadsheet for easy updating and evaluation.

OUTCOME

The steward and the planning team capture responses that can be used for evaluating ecological changes.

STAFF

Planner trains stakeholders during the planning process.

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Potential Measurements

The following measurements can be obtained through baseline monitoring.

SOIL TEST

- soil texture
- N, P, K, Mb, Zn, Fe, Mn, Cu
- Available N (NO3)
- pH
- Electrical conductivity
- sodium adsorption ratio (SAR)

AGGREGATE STABILITY

- Resistance to erosion or degradation due to:
  - Organic matter content
  - Texture

INFILTRATION RATE

- Speed at which water enters the soil

VEGETATION COVER

- Litter, plant, biocrust, stone cover, etc.
- Plant diversity (functional and/or species)

CLIP PLOT

- Forage and/or biomass production

BULK DENSITY

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Materials

GENERAL

- Clipboard
- Data forms
- Pencils
- Field notebook
- Hammer
- Keys/gate combinations
- Smart phone
- Two 100 meter transect tapes

SETUP PLOTS

- Long nails/Wooden Stakes to mark transect ends.
- Measuring tape
- Post driver
- Fence posts
- Cattle fence
- Wire cutters
- Pliers to bend bottom
- Wire to secure one side to make a “door”

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Materials

AGGREGATE STABILITY

- Slake test kit or window screen sieve/pvc pieces
- cup/jar
- Irrigation water/distilled water

LAB TESTS

- Soil core (3/4” diameter OR use bulk density soil core)
- Ziplock bags
- Sharpie
- Pencil

BULK DENSITY

- Soil core (3” diameter x 10cm tall) - mark the inside depth at 8cm with a sharpie.
- Trowel or soil knife
- Small piece of 2x4
- Rubber mallet (NOT metal - metal can damage the soil core!)
- Ziplock bags
- Sharpie

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Materials

INFILTRATION RATE

- Metal ring
- Plastic
- Water
- Measuring device
- Stopwatch

VEGETATION COVER

- Measuring tape or quadrat
- Dowel or stick or flag
- Meter stick

CLIP PLOT

- PVC quadrat
- Clippers/Scissors
- Paper bags
- Sharpie
- Tray or plate
- forcepts/tweezers
- Coin envelopes
- Sharpie
- Scale

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Site Setup

SITE SELECTION

Site selection is guided by the management goals of the producer.

Selecting an actively managed field or one that will be in the future gives the producer the opportunity to track changes over time and evaluate the outcomes of conservation practices.

Sampling should occur at least 25-50 feet away from a road, as dust and disturbance can alter the organisms that live in the areas nearby. If there are sites with a lot of burrowing animal activity, these should be avoided as well because they may not be a great indicator of the general conditions of the soil.

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Site Setup

SITE SELECTION

For rangeland, using Ecological Site Descriptions help to align one's activities with the NRCS. Thus, sampling should occur at 1-2 of the dominant Ecological Sites for a given ranch, with a representative area of approximately an acre for each one.

For cropland, if the management history differs dramatically between fields, sampling should be unique to each management unit and prioritized based on the steward's interests, priorities, and activities.

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Sampling Layout

TRANSECTS

Sampling will be based on a minimum of 2 transects of 100 meters, running parallel to the contour of the land.

Both ends of each transect will be marked with a wooden stake or some other distinct marker. Take a photo and record a GPS coordinate from both ends of the transects, as this will make it easier to find in future years. And take care to not walk on the transect, instead walking alongside it to reduce trampling.

EXCLOSURE

Ideally, an exclosure should be located adjacent to or in the middle of the transects (minimum 1m x 1m, but larger if possible) to exclude livestock and large mammalian herbivores.

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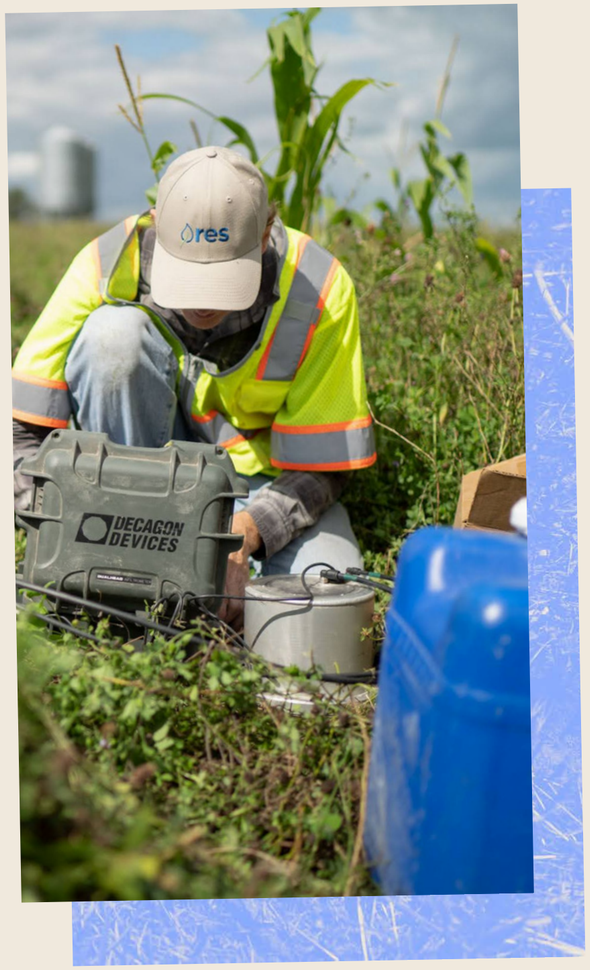

Soil Test

Soil tests provide information on soil texture (i.e. silt, sand, or clay) as well as chemical composition and other characteristics.

Texture only needs to be collected for baseline monitoring, as it is unlikely to change over human relevant timescales. However, if a major erosion or deposition event occurs, it would be a good idea to measure texture again.

Routine soil laboratory tests typically include the following data:

- pH
- electrical conductivity
- organic matter
- nitrate
- phosphorus
- potassium
- zinc
- iron
- manganese
- copper
- sulfur
- boron
- lime
- texture estimates

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Site Setup

SAMPLING PROTOCOL

View sampling instructions and a sample lab chain of command form.

Things to remember:

- Collect soil samples randomly throughout the monitoring site.
- The minimum number of replicates in a single monitoring site to be aggregated is 10.
- Soil samples should be collected from 0-15 cm. deep, removing any loose plant litter from the surface before collecting a ¾" diameter soil core vertically into the soil.
- Samples should be placed in a ziplock bag, then air dried (can leave ziplock open for a few days), resealed, and stored in a refrigerator if not sent to a lab within a week.
- Sample bags should be labeled with the date of collection, the initials of the person who collected the sample, and the site and plot information per project.

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Bulk Density

Bulk density can be collected every few years, depending on the management. If on rangeland, where more heavy animals tread the soil, sampling year after year can be helpful; if on cropland, bulk density should be collected after changes in management occur.

Bulk Density Protocol:

1. Take two randomly selected bulk density samples per monitoring site.
2. Press or hammer the can of known volume into the soil to a depth of 8 cm.
3. Excavate the can using the trowel.
4. Trim the bottom of the soil sample such that it is flush with the top and bottom of the can. Try not to let the soil fall out the top!
5. Push the sample out into a labeled plastic bag, making sure that you got ALL of the sample into the bag (or just save lots of cans and put the entire can in the plastic bag to dry out).

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Aggregate Stability

Aggregate stability should be done approximately annually to assess if stable structure is increasing or decreasing.

Aggregate Stability Protocol ("Slake Test", n.d.):

1. Use the soil knife to remove six to nine ~¼" diameter, ⅛" thick aggregates from the soil surface, at least 50 cm off from the transects, and let them air dry on the piece of window screen.
2. Air dry for at least 1 week (depending on initial moisture, it may take up to 1 month; most rangeland soils are already very dry and could potentially air dry in the field for an hour before running the test).
3. Set up jars with 1" of distilled or irrigation water (note: NRCS protocol calls for distilled water, though using irrigation water can provide a better idea of how the soil will behave when irrigated; just record which type of water end up using).

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Aggregate Stability

Aggregate Stability Protocol, continued:

4. Place soil clods into a mesh basket, lower it into the water, and start the timer. Observe the soil fragment for five minutes. Refer to the stability class table below to determine classes 1 and 2.
5. After five minutes, raise the basket out of the water, then lower it to the bottom. It should take one second for the basket to clear the surface and one second to return to the bottom. Repeat immersion four times (total of five immersions).
6. Refer to the stability class table to the right to determine classes 3 through 6. Record ratings.
7. Soil stability is rated according to the time required for the fragment to disintegrate during the five-minute immersion, and by the proportion of the soil fragment remaining on the mesh after the five extraction-immersion cycles (see table below). Record the stability ratings for all 16 soil fragments or aggregates.

Stability class	Criteria for assignment to stability class (for "Standard Characterization")
0	Soil too unstable to sample (falls through sieve).
1	**50 %** of structural integrity lost within **5 seconds** of insertion in water.
2	**50 %** of structural integrity lost **5 - 30 seconds** after insertion.
3	**50 %** of structural integrity lost **30 - 300 seconds** after insertion or **< 10 %** of soil remains on the sieve after 5 dipping cycles.
4	**10 - 25%** of soil remaining on sieve after 5 dipping cycles.
5	**25 - 75%** of soil remaining on sieve after 5 dipping cycles.
6	**75 - 100%** of soil remaining on sieve after 5 dipping cycles.

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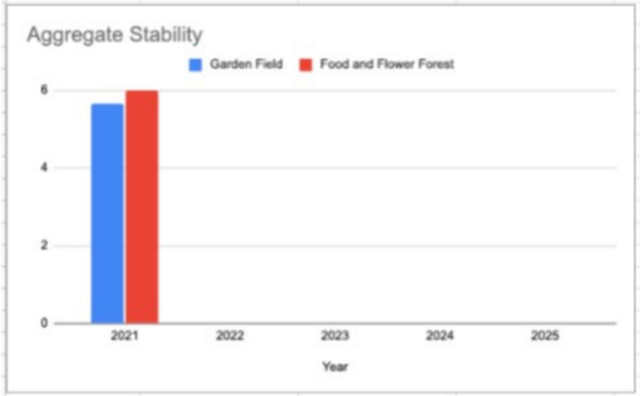
Aggregate Stability

Below is a sample recording of aggregate stability.

Date of Collection	Year	Monitoring Site Name	Observer	clod 1	clod 2	clod 3	clod 4	clod 5	clod 6
8/7/2021	2021	Garden Field	Jess	5	5	6	6	6	6
8/7/2021	2021	Food and Flower Forest I	Jess	6	6	6	6	6	6
	2022	Garden Field							
	2022	Food and Flower Forest	Field						
	2023	Garden Field							
	2023	Food and Flower Forest	Field						
	2024	Garden Field							
	2024	Food and Flower Forest	Field						
	2025	Garden Field							
	2025	Food and Flower Forest	Field						

Add new information in GREEN squares as you collect it - the graph will update automatically!



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Infiltration Rate

This should be measured as a baseline, and then it can be done every few years thereafter, unless any management changes occur.

NRCS Infiltration Rate Protocol ("Infiltration Test", n.d.):

1. Along each transect, randomly choose 1-2 locations, then set up the test 50 cm. from the transect towards the inside of the plot. Take a total of 3-5 replicates per plot. Record the distance to ensure that subsequent measurements aren't taken in the same place.
2. Record the date, transect, treatment, and location on the transect of the sample.
3. Clear the sampling area of surface residue. If the site is covered with vegetation, trim it as close to the soil surface as possible.
4. Install infiltration ring using a board and mallet to depth of 3 inches.
    a. If the soil contains rock fragments and the ring cannot be inserted to depth, gently push the ring into the soil until it hits a rock fragment. Measure the height from the soil surface to the top of the ring in centimeters (cm) and record.

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Infiltration Rate

NRCS Infiltration Rate Protocol, continued:

5. With the 6-inch diameter ring in place, use your finger to gently firm the soil surface around the inside edges of the ring to prevent extra seepage. Minimize disturbance to the rest of the soil inside the ring.
6. Line the soil surface inside the ring with a sheet of plastic wrap to completely cover the soil and ring. This procedure prevents disturbance to the soil surface when adding water.
7. Fill a plastic bottle or graduated cylinder to the 444 mL mark with distilled water. Pour the 444 mL of water (1" of water) into the ring lined with plastic wrap.
8. Remove the plastic wrap by gently pulling it out, leaving the water in the ring.
9. Note the time. Record the amount of time (in minutes) that it takes for the 1" of water to infiltrate the soil. Stop timing when the surface is just glistening. If the soil surface is uneven inside the ring, count the time until half of the surface is exposed and just glistening.

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Infiltration Rate

NRCS Infiltration Rate Protocol, continued:

10. Record the amount of time in minutes.
11. Repeat infiltration test in the same ring, with a second inch of water. 12. Record the number of minutes elapsed for the second infiltration measurement. If soil moisture is at or near field capacity, the second test is not necessary.
    a. The moisture content of the soil will affect the rate of infiltration; therefore, two infiltration tests are usually performed (if soil is dry). The first inch of water wets the soil, and the second inch gives a better estimate of the infiltration rate of the soil.

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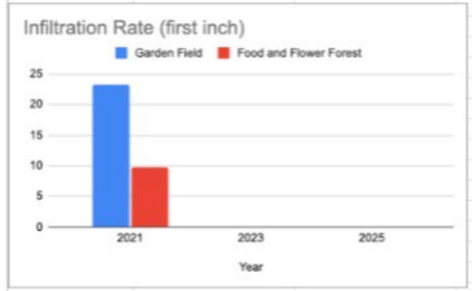
Infiltration Rate

Below is a sample recording of infiltration rate.

Date of Collection	Year	Monitoring Site Name	Observer	Time (min) for 1 inc	seconds for first inc	Min for 2nd inch	Sec for 2nd inch	Notes (indicate current moisture content)
8/7/2021	2021	Garden Field	T	29	1	not collected		
8/7/2021	2021	Garden Field	T	17	21	not collected		
8/7/2021	2021	Food and Flower Forest Fie	J	7	57	not collected		
8/7/2021	2021	Food and Flower Forest Fie	J	11	32	not collected		
	2023	Garden Field						Add information to GREEN squares. The graphs will update automatically!
	2023	Garden Field						
	2023	Food and Flower Forest Field						
	2023	Food and Flower Forest Field						
	2025	Garden Field						
	2025	Garden Field						
	2025	Food and Flower Forest Field						
	2025	Food and Flower Forest Field						



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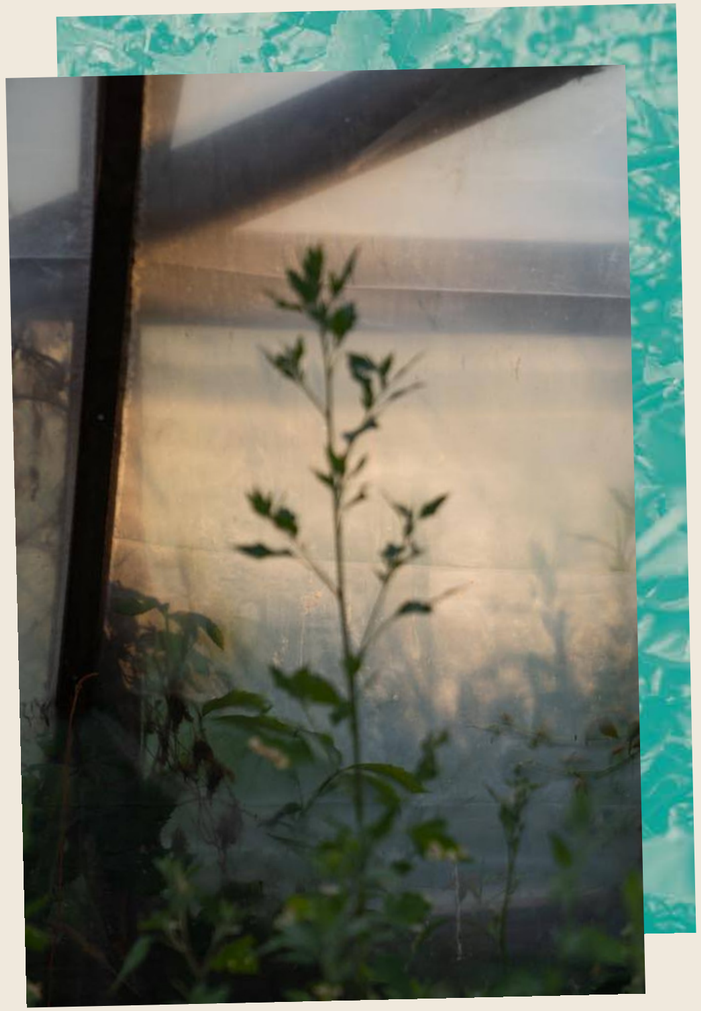
Vegetation Cover



This can be measured seasonally, annually, or more infrequently, depending on the steward's goals and the degree of management change.

It is recommended that this test be performed at the same time of year for better comparisons over time, given that some plant species are green and active early in the spring, while others are in monsoon season.

For rangeland, the line intercept transect method will provide more accurate data due to its tendency to be more spatially variant.

For irrigated pasture with fairly homogenous cover, the quadrat method is recommended.

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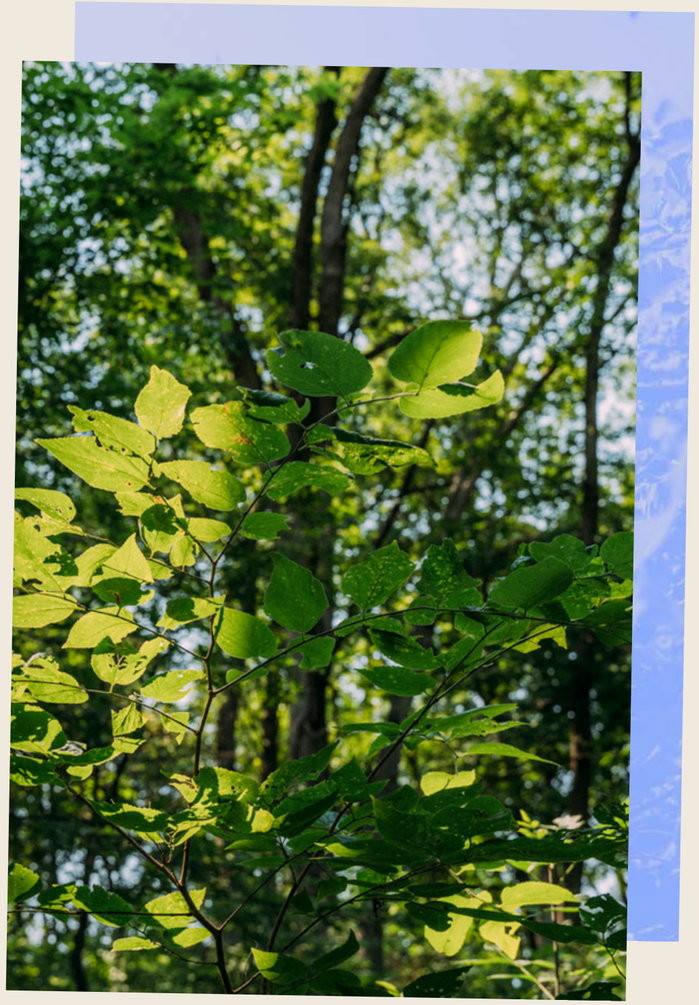
Vegetation Cover

TRANSECT METHOD

1. Each transect will have ~50 points, for a total of ~100 points for the entire plot. Pick an interval that is easy to remember (eg. 5 or 10)
2. Fill in every square of your datasheet. If there is no canopy layer, mark “none” or a dash so that you know that you didn’t forget to record it.
3. Use a thin dowel or stick placed vertically at the intercept point and determine what is at the ground plus height, and what is overhanging herbaceous, shrub, and canopy layer.
    a. Ground level can include categories such as loose soil, physical crust (no filaments), biocrust (has filaments), moss, lichen, fine litter (dead plant material, < 2.5cm in diameter), woody litter (>2.5cm in diameter), or plants with the plant bases at the intercept.



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Vegetation Cover

TRANSECT METHOD, CONT.

3. b. Plants can be defined either by species (which requires specialized knowledge) or by functional group, or a hybrid (see example on next slide).

Species may include:

- Grass (or grass-like, especially in riparian areas). Determining annual/perennial can be somewhat more difficult, but annual grasses tend to be less robust and don't form bunchgrass structures.
  - It can be helpful to specify seedlings compared to mature plants.
- Forb (herbaceous flowering plant). Given woodiness, you can assume it is perennial, and less robust structures can indicate an annual plant. If these criteria are of interest, be sure to mark them.
  - It can be helpful to specify seedlings compared to mature plants.
- Shrub (perennial, multi-stemmed, woody plant typically more than .5m and less than 4-5m.) Eg. creosote, rabbitbrush, saltbrush.
- Tree (woody, >4m when mature). Eg. Juniper, Pinyon, Ponderosa.

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Vegetation Cover

Below is an example datasheet for collecting vegetation cover data via the transect method.

	Ground (on soil surface)		**Herbaceous layer (up to 0.5m)**	**Shrub layer (o.5-4m)**	**Canopy layer (>4m)**
Distance (cm)	**ID**	**Height (cm)**			
0	SPORAB (Sporabolus spp.)	5	GUSA (snakeweed, Gutierrezia sarothrae)	LATRI (Creosote, Larrea tridentata)	-
50	LN (Lichen)	0	GUSA	-	-
100	B (bare ground)	0	-	-	-
150	L (litter)	0	-	ATCA (Saltbrush, Atriplex canescens)	
200	S (stone)				

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Vegetation Cover

QUADRAT METHOD

1. Locate the sampling plot using random sampling within the monitoring site.
2. Lay out the quadrat on the ground at the first sampling point you have chosen. Be careful not to step in the quadrat while laying it out.
3. For the ground layer, estimate percent bare ground, litter, stone cover, etc.
4. For the above ground layer, estimate what percent of the plot area each functional group (herbaceous, shrub, canopy) is covering (i.e. percent cover). Record the percent cover separately for each species on the datasheet.
5. Repeat steps 2–5 for each plot you are sampling.

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Vegetation Cover

Below is an example datasheet for collecting vegetation cover data via the quadrat method.

Clip Plot	Ground (on soil surface)	% Cover	Herbaceous	% Cover	Shrub	% Cover
1	L (litter)	5	GUSA (snakeweed, Gutierrezia sarothrae)	85	LATRI (Creosote, Larrea tridentata)	25
	B (bare ground)	25	SPORAB (Sporabolus spp.)	15	-	-
2						

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Clip Plots

This can be measured seasonally, annually, or less frequently. As with vegetation cover, it should be measured at similar times of year each time.

Clip Plot Protocol:

1. Choose 2-3 random locations throughout the monitoring site to take clippings.
2. Place the quadrat down and use scissors to clip to 1-2 cm above the ground, then place all standing green, living tissue in the bag. Discard any standing dead/brown tissue. Clip exactly what is in the lines of the clip plot, even if this means taking half a leaf/half a plant, etc.
3. Take samples back home and dry them in the oven for 20-30 minutes at 100 degrees F until all moisture has evaporated from the tissue. Use a small scale to weigh the dry plant biomass and subtract the weight of the bag. Record the mass in grams.
4. To calculate forage production from a 1.92 ft squared plot (1.386 ft x 1.386 ft) the conversion faction is:
5. Grams collected x 50 = pounds per acre.
6. If calculating from a different sized clip plot, reference this table for more conversation factors.

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Additional Resources

NRCS assessments for evaluating rangeland, pasture, and cropland health:

- Indicators of Rangeland Health Assessment
- Cropland In-Field Soil Health Assessment
- Pasture Condition Scoring Guide and Score Sheet

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References

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The End

Continue exploring tools for the second phase of our Regenerative Stewardship Curriculum, Develop, here.

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