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USDA LTAR Common Experiment measurement: Cropland plant diversity

 In 2 collections

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Brook J. Wilke¹, Elizabeth H. Boughton²

¹Michigan State University, W.K. Kellogg Biological Station, Hickory Corners, MI;

²Archbold Biological Station, Department of Agroecology, Lake Placid, FL



Lori J. Abendroth

USDA ARS Cropping Systems and Water Quality Research Unit



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We use this protocol and it's working

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Abstract

Couple this protocol with the *USDA LTAR Common Experiment measurement: Aboveground biomass* protocol to estimate plant species composition and abundance in LTAR Croplands Common Experiment plots and fields. Perform measurements by separating the destructive biomass sample by individual species (preferred) or visually assessing plant species in the sample area before destructive sampling.

Before start

Begin with the Aboveground Biomass protocol (Wilke et al., 2024), which outlines the process for destructively sampling plants from experimental plots and fields.

Preferred method - Separating sampled biomass by species

5d

- 1 **These steps describe the preferred method but users need to be aware it is more time-consuming compared to the alternate method described below.**
- 2 Sampling quadrat locations are based on random or preselected stations in each treatment replicate.
- 3 All plants rooted within the boundary of a sampling quadrat are hand-clipped at ground level (or slightly above the crown of perennial grasses) and sort according to species directly in the field while being clipped or later in the lab for samples stored at  4 °C .



Field technicians Holly Warren and Josh Gower collect alfalfa samples, part of the KBS LTER Main Cropping System Experiment. Photo Credit: K.Stepnitz, Michigan State University.

- 4 Place each species in its own labeled paper bag or envelope depending on the quantity of plant material.
- 5 Identify the plants to species and verify with a site-based plant reference collection.

- 6 Give species the codes (e.g., the USDA Plant database code) typically comprising the first three letters of the genus and the first two letters of the species for herbaceous species or the first three letters for woody species.
- 7 After removing all standing plant material from within the quadrat, collect the dead plant material remaining on the soil surface (surface litter). Combine and label as unsorted plant fragments that cannot be assigned to a species. After collecting dead plant material, identify and record the presence of any additional plant species that were too small to collect biomass for, but present in the plot.



Sorting plant samples in the KBS LTER field lab: K.Stepnitz, Michigan State University.

- 8 Dry all bags and envelopes containing plant material at  60 °C for 48 to 72 hours until a constant mass and weighed.
- 8.1 If drying space prohibits drying the whole sample, then a subsample will need to be dried to calculate dry biomass.
- 8.2 Weigh the entire sample fresh from the field, and then take a representative subsample of at least 500 grams. Weigh the subsample before drying at 60 C for 48-78 hours and weigh again after drying to generate fresh and dry weight biomass for the formula in Step 16 below.
- 9 Remove plant material from envelopes and 2 lb. bags for weighing. For 5 lb. bags or larger, place 10 paper bags of each size used in the oven along with plant material;





subtract the average dry weight of the bag size from the total weight of the plant samples to determine the plant biomass.

- 10 After recording biomass for each species, recombine all species within one quadrat for biomass processing, analysis, and archiving unless site-specific archiving protocols call for keeping species separate.

Alternate method - Percent cover by species within a quadrat

- 11 After laying the quadrat in the field, identify the species in the quadrat.
- 12 Estimate the canopy percent cover of each species rooted in the plot to the nearest 1% (Daubenmire 1959).
- 13 In addition, estimate percent cover for woody overstory, litter, bare soil, animal digging/disturbances, and rocks, if any.

Note

Total cover will typically exceed 100% because species cover is estimated independently for each species and if there are multiple vegetation layers. Use cardboard cut outs to facilitate percent cover estimation and use photos if the timing is short.

- 14 **Photograph the quadrat.** While standing in the middle of the south edge outside the quadrat, take a plane-view picture of the quadrat such that the subplot frame fills the photograph.

Note

If standing at the south edge is impossible, move to the west, north, and east edge in that order.

Covariate metrics to be sampled concurrently

- 15 The number of individuals for each species can be counted within the quadrat. This step is for crop plants only and optional for all other species. It is not required however for any of the calculations that follow, if users have either the percent cover of individual species or the weights of individual species.

Note

For some species in which separating individual plants is not possible (e.g., wheat individual plants have many tillers), count the number of reproductive stems instead.

Calculations

16 Aboveground biomass by species

If aboveground biomass is collected and separated by species, use the following calculations.

The target units are kg dry biomass/ha for each plant species. For each species:

- 16.1 This calculation is needed if a subsample is dried rather than the whole sample. Note that fresh weights are needed to properly calculate total dry weight.

Weight basis (g)

$\text{Total biomass}_{\text{DW}} = \text{Total biomass}_{\text{FW}} \times (\text{Subsample biomass}_{\text{DW}} / \text{Subsample biomass}_{\text{FW}})$

where DW = dry weight, and FW = fresh weight

16.2 Area basis (kg/ha)

$\text{Total biomass (kg/ha)} = \text{Total biomass}_{\text{DW}} \times (\text{## m}^2 \text{ sampling area}) \times 10$

where DW = dry weight, and FW = fresh weight

17 Percent cover by species

No additional calculations are necessary beyond measuring the percent cover for each species within a quadrat.

If desired, relativize species cover so that the cumulative cover of species is 1.

18 Plant diversity calculations

These metrics can be calculated if a measure of relative abundance of each species was collected (e.g. Relative percent cover, or Relative Biomass from Biomass sorting, or relative proportion of individuals from stem counting).

Species richness per plot = the number of species in a quadrat

Equation 1. Shannon diversity index

$$H' = -\sum_{i=1}^S p_i \ln p_i$$

where p_i = the proportion of individuals belonging to species i , and S = the number of species

Effective Shannon diversity per plot (Jost 2006) = effective Shannon diversity = $\exp(H')$. The number of equally common species required to give a particular value of an index is called the "effective number of species." This number is the true diversity of the community in question. For example, the true diversity associated with a Shannon–Wiener index of 4.5 is $\exp(4.5) = 90$ effective species.

If multiple plots are surveyed, estimate the degree of compositional heterogeneity using any beta diversity metric (Anderson et al. 2006, 2011).

Quality assessment and quality control

- 19 Maintain an appropriate plant reference collection to assist appropriate species identification. Train field staff on the appropriate methods for estimating percent cover (if used) and counting individual plants/reproductive stems for each species in the experiment.

Archiving

- 20 Keep the species separate or combined after drying and weighing for further processing and archiving.

See the Aboveground Biomass protocol for further information on archival practices. If possible to keep in an air conditioned environment with no excess humidity, that is recommended.

Recommendations for data collection

- 21 Table 1. Summary of recommendations for measuring Cropland Plant Diversity.

	A	B	C	D
	Attribute	Preferred	Minimum	Comments



	A	B	C	D
	Spatial scale	Both (field and plot)	Field or plot	Plots and fields may not be identical, so sampling both is preferred. However, if resources are limited, sampling one scale is better than none.
	Frequency	Maximum vegetative and reproductive biomass	Every crop harvest	Some crops are harvested annually (e.g., corn), while others may be harvested multiple times per year (e.g., alfalfa). Cover crops and weeds may also be present and sampled before termination prior to crop planting.
	Covariate metrics	Biomass by species or percent cover by species		This information allows us to calculate the Shannon Diversity index

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