**Soil Sampling**

Equipment and Supplies:

* Slide Hammer core samplers, note: while sampling check often that the threads are clean and that the connections are tight
* Sleeves for core sampler optional depending on soil moisture (if really dry you can re-use sleeves, core falls out; if really wet consider bringing extra sleeves)
* Dowel for pushing out cores
* Toothbrush (for cleaning corer)
* Plastic bags (sandwich size Ziploc bags hold 2x cores 10cm deep 1” diameter)
* Printed labels (including plot number, date, and site) for sticking onto bags in the field—though in wet weather printed paper labels are useless
* Sharpie
* Large shovel for digging for soil to fill in holes
* Buckets and small shovels (for filling holes)
* Flags labeled with date
* Coolers with ice
* Labeling tape (for repairing bags in field)
* Maps of site, marked with target plots

Steps:

1. Find spot away from plots and shovel soil into buckets for filling holes. Make sure to remove litter and plants from the soil before putting in bucket. Each team should have their own bucket and small shovel.
2. Before taking samples from plots, clear litter from area to be sampled.
3. Use hammer core sampler to take 2 soil cores from each plot.
4. Mark spot where samples were taken with flag.
5. Put both soil cores into the same labeled bag.
6. Place in cooler on ice.
7. Fill holes with soil from bucket.
8. Transport cooler with samples back to lab.
9. Put samples in cold room.

**Sieving**

Bulk density is the ratio of a soil core’s mass:volume (g/cm3). It is necessary to account for how much of that mass is moisture, using the wet/dry conversion factor that will come from the soil moisture. So don’t forget to record the fresh total core mass. Since we want the bulk density of the soil, not the other stuff that is in the soil, we need to sieve the soil and pick out the other stuff. From the known volume of the total core we need to account for this non-soil stuff, so we need the mass and volume of these in addition to the soil so we can subtract them from the total core. Also, if you are interested in measuring belowground biomass, sort the stuff into two piles: live roots and everything else. Differentiating between live and dead roots is best learned from an experienced root picker in person.

Equipment and Supplies:

* No. 4 (4.75mm) sieves
* Brushes for cleaning sieves
* Clean towels for drying sieves / otherwise you use a ton of paper towels
* Cooler with ice for holding samples not being sieved
* Tweezers for picking out smaller debris
* Labeled coin envelopes, 2 per sample for holding live roots and debris. Labeled with plot number and “roots” or “debris.” Wrapping wet roots and debris in foil is helpful
* Large plastic weigh boats (or some other shallow dish) for rinsing roots twice (in two separate baths of DI water)
* Aluminum foil to fold a packet for the roots and debris inside of coin envelopes (helps prevent roots and debris from sticking to the inside of the envelope; one edge of foil packet should be left open to allow moisture to escape)
* Beakers with DI water for washing dirt off roots and debris
* Data sheet (columns: plot number, wet weight of total core pre-sieved, root volume, root mass, debris volume, debris mass).
* Graduated cylinders (sizes depend on amount of roots and debris and soil core size; for our collection of 1” x 10cm cores we use a 5 mL grad. cylinder with 0.1mL graduations and a 10mL grad. cylinder with 0.5mL graduations)
* DI water
* forceps

Steps:

1. If your soil is in the USDA fire ant quarantine zone, remember to handle soil waste appropriately. See the Field Guide to the Wright lab above the sink.
2. Weigh soil collected (including bag—measure a few empty bags to average and subtract from each sample).
3. Sieve soils. Pick out smaller debris (roots, rocks, etc.). This can be done before or after pushing soil through the sieve. Picking out roots before pushing them through the sieve means less get tangles up in the mesh. Put roots in a rinse bath (weigh boat with water), and once finished sieving, put all the roots in another fresh bath to further remove more soil. Put the debris in another bath.
4. Put sieved soils back into labeled plastic bags. Keep on ice. Try to minimize time soil bags are open and not on ice.
5. Fill graduated cylinder (use smallest volume cylinder as possible for more precision) with DI water part-way and note the volume.
6. Remove the roots from the bath, pat dry with a paper towel and submerge in the water in the grad. cylinder. Record the new volume. The new volume – initial volume = volume of the roots. Record on datasheet.
7. Pat-dry the roots with a paper towel and wrap in a pocket of foil and put in a labeled envelope (plot number and “roots”). Put these in the drying oven to be weighed once they are dry (after at least 24h in the oven). The foil keeps the roots from sticking to the paper as they dry.
8. Dump the water into a collecting bucket and rinse the grad. cylinder with DI before re-using.
9. Repeat this process for the debris bath. Remember to label the envelope with plot number and “debris.”
10. Rinse and scrub sieves and pans into a bucket to prevent clogging the drain, between each sample.
11. Sieves and pans can be washed with a low-nutrient soap like Liquinox. Be sure to rinse and dry thoroughly. Water sitting on the metal will corrode it.

**Belowground biomass, soil moisture, bulk density & soil organic matter**

* Calibrated balance with at least 3 decimal places
* Aluminum weigh boats
* Drying oven
* Muffle furnace
* Desiccator (glass preferable, good seal, and fresh desiccant / Dry Rite)
	1. After the roots have been in the drying oven for at least 24 h at 100-110˚C, weigh the roots. This is **belowground biomass** per unit area (surface area cored).
	2. Emboss the sample number on an aluminum weigh boat using a ball point pen. Weigh out 10-15 g of sieved soil into the aluminum weigh boat. Note the mass of the boat and the soil.
	3. Put these into the drying oven for at least 24 h at 100-110˚C, and re-weigh. At this point you can calculate % soil moisture (see below).  *Do not throw away these samples if you want to measure soil organic matter!*
	4. Put the oven-dried soils in the muffle furnace, be sure to turn the fume hood on anytime you use the muffle furnace. Set the muffle furnace to 360˚C\*\*. It takes about 15 min. for the furnace to get up to temp, so after 2h 15 min, turn off the muffle furnace.
	5. Open the muffle furnace door for 1-2 min to release some heat before you use heat protection gloves and tongs to carefully remove each tin and place it in a desiccator to cool for about 30 min.
	6. Weigh the tins in small batches, you will most likely be able to see the mass increasing slowly as the sample takes on moisture since it is much drier than the lab air. So minimize the amount of time the tin is sitting out on the bench before it gets weighed.

\*\*See Salehi et al 2011—citation below.

Calculations:

**% Soil Moisture** = ((mass of fresh soil - mass of oven-dried soil) / mass of fresh soil)\*100

Bulk density = First, calculate the oven dried mass of the total soil sample (entire bag) by multiplying the total fresh mass by the ratio: g oven dried subsample / g wet subsample = wet:dry ratio …multiplying this by the total fresh mass will give you the amount of dry soil in that entire bag.

Then subtract the mass of the dried roots and debris from the calculated total dry weight (previous step) to get g dry soil. Similarly, subtract the volume of the roots and debris from the total core volume to get cm3 soil. The total core volume is calculated based on the dimensions of the corer and depth of core. Remember that 1cm3 = 1mL. Double these dimensions if the original sample was two (or more) cores in one bag.

Calculate **bulk density (g/cm3)** by dividing the g dry soil by the cm3 soil. Bulk density normally ranges from 1.0-1.4 g/cm3 (can be 0.6-1.8)

**% soil organic matter (SOM)** = (mass oven dried subsample – mass muffled subsample) / (mass oven dried subsample) …be sure to subtract the mass of the weighboat from each.

For more information see:

Elliott, E. T., J. W. Heil, E. F. Kelly, and H. C. Monger. 1999. Soil structural and other physical properties. in Robertson, G. P., D. C. Coleman, C. S. Bledsoe, and P. Sollins. Standard Soil Methods for Long-Term Ecological Research. Oxford University Press. pp 74-85.

Salehi, M. H., O. Hashemi Beni, H. Beiji Harchegani, I. Esfandiarpour Borujeni and H. R. Motaghian. 2011. Pedosphere 21(4): 473-482. Refining soil organic matter determination by loss-on-ignition.

Storer, D. A. 1984. A simple high sample volume ashing procedure for determination of soil organic matter. Commun. In Soil Sci. Plant Anal. 15(7): 759-772.