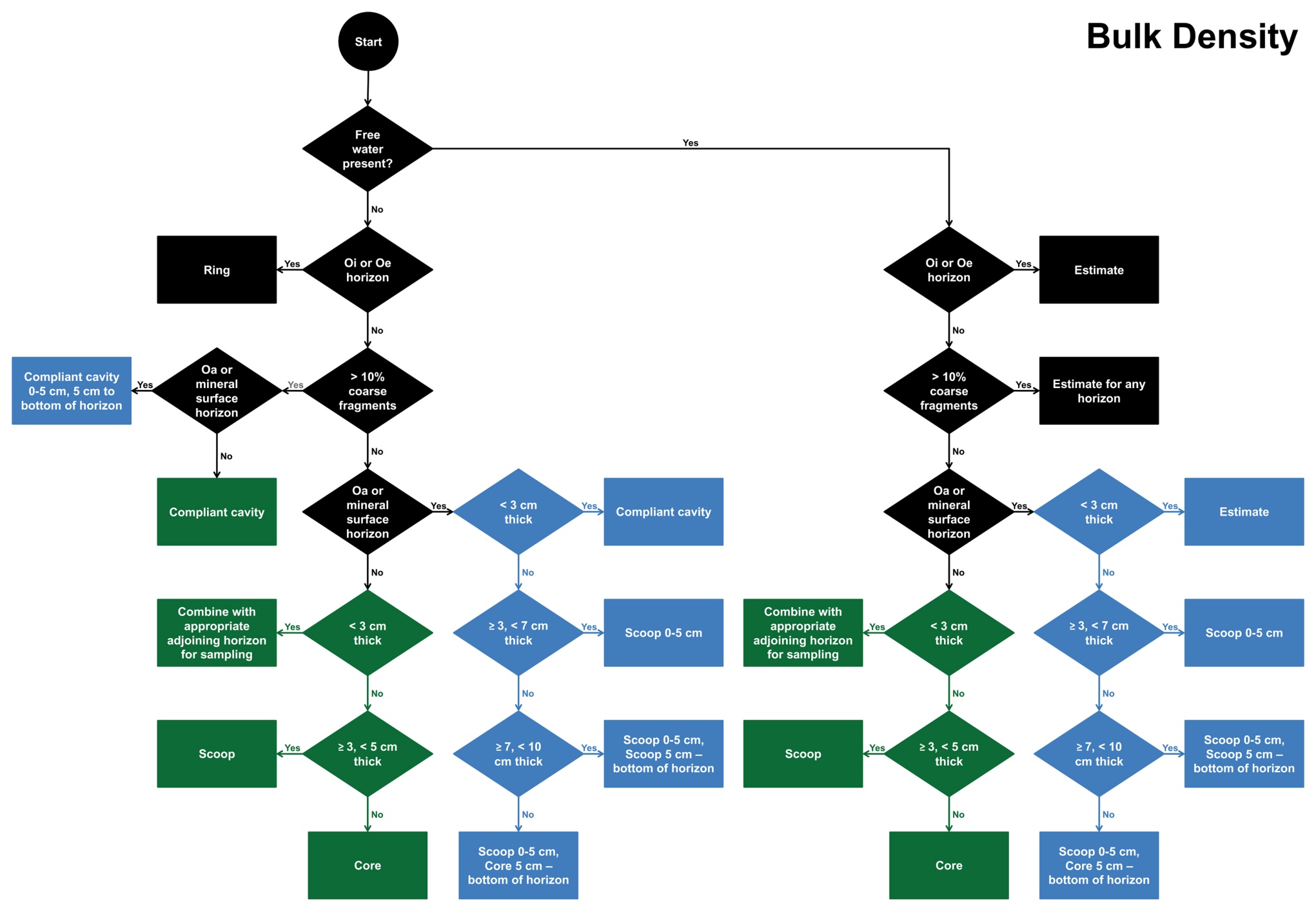
****

**Bulk Density (Db) Data and Sample Collection (choose method with flow-chart)**

1. As Samples are collected fill out the “Bulk Density Information” form (field names are underlined)
   1. Record horizon designation and the upper and lower boundary for the horizon from which the sample was taken (the entire horizon may not have been sampled, but the results will be applied to the entire horizon)
   2. Record Bulk Density Method Used
   3. Record Information in the appropriate spaces for the method used

**Bulk Density Methods**

**Soil Scoop**

* 1. Optional method; For Horizons 5 cm thick only
     1. Line up the top of the scoop with the horizon surface
     2. Prepare pit face so that there is flat wall and surface.
     3. Insert into side of pit wall until back is flush with pit face
     4. Cut vertically in front of scoop edge then remove scoop
     5. Trim material extending over the edge of the scoop (use angle to trim to avoid disrupting the sample)
     6. Record Variable Volume Core / Scoop 1st depth – 4th depth as 0.
  2. For Horizons <5 cm thick
     1. Line up the bottom of the scoop with the bottom of the horizon
     2. Prepare pit face so that there is flat wall and surface.
     3. Insert into side of pit wall until back is flush with pit face
     4. Cut vertically in front of scoop edge then remove scoop
     5. Trim material extending over the edge of the scoop (use angle to trim to avoid disrupting the sample)
     6. Measure the distance from the top of the scoop to the top of the sampled soil in 4 representative places
     7. Record as : Variable Volume Core / Scoop 1st – 4th depth

1. **Compliant Cavity**
   1. Place foam donut on ground and cover with rigid ring (130 mm inside diameter). Mount the assembly on the soil surface by securely driving threaded rods (being careful not to damage the threads) into the ground through holes in ring and by tightening ring with wing nuts.
   2. Line cavity with ½ mil plastic. Fill cavity to the upper surface of the rigid ring with millet. Strike off excess millet with a straight edge and return excess to storage container.
   3. Remove plastic film and millet. Measure the volume of millet in the graduated cylinder. This volume (Vd) is the measurement of cavity volume prior to excavation (dead space). Record this as Initial Vol on the form to the nearest 5 ml.
   4. Excavate soil from inside the cylindrical form to required depth, place in a labeled bag, and seal. Line the cavity with ½ mil plastic film. Fill the cavity with millet to the top of the rigid ring. Strike off excess millet. Measure the volume of millet. This is the Final Vol on the form to the nearest 5 ml.

\*The volume is the measurement of excavated soil and empty space. The difference between the two millet volumes (Final Vol – Initial Vol) is the volume of excavated soil.

1. **Ring Excavation**
   1. Place a 25.4 cm diameter plastic ring on the soil surface.
   2. Drive three sharpened rods into the soil, equally spaced around the outside of the ring. Drive the rods at a distance from the ring such that the washers under the wing nuts on the pins just touch the top surface of the ring. Press the ring down lightly, and tighten the wing nuts enough to prevent the ring from shifting.
   3. Line the ring with the ½ mil plastic, fill with millet, and strike off the excess above the upper surface of the ring. Pour the millet in the ring into the graduated cylinder and measure its volume. You may have more than one cylinder full. Record the total millet volume as Initial Vol to the nearest 5 ml.
   4. Excavate soil to the desired depth. Place the soil in a labeled bag and seal it.
   5. Line the ring with the ½ mil plastic, fill with millet, and strike off the excess above the upper surface of the ring. Pour the millet in the ring into the graduated cylinder and measure its volume. You may have more than one cylinder full. Record the total millet volume as Final Vol to the nearest 5 ml.
2. **Frame Excavation**
   1. Assemble wooden frame and place on ground surface
   2. Use plastic plate and tool to measure the distance to the soil surface at ~40 regularly spaced intervals
   3. Determine average depth and multiply \* 1000 – this is your Initial Vol in the bulk density worksheet.
   4. Excavate soil to desired depth. Place soil in a labeled bag and seal. (include coarse fragments <20mm and note the volume of any larger fragments).
   5. Repeat measurements of distance to new exposed surface.
   6. Determine the average depth and multiply by 1000 – this is your Final Vol

\*The volume is the measurement of excavated soil and empty space. The difference between the two distance (Final Vol – Initial Vol) is the volume of excavated soil and is equivalent to using the difference in distance measured \* 1000 g cm-3.

1. **Soil Cores**
   1. Variable volume core (VVC) refers to a partially filled core, the volume of the sample will vary depending on the sample. Constant volume core (CVC) refers to a core that is completely filled and will have the same volume of sample every time it is filled. A core taken with a hydraulic probe is considered constant volume as the core is always completely full.
   2. Record core length (VVC Len) and diameter (VVC Diam), to the nearest tenth of a cm (one decimal place), above point one on the Bulk Density Information Form. The measurements should be checked periodically, after maintenance (edge sharpening) or at any time damage occurs to the core.
   3. Prepare flat surface, either horizontal or vertical, at required depth in sampling pit.
   4. Press or drive core sampler into soil. If a hammer is required, place a wood block on top of the core tube before striking it. Strike squarely on wood block.
   5. Remove the core from the soil by digging out beside it and cutting the soil in front of the core cutting edge so excess soil in front of the core is still attached.
   6. Trim protruding soil flush with ends of cylinder.
   7. If the core is full, Record the diameter and length under “CVC / hydraulic probe”
   8. If the core is not full, place a straight edge across the top of the core and measure and record the depth from the straight edge to the soil surface in four representative locations Variable Volume Core / Scoop 1st depth – 4th depth to the nearest tenth of a cm.
   9. Place the entire soil sample in a labeled bag and seal air-tight.

**Label, Transport and Store Samples in Field Office Lab**

Place the entire soil sample in a labeled bag and seal air-tight. Consider placing the first bag inside another bag to minimize chance of spilling or tearing

Minimum Label:

1. DSP Plot ID
2. User Pedon ID
3. Layer/sample Sequence
4. Horizon Designation
5. Horizon/Layer Depths

For example, the surface sample (Ap) from the first point/pedon of plot 1 of K-RP should have the following on the label:

**K-RP-1**

**S2004WA027009**

**1**

**Ap**

**0 – 5 cm**

This step will be carried out according to the logistical constraints of each field office lab. The goal is to store samples at the field moisture content (as sampled) until they can be weighed

**Field Office Lab Analysis: Sample Processing and Data Entry**

*Note 1: For all weights taken in the procedure, record to at least one decimal place; two places is preferred.*

*Note 2: In this document, spreadsheet data element names are indicated by angle brackets (<>) around the name.*

1. Ensure layers are entered in <Bulk Density Worksheet>
2. Weigh Field Moist Samples
   1. Tare balance with tray or weight boat
   2. Completely empty bag in tray
   3. Record weight in <Moist Wt>
3. **Air Dry Sample** 
   1. **Place on tray or plate and cover loosely**
4. **Weigh Air Dry Sample**
   1. Tare balance with tray or weight boat
   2. Completely empty bag in tray
   3. Record weight in < Air Dry Wt Wt>
5. **Sieve**
   1. Crush the sample with a rolling pin, rubber or wood wheel, or large pipe roller. Unless you are positive the sample contains no coarse fragments, do not use a mortar and pestle or mechanical crusher.
   2. Sieve the sample through a 2 mm square hole sieve. Transfer the sample that has passed through the sieve back to its original sample bag.
6. **Weigh Coarse Fragments**
   1. Tare balance with tray or weight boat
   2. Completely empty all fragments retained on sieve into tray
   3. Record weight in < C frag wt>
7. **Oven Dry Sub-samples**
   1. Record an aluminum pan number for each sample in **<Pan ID>** column.

NOTE: the pan should be embossed with a permanent mark (such as with a sharpie)

* 1. Weight empty pan <Pan Wt>
  2. Stir the < 2mm sample in the bag so that larger and smaller particles are mixed. This can be done by stirring with a scoop or spatula.
  3. After mixing, transfer ~30-40 g of sample to the weighing pan, weigh, and record **<Subsample, Air dry + pan wt>**. If the sample has high organic matter, fill the pan level for maximum mass.
  4. Place the weighing pan(s) in a 110+/- 5°C oven for 12-16 hours.
  5. Weigh the numbered weighing pan(s) and sample(s) as soon as they have cooled, and record **<Subsample, Oven dry + pan wt>**, approximately 10 min after removing from the drying oven.

*Note: Do not allow to stand at room temperature for longer than that, to prevent the samples from “rewetting” or reabsorbing moisture in ambient air.*

1. Complete Bulk Density Calculation
   1. Check that values are realistic.
   2. Check Field and SSO lab entry fields for transcription errors.
2. Import Data to NASIS

**Appendix: Bulk Density (Db) Methods**

**Soil Scoop**

**Modified from Rapid Carbon Assessment Protocols**

**Application**

Bulk density by the scoop method offers the opportunity to obtain bulk density information without the expense incurred to obtain water retention. The sides of the scoop can be used as a gauge for collecting a standard 0-5 cm surface sample for bulk density. Field-state bulk density by the scoop method is particularly useful if the soil layers are at or above field capacity and/or the soils have low extensibility (shrink-swell) and do not exhibit desiccation cracks even if below field capacity.

**Summary of Method**

A metal scoop is pressed or driven into the soil. The scoop is removed, extracting a sample of known volume. The moist sample weight is recorded. The sample is then dried in an oven and weighed.

**Interferences**

Rock fragments and large roots in the soil interfere with sample collection. Dry or hard soils often shatter when the scoop is hammered into the soil. Pressing the scoop into the soil reduces the risk of shattering the sample. If soil cracks are present, select the sampling area so that crack space is representative of the sample, if possible. If this is not possible, make measurements between the cracks and determine the aerial percentage of total cracks or of cracks in specimen.

**Safety**

Be careful when using an oven. Avoid touching hot surfaces and materials. Follow standard field and laboratory safety precautions.

**Equipment**

1. Four mil 15.2 X 22.9 cm air-tight plastic bags
2. Marking pen to label bags
3. Electronic balance, ±0. 1-g sensitivity.
4. Sieve, No. 10 (2 mm-openings)
5. Metal scoop – the base is 10 cm X 10 cm. The sides are 5 cm high. The material is 1.59 mm steel, folded to shape. A 3.17 mm steel plate is welded to the back to strengthen the scoop if it is hammered into the soil. The cutting edge of the bottom and sides is sharpened from the outside.
6. Wood block
7. Hammer
8. Weighing pan, aluminum, 50.8 mm diameter, 15.9 mm depth
9. Oven, 110 ±5 °C
10. First-aid kit

**Reagents**

None.

**Procedure**

1. Prepare flat vertical surface, at required depth in sampling pit. The sampling area must be excavated to the top of the layer to be sampled, with the top of the layer relatively smooth. Record scoop volume.
2. Press or drive scoop into soil. Use a wood block against the back of the scoop if driving with a hammer or pressing with a jack. Maintain horizontal travel as the scoop advances into the soil. The sides of the scoop can be used as a gauge. Cut the soil along the front of the scoop after the scoop has been pushed into the soil to the full 10 cm distance. If the layer sampled is less than the full 5 cm height of the walls, place a straight edge across the top of the scoop and measure and record the distance from the straight edge to the soil surface in four representative locations. Remove the sample from the scoop, and place in air-tight labeled bag for transport to laboratory.
3. At the laboratory, weigh the bag on a balance tared with a similar bag.
4. Air dry the core. Break it up for faster drying.
5. Weigh the air dry sample.
6. Crush the fine earth portion of the air dry sample and pass it through a 2 mm sieve. Weigh the sieved sample.
7. Weigh the coarse fragments, determine their density, and discard.
8. Tare a weighing pan on a balance. Add ~50 g of air dry soil to it. Record the soil weight.
9. Dry the weighing pan of air dry soil in oven at 110 °C until weight is constant.
10. Remove the pan from the oven, and weigh as soon as it is cool on a balance tared with a weighing pan.

**Calculations**

ODW = ADW/(ADS/ODS)

Db = ODW/[SV - (RF/PD)]

Where:

ODW = Oven-dry weight of the <2 mm fraction

ADW = Air dry weight of the <2 mm fraction

ADS = Air dry weight of the sub-sample

ODS = Oven dry weight of the sub-sample

Db = Bulk density of <2-mm fabric at sampled field water state (g cm-3)

RF = Weight of rock fragments

SV = Soil volume – is scoop volume for 5 cm thick sample. It is scoop volume – 100\*(avg of four measurements from soil surface to scoop top) if scoop is not full.

PD = Density of rock fragments

**Compliant Cavity**

**After Grossman and Reinsch (2002) and Soil Survey Staff (2014)**

**Application**

Compliant cavity method (Grossman and Reinsch, 2002) is useful for fragile cultivated near-surface layers or layers with appreciable amounts of coarse fragments. This method has the important advantage that it is not necessary to flatten the ground surface or remove irregularities, i.e., the surficial zone is usually not altered (Grossman and Reinsch, 2002). The procedure described herein is after Grossman and Reinsch (2002) and the Soil Survey Staff (2004, method 3B3a), modified for the Rapid Carbon Assessment project.

**Summary of Method**

By this procedure, the cavity volume on the zone surface is lined with thin plastic and small rounded objects are added to a datum level. Soil is quantitatively excavated in a cylindrical form to the required depth. The difference between the initial volume and that after excavation is the sample volume. The excavated soil is dried in an oven and then weighed. A correction is made for the weight and volume of rock fragments.

**Interferences**

Bulk density by compliant cavity can not be determined if free water is present in the hole.

**Safety**

Be careful when using an oven. Avoid touching hot surfaces and materials. Follow standard laboratory and field safety precautions. **Equipment**

1. Fabricated Plexiglass rings, 9 mm thick, 130 mm inside diameter, and >200 mm outside diameter. Make three 16 mm diameter holes that are 10 mm from the outer edge of ring. Position holes equidistant apart.
2. Make 50 mm thick foam rings from flexible polyurethane with an "Initial Load Displacement" of 15 to 18 kg. Foam rings have the same inside diameter as the Plexiglass rings.
3. Use wing nuts and three, 380 mm long, 10 to 13 mm diameter, threaded rods to mount and position the compliant cavity. Sharpen the rods. Place two regular nuts at the end of threaded rod to increase the area of surface struck.
4. Plastic film, ½ mil, 380 mm to 460 mm wide
5. Four mil 15.2 X 22.9 cm air-tight plastic bags
6. Millet grain
7. Funnel, plastic, 25.4 cm
8. Marking pen to label bags
9. Graduated cylinder, plastic, 1000 mL
10. Kitchen knife, small
11. Scissors, small, to cut fine roots
12. Hacksaw blade to cut large roots
13. Straight edge, at least 15 cm long
14. Weights for plastic film
15. Clothespins. If wind, use clothespins for corners of plastic film.
16. Hard rubber or plastic mallet
17. Weighing pan, aluminum, 50.8 mm diameter, 15.9 mm depth
18. Sieve, square-hole, 10 mesh, 2 mm
19. Oven, 110 ±5 °C.
20. First-aid kit

**Procedure**

1. Place ring of plastic foam on ground and cover with rigid ring (130 mm inside diameter). Mount the assembly on the soil surface by securely driving threaded rods into the ground through holes in ring and by tightening ring with wing nuts.
2. Line cavity with ½ mil plastic. Fill cavity to the upper surface of the rigid ring with millet. Strike off excess millet with a straight edge.
3. Remove plastic film and millet. Measure the volume of millet in the graduated cylinder (nearest 5 ml). This volume (Vd) is the measurement of cavity volume prior to excavation (dead space).
4. Excavate soil quantitatively and in a cylindrical form to required depth, place in a labeled bag, and seal. Line the cavity with ½ mil plastic film. Fill the cavity with millet to the top of the rigid ring. Strike off excess millet. Measure the volume of millet (nearest 5 ml). This volume (Vf) is the measurement of excavated soil and dead space. The difference between the two millet volumes (Vf - Vd) is the volume of excavated soil (Ve).
5. At the laboratory, weigh the bag on a balance tared with a similar bag.
6. Air dry the sample. Break it up for faster drying.
7. Weigh the air dry sample.
8. Crush the fine earth portion of the air dry sample and pass it through a 2 mm sieve. Weigh the sieved sample.
9. Weigh the coarse fragments, determine their density, and discard.
10. Tare a weighing pan on a balance. Add ~50 g of air dry soil to it. Record the soil weight.
11. Dry the weighing pan of air dry soil in oven at 110 °C until weight is constant.
12. Remove the pan from the oven, and weigh as soon as it is cool on a balance tared with a weighing pan.
13. Compute bulk density. Weight of macroscopic vegetal material (g cm-3) also may be reported.

**Calculations**

Ve = Vf - Vd

where:

Ve = Excavation volume of whole soil

Vf = Millet volume measurement of excavated soil and dead space (cc)

Vd = Millet volume measurement of dead space (cc)

ODW = ADW/(ADS/ODS)

where:

ODW = Oven-dry weight of <2 mm soil (g)

ADW = Air dry weight of the <2 mm fraction

ADS = Air dry weight of the sub-sample

ODS = Oven dry weight of the sub-sample

Db = ODW/[Ve - (RF/PD)]

where:

Db = density of <2-mm fabric at sampled field water state (g cm-3)

ODW = Oven-dry weight of <2-mm soil (g)

Ve = Excavation volume of whole soil (cm-3)

RF = Weight of rock fragments

PD = Density of rock fragments

**Report**

Bulk density is reported to the nearest 0.01 g cm-3 (g cc-1).

**Ring Excavation**

**After Grossman and Reinsch (2002) Soil Survey Staff (2004)**

**Modified for the Rapid Carbon Assessment Project**

**Application**

Ring excavation (Grossman and Reinsch, 2002) is a robust, simple, and rapid procedure that is good where local variability is large. The diameter can range down to 15 cm and upwards to 30 cm or more. It is not necessary to excavate from the whole area within the ring. A limit of 2 cm on the minimum thickness of the sample should be considered. The procedure described herein is after Grossman and Reinsch (2002) and the Soil Survey Staff (2004, method 3B4a), modified for the Rapid Carbon Assessment project.

**Summary of Method**

A 25.3 cm ID ring is placed on the ground and fastened with three pins driven into the soil. The ring is lined with ½ mil plastic and filled to the upper ring surface with small spherical objects. The volume of the filler material is determined. The soil is excavated to the desired depth, and the cavity is again lined with plastic film and filled to the upper ring surface. The volume of the filler material is again determined. The change in volume is calculated. This is the volume of soil excavated. The excavated soil is weighed field moist and air dry, and the air-dry/oven-dry ratio is calculated. If rock fragments are present, the weight and volume of >2-mm material in sample are corrected and bulk density computed. Bulk density of soil is reported in g cm-3.

**Interferences**

The method can not be used if free water is present in the excavated hole.

**Safety**

Be careful when using an oven. Avoid touching hot surfaces and materials. Follow standard field and laboratory safety precautions.

**Equipment**

1. Four mil 15.2 X 22.9 cm air-tight plastic bags
2. Marking pen to label bags
3. Electronic balance, ±0.1-g sensitivity
4. Weighing pan, aluminum, 50.8 mm diameter, 15.9 mm depth
5. Plastic cylinder, 25.3 cm diameter, 4.4 cm high
6. Steel pins, sharpened, 38 cm long, with wing nuts and washers
7. Plastic film, ½ mil, 458 mm wide
8. Millet grain
9. Graduated cylinder, plastic, 1000 ml
10. Straight edged tool or ruler at least 30 cm long
11. Plastic funnel, 25.4 cm diameter
12. Hand digging equipment
13. Sieve, No. 10 (2 mm-openings)
14. Oven, 110 ±5 °C
15. First-aid kit

**Reagents**

None.

**Procedure**

1. Place a 25.4 cm diameter plastic ring on the soil surface.
2. Drive three sharpened rods into the soil, equally spaced around the outside of the ring. Drive the rods at a distance from the ring such that the washers under the wing nuts on the pins just touch the top surface of the ring. Press the ring down lightly, and tighten the wing nuts enough to prevent the ring from shifting.
3. Line the ring with the ½ mil plastic, fill with millet, and strike off the excess above the upper surface of the ring. Pour the millet in the ring into the graduated cylinder and measure its volume (nearest 5 ml). You may have more than one cylinder full.
4. Excavate soil to the desired depth. Place the soil in a labeled bag and seal it.
5. Line the ring with the ½ mil plastic, fill with millet, and strike off the excess above the upper surface of the ring. Pour the millet in the ring into the graduated cylinder and measure its volume (nearest 5 ml). You may have more than one cylinder full.
6. Calculate the change in volume on removal of the soil (Ve).
7. At the laboratory, weigh the bag on a balance tared with a similar bag.
8. Air dry the sample. Break it up for faster drying.
9. Weigh the air dry sample.
10. Crush the fine earth portion of the air dry sample and pass it through a 2 mm sieve. Weigh the sieved sample.
11. Weigh the coarse fragments, determine their density, and discard.
12. Tare a weighing pan on a balance. Add ~50 g of air dry soil to it. Record the soil weight.
13. Dry the weighing pan of air dry soil in oven at 110 °C until weight is constant.
14. Remove the pan from the oven, and weigh as soon as it is cool on a balance tared with a weighing pan.
15. Compute bulk density. Weight of macroscopic vegetal material (g cm-3) also may be reported.

**Calculations**

ODW = ADW/(ADS/ODS)

where:

ODW = Oven-dry weight of <2 mm soil (g)

ADW = Air dry weight of the <2 mm fraction

ADS = Air dry weight of the sub-sample

ODS = Oven dry weight of the sub-sample

Db = ODW/[Ve - (RF/PD)]

where:

Db = density of <2-mm fabric at sampled field water state (g cm-3)

ODW = Oven-dry weight of <2-mm soil (g)

Ve = Excavation volume of whole soil (cm-3)

RF = Weight of rock fragments

PD = Density of rock fragments

**Report**

Bulk density is reported to the nearest 0.01 g cm-3 (g cc-1).

**Soil Cores**

**After Soil Survey Staff (2004)**

**Modified for Rapid Carbon Assessment Project**

**Application**

Bulk density by the core method offers the opportunity to obtain bulk density information without the expense incurred to obtain water retention. Field-state bulk density by the core method is particularly useful if the soil layers are at or above field capacity and/or the soils have low extensibility (shrink-swell) and do not exhibit desiccation cracks even if below field capacity. This method is not intended for weak or loose soil material, or material with an appreciable amount of coarse fragments. The procedure described herein is after the Soil Survey Staff (2004, method 3B6a), modified for the Rapid Carbon Assessment project.

**Summary of Method**

A metal cylinder is pressed or driven into the soil. The cylinder is removed, extracting a sample of known volume. The moist sample weight is recorded. The sample is then dried in an oven and weighed.

**Interferences**

During the coring process, compaction of the sample is a common problem. Compression can be observed by comparing the soil elevation inside the cylinder with the original soil surface outside the cylinder. If compression is excessive, the soil core may not be a valid sample for analysis. Rock fragments in the soil interfere with core collection. Dry or hard soils often shatter when the cylinder is hammered into the soil. Pressing the cylinder into the soil reduces the risk of shattering the sample. If soil cracks are present, select the sampling area so that crack space is representative of the sample, if possible. If this is not possible, make measurements between the cracks and determine the aerial percentage of total cracks or of cracks in specimen.

**Safety**

Be careful when using oven or microwave. Avoid touching hot surfaces and materials. Follow standard field and laboratory safety precautions.

**Equipment**

1. Four mil 15.2 X 22.9 cm air-tight plastic bags
2. Marking pen to label bags
3. Electronic balance, ±0.1-g sensitivity
4. Sieve, No. 10 (2 mm-openings)
5. Weighing pan, aluminum, 50.8 mm diameter, 15.9 mm depth
6. Steel core ring, 7.6 cm ID, 7.6 cm long, 1.6 mm thick wall
7. Wood block
8. Hammer
9. Oven, 110 ±5 °C
10. First-aid kit

**Procedure**

1. Prepare flat surface, either horizontal or vertical, at required depth in sampling pit. Record the core dimensions.
2. Press or drive core sampler into soil. If a hammer is required, place a wood block on top of the core tube before striking it. Remove the core from the soil by digging out beside it and cutting the soil in front of the core cutting edge so excess soil in front of the core is still attached. Trim protruding soil flush with ends of cylinder. If the core is not full, place a straight edge across the top of the core and measure and record the distance from the straight edge to the soil surface in four representative locations. Place the soil sample in a labeled bag and seal air-tight.
3. At the laboratory, weigh the bag on a balance tared with a similar bag.
4. Air dry the core. Break it up for faster drying.
5. Weigh the air dry sample.
6. Crush the fine earth portion of the air dry sample and pass it through a 2 mm sieve. Weigh the sieved sample.
7. Weigh the coarse fragments, determine their density, and discard.
8. Tare a weighing pan on a balance. Add ~50 g of air dry soil to it. Record the soil weight.
9. Dry the weighing pan of air dry soil in oven at 110 °C until weight is constant.
10. Remove the pan from the oven, and weigh as soon as it is cool on a balance tared with a weighing pan.

**Calculations**

ODW = ADW/(ADS/ODS)

Db = ODW/[SV - (RF/PD)]

where:

ODW = Oven-dry weight of the <2 mm fraction

ADW = Air dry weight of the <2 mm fraction

ADS = Air dry weight of the sub-sample

ODS = Oven dry weight of the sub-sample

Db = Bulk density of <2-mm fabric at sampled field water state (g cm-3)

RF = Weight of rock fragments

SV = Soil volume – is core volume if the core is full. If not, calculate (avg of four measurements from core end to soil (in cm))\*(pi\*core radius in cm squared) and subtract the resulting value from the core volume.

PD = Density of rock fragments

**Frame Excavation**

**After Grossman and Reinsch (2002) and Soil Survey Staff (2014)**

**Application**

Frame method (Grossman and Reinsch, 2002) is good where local variability is large and commonly rock fragments are present. A size of 0.1 m2 is sufficient to encompass considerable local variability. The procedure described herein is after Grossman and Reinsch (2002) and the Soil Survey Staff (2014b, method 3B5a).

**Summary of Method**

The assembled frame is placed on the ground surface. The four threaded rods are pushed through the holes in the corners of the frame deep enough to hold. The frame is then secured onto the soil surface by screwing down wing nuts and plastic placed over the frame and secured. The depth-measurement tool is placed on top of a slot to measure the distance to the soil surface. The slots are traversed, and measurements of the distance to the ground surface are made at about 40 regularly spaced intervals. The plate is then removed, and soil is excavated and retained. Measurements of the distance to the ground surface are repeated. The volume of soil is determined by taking the difference in height and multiplying by 1000 cm2. The rock fragments up to 20 mm are included in the sample. Excavated soil is oven-dried and weighed. Bulk density of soil is reported in g cm-3.

**Interferences**

None.

Safety Be careful when using an oven or microwave. Avoid touching hot surfaces and materials. Follow standard field and laboratory safety precautions.

**Equipment**

1. Lumber for square wooden frame with 0.1 m2 inside area. Frame is made from 8 pieces of wood: 2 pieces, 2 x 4 x 46 cm; 2 pieces, 2 x 4 x 53 cm; and 4 blocks, 4 x 5 x 9 cm.

2. Square Plexiglass, 35 cm on edge x 0.6 cm thick, with 5 parallel equally spaced slots, 1.5 cm across x 28 cm long

3. Four threaded rods, 50 cm long x 0.6-cm diameter, with wing nuts

4. Depth-measurement tool (Grossman and Reinsch, 2002; p. 209)

5. Hand digging equipment

6. Oven, 110 ±5 °C, or microwave. Refer to Section 3.5.1 of this manual for information on drying soils in a standard laboratory oven or microwave.

7. First-aid kit

Reagents

None.

Procedure

1. Assemble the square wooden frame by attaching the 9-cm side of a 4 x 5 x 9 x cm block to each end of both 53-cm long pieces. Two-centimeter wide cuts are made half-way across each of the 46- and 53-cm-long pieces to provide half-lap joints. Cuts are 5 cm in for the 46-cm long pieces. Holes 1.0 to 1.5 cm in diameter are drilled in the center of the attached blocks. Four pieces are joined by the vertical half-lap joints to form a square frame.

2. Place frame on ground surface. Push the four threaded rods through holes in the corners of frame sufficiently deep to hold. Secure onto the soil surface by screwing down wing nuts.

3. Place plastic plate over the frame and secure. 4. Place depth-measurement tool on top of slot and measure the distance to the soil surface.

5. Traverse the slots, making measurements of the distance to the ground surface at about 40 regularly spaced intervals. Remove plate.

6. Excavate and retain soil. Walls of the cavity should be vertical and coincident with the edge of frame.

7. Repeat measurements of the distance to ground surface. Determine difference in height and multiply by 1000 cm2 to obtain the volume of soil excavated. Usually, rock fragments up to 20 mm are included in sample.

8. Dry excavated soil in oven at 110 °C or in a microwave. Refer to Section 3.5.1 of this manual for information on drying soils in a standard laboratory oven or microwave. If necessary, make correction for weight and volume of >2-mm material in sample and bulk density computed. Weight of macroscopic vegetal material (g cm-3) also may be reported.

**Calculations**

Wf = Wo − We

where:

Wf = Oven-dry weight of <2-mm soil (g)

Wo = Oven-dry weight of excavated soil (g)

We = Oven-dry weight of rock fragments (g)

Db = Wf / Ve

where:

Db = Bulk density (g cm-3)

Wf = Oven-dry weight of <2-mm soil (g)

Ve = Excavation volume of <2-mm material (cm-3)

Report Bulk density is reported to the nearest 0.01 g cm-3 (g cc-1).

References

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