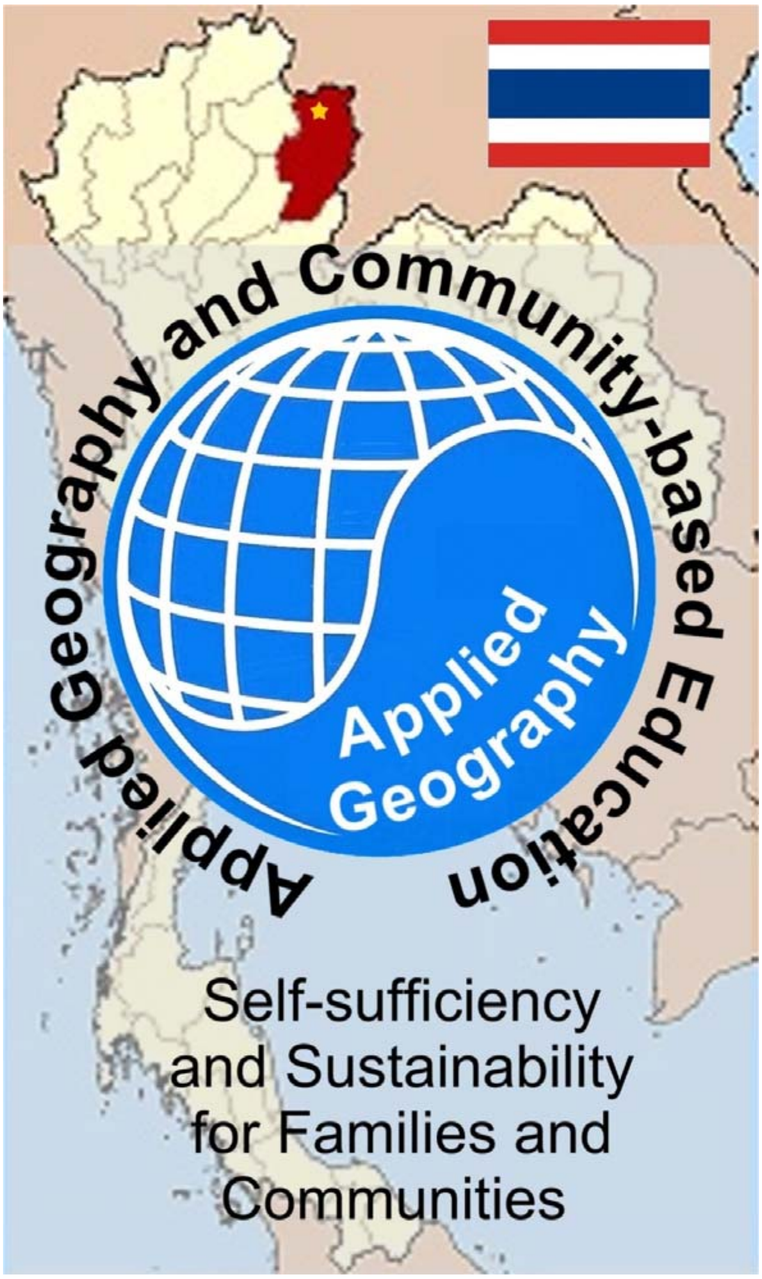

S.O.S. (Save Our Soil)

Basic Recon Soil Survey Methods

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Basic Recon Soil Survey Methods

1.0 INTRODUCTION

Soil is the unconsolidated material that overlies bedrock and is clearly distinguishable from bedrock. Relative to the Geographic Systems Model, you can see that all four environmental spheres contribute to making soil. Soil is the accumulation of disintegrated (weathered) rock material (Lithosphere) mixed with nearly equal amounts of water (Hydrosphere) and air (Atmosphere), and a smaller portion of decayed organic material (Biosphere). ***Location*** plays a role in soil development. Gravity pulls weathered rock materials, water, and decayed organic materials down slope. Thus, in erosional areas material is being removed and soils tend to be thinner and less developed. In depositional areas, soils tend to be deeper and more developed. The climate of a place also influences soil development. ***Time*** is also a factor in soil development. Obviously it takes time for the soil making processes to happen. Over time, more weathering and decay can take place, and more soil can accumulate.

Soil is systematically characterized using the following attributes:

- Color
- Texture
- Structure
- Chemistry

2.0 SOIL SAMPLING

For this paper, the soil sampling methods are directed toward agriculture. The array of basic soil sampling choices includes the following:

- **Depth:** Most plant roots are in the top 100 cm / 39 in of soil. For recon survey purposes, samples will be either shallow or deep.
  - Shallow samples will come from a depth of 30-45 cm below the surface.
  - Deep samples will come from 45-100 cm or more below the surface.

  > Soil profiles are another method to characterize the soil. This requires a deep hole or trench to examine the vertical soil column. See Appendix 1.

- **Type:** The soil sample can be from a single spot (separate) or from an area (aggregated).
  - **Spot:** A single hole is the source of the soil sample.
  - **Aggregated:** Soil from a number of holes from an area is combined to represent the area in a single mixed sample.
- **Sampling Distribution:**
  - **Line Transect Survey:** A soil survey can be done as a regular or random transect line. (For more on this subject, see the RTC GSM Basic Recon Line Survey Methods paper.)
    - **Regular Layout:** The survey line(s) follow a regular orientation (e.g. single line parallel lines in a predetermined azimuth).

    - **Random Layout:** The initial orientation of the survey line (or parallel lines) is picked at random
- **Pattern Survey:** The soil survey is done using geometric shapes (e.g. grid, box, triangle, diamond, etc.) The shape and orientation can be regular or irregular.
    - **Regular Pattern:** A standard geometric pattern is used with a pre-selected azimuth alignment.
    - **Irregular Pattern:** The survey pattern is an irregular polygon with random orientations.

Plan a soil sampling survey by picking one item from each major category.							
Sampling Depth		**Sampling Type**		**Sampling Distribution**			
				Line Transect		Pattern	
Shallow	Deep	Spot	Aggregated	Regular	Random	Regular	Random
30-45 cm below the surface	45-100 cm or more below the surface	Soil from a single hole is the sample	Soil from multiple holes is mixed to make one sample	Single or multiple lines with a planned orientation	Single or multiple lines with a randomly selected orientation	Regular shape with a planned orientation	Irregular shape with a randomly selected orientation
Details for these soil sampling methods are presented in Appendix 3 of this document.				See the RTC GSM Basic Recon Line Survey Methods paper.			

A summary of the various basic recon soil survey tests is given in Appendix 2. Detailed procedures for collecting soil samples are found in Appendix 3.

3.0 SOIL COLOR

Color is the most obvious and noticeable soil characteristic, even from a distance. Color is a useful indicator of the predominant processes involved in soil formation and maturation. The color of a soil is different at the surface than below the surface. And it also varies with depth in its profile. (A soil profile is the vertical layering you see a hole dug in the ground.)

Soil color can also be misleading. There are other reasons for the apparent color of a soil, so look carefully. The amount of moisture, chemical pollution, amount and degree of decomposed organics, and the residuals of burnt materials are some of the factors affecting original soil color from the parent rock materials. The range of possible soil colors is infinite.

The Munsell Soil Color Chart is a standard system used internationally for classifying soil colors. The full color chart is quite expensive to buy. For the sake of simplicity, use the terms from the table below to describe soil colors.

Simplified Soil Color Terms		
Light	**Medium**	**Dark**
White, tan, light yellow	Light red/yellow to brown	Dark brown to dark gray to black
When starting to work in a specific area, collect samples and create a “standard” local color key to help speed the training of local workers. Referring to the key frequently will shorten the learning curve and reduce variance in soil color classification. (See Appendix 4 for Soil Color Classification training ideas.)		

4.0 Soil texture

Texture is the particle size classification for the surface materials. Soil particles are divided into 2 broad classifications: Coarse-grained and fine-grained.

- **Coarse-grained** soils can be recognized easily. Spread a dry sample on a flat surface. If you can see most of the soil components are larger grain sizes, the sample is a coarse-grained soil.
- **Fine-grained** soils are identified by their plasticity determined by breaking and powdering a small dry sample with your fingers. Highly plastic soils can be powdered only with great effort; non-plastic soils crumble easily using your fingers.

There are standard more specific particle size terms: Gravel, Sand, Silt, and Clay. These terms pertain only to the size of the particle, not to its chemical composition. All types of rocks (igneous, sedimentary, and metamorphic) can be broken down to all of the different particle sizes. Other modifying terms besides coarse, medium and fine refer to the shape of the particles (see Appendix 8).

- **Gravel** is the term used for loose, water-worn particles ranging in size from 2 mm / 0.08 in to 50 mm / 2 in. in diameter (often mixed with sand, silt, clay).
- **Sand** is the size term for particles from about 0.6 cm / 0.25 in or smaller. It can be modified by the terms coarse, medium, and fine. Particle shapes can be described as angular or rounded.
- **Silt** refers to particles smaller than sand and ranges in size from 0.006 mm to 0.02 mm / 0.002 in to 0.00008 in. It lacks plasticity and has little or no cohesion when dry.
- **Clay** generally consists of microscopic particles (less than 0.002 mm / 0.00008 in) with outstanding plastic and adhesive qualities. Clays vary from lean (low plasticity) to fat (high plasticity).

US Standard Soil Particle Size Classification					
Large--→ Small					
Coarse-grained material			**Fine-grained material**		
Gravel	**Sand**		**Silt**		**Clay**
More than 2-50 mm (0.08-2.0 in)	Very Coarse	1-2 mm (0.04-0.08 in)	Coarse	0.02-0.05 mm (0.0008-0.002 in)	Less than 0.002 mm (0.00008 in)
	Coarse	0.5-1 mm (0.02-0.04 in)	Medium	0.006-0.002 mm (0.00024-0.0008 in)	
	Medium	0.25-0.5 mm (0.01-0.02 in)			
	Fine	0.1-0.25 mm (0.004-0.01 in)	Fine	0.002-0.006 mm (0.00008-0.00024 in)	
	Very Fine	0.05-0.1 mm (o.002-0.004 in)			
Note: The soil sieve screen sizes you use may not coincide with the standard sizes listed in this table. Measure the sieve screens and then use the most appropriate descriptive term.					

4.1 Soil Texture Tests: This paper presents 2 general methods for testing soil texture:

- **Field methods** can be done in the field fairly quickly (a few minutes) to get a general soil texture estimate. They rely on directly touching the soil sample. Two methods are summarized below: The "Soil Ball" and the "Finger Rub." These general methods give you three broad texture classes: Sand, Silt, and

Clay. It is a subjective estimate for some of the sand-silt-clay mixtures (e.g. loam, sandy clay, sandy clay loam, etc.).

- **Laboratory methods** requires more time (a few days up to several days) but gives numerical results for more precise soil texture classification. This is more suitable for a lab set up or a more stable base camp field situation. It is more common to carefully collect soil samples and carry them back to the lab for further analyses. The details are given in a summary table in the following pages of this section. The soil sample must be properly dried and prepared for the test. You need certain equipment and do some math calculations to determine the relative percentages of sand, silt, and clay in the soil. The Sedimentation / Soil Texture Triangle method can be done at low-cost.

4.1.1 Soil Texture Test by Touch (Tactile / Visual)

<table>
<tr><td colspan="6">This is a general field test method to determine soil texture for sand, silt, and clay. Gravel is large enough to be determined by visual inspection.</td></tr>
<tr><td></td><td colspan="2">Soil Ball</td><td colspan="3">Finger Rub</td></tr>
<tr><td>Check for Sand</td><td colspan="2">Get some soil in your hand and squeeze your fist tight. Slowly open your fist to see if the soil formed a ball. If not, the soil is sand. If it formed a ball, go to “Check for Silt or Clay” below.</td><td colspan="3">Get some soil and put it in the palm of your hand. Add a little water to form a small puddle. Use a finger to rub some soil in the puddle. If it feels “gritty”, the soil is sandy. If it feels slippery, go to “Check for Silt or Clay” below.</td></tr>
<tr><td>Check for Silt or Clay</td><td colspan="2">Get a damp golf ball size soil sample and roll it between your two palms to make a “worm” or “rope” about 4 mm ($1/8^{th}$ inch) in diameter. Keep rolling the “worm” to see how long it will get before it breaks off from your hands. Then use the Finger Rub method to classify the soil.</td><td colspan="3">If you think the soil may be silt or clay, rub some of the moistened slippery soil between your thumb and index (pointing) finger. Stop rubbing. Then gently lift you fingertip away from your thumb. If the sample remains smooth, the soil is silt. If the sample feels sticky or tacky, and some of it lifts up making small spikes, the soil is clay.</td></tr>
<tr><td>High</td><td rowspan="2">Worm / rope with finger rub, the sample feels...</td><td colspan="4">Worm / Rope Length</td></tr>
<tr><td rowspan="4">←-- %Sand --→</td><td>< 2.5 cm
(< 1 in)</td><td>2.5-5 - <5.0 cm
(1 - <2 in)</td><td>5-7.5 cm
(2-3 in)</td><td>> 7.5 cm
(> 3 in)</td></tr>
<tr><td>Very gritty</td><td rowspan="3">No finger rub needed; Sand</td><td>Sandy Loam</td><td>Sandy Clay Loam</td><td>Sandy Clay</td></tr>
<tr><td>neither gritty nor smooth</td><td>Loam</td><td>Clay Loam</td><td>Clay</td></tr>
<tr><td>very smooth</td><td>Silty Loam</td><td>Silty Clay Loam</td><td>Silty Clay</td></tr>
<tr><td>Low</td><td colspan="4"><-- % Clay ---------------------------------------></td><td>High</td></tr>
<tr><td colspan="6">For more specific soil texture categories, you can use the “Soil Texture by Sedimentation Bottle and Texture Chart” method. This requires preparing the sample before a test that could take 2-5 days to complete.</td></tr>
</table>

4.1.2 Soil Texture Test by Sedimentation Bottle and Texture Triangle

This is a more specific and technical classification of your soil. You will need to get some simple equipment and do some simple measurements and calculations.

Materials	Equipment	Knowledge / Skills
• Soil sample • Newspaper / rolling pin • Water • Powdered dish detergent • Old tablespoon	• Empty bottle with cap • Ruler / Calculator • Pencil / eraser / notepad • Soil texture triangle • Watch or clock • Wire screen / sieve	• Make linear measurements • Calculating percentages • Measure time • Reading and using a chart.

Step 1. Get a soil sample. Spread it on newspaper in the sun to dry for 1 – 2 days. Cover the dried soil with newspaper and gently crush it to break up any clumps. Use a wire screen / sieve to remove pebbles and any plant materials.

Step 2. Put about 237 ml / 1 cup soil into an empty water bottle. Add 1 tablespoon of powdered dish detergent to keep the soil particles from sticking together.

Step 3. Fill the bottle with water to the top. Screw the cap on tight. Shake for 3 minutes. Make sure no soil sticks together inside the bottle.

Step 4. Put the bottle on a flat, level surface and let the sediments settle.

- Sand settles first at the bottom. This takes about 1-2 minutes. Measure the thickness of this layer and record it in Row A below.
- Silt settles out second on top of the sand. This takes about 1-2 hours. Measure the thickness of this layer and record it in Row B below.
- Clay settles out last on top of the silt. This takes about 1-2 days (24-48 hrs). Measure the thickness of this layer and record it in Row C below.

Step 5. Once all the particles settle out, measure the total sediment height in the bottle. Measure the thickness of this layer and record it in Row D below.

Step 6. Calculate the percentage for each separate in the total sample. Be sure to double-check your calculations.

<table>
<tr><td colspan="5">Location:</td><td>Sample ID:</td></tr>
<tr><td>Test Date:</td><td colspan="4">Tested by:</td><td>Checked by:</td></tr>
<tr><td rowspan="2">Estimated Time</td><td rowspan="2">Sediment Layers</td><td colspan="2">Sediment Thickness</td><td rowspan="3">% of Total Sample</td><td rowspan="6">To Calculate Percentage of Total Sample:

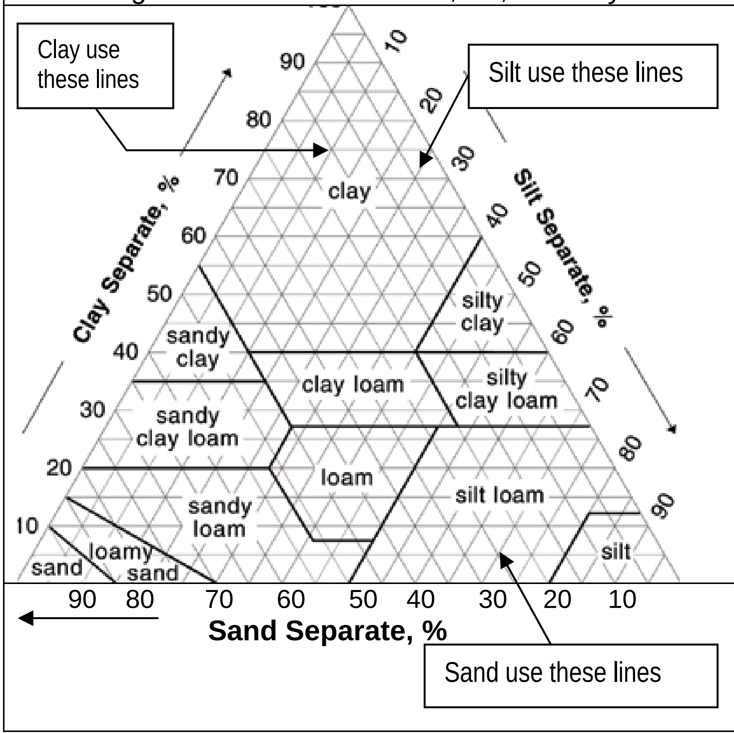
Divide the thickness of each sediment layer (Lines A, B, and C) by the total sediment height (Line D) to get the percentage for each separate.

Example: A = 2 in; B = 2 in; C = 1 in; D = 5 in. Then, A = 40%, B – 40%, C = 20 %. Then go to the soil texture triangle.</td></tr>
<tr><td>☐ mm ☐cm</td><td>inches</td></tr>
<tr><td rowspan="2">24-48 hours</td><td>D. Total Height</td><td></td><td></td></tr>
<tr><td>C. Clay layer</td><td></td><td></td><td></td></tr>
<tr><td>1-2 hours</td><td>B. Silt layer</td><td></td><td></td><td></td></tr>
<tr><td>1-2 minutes</td><td>A. Sand layer</td><td></td><td></td><td></td></tr>
</table>

You can automatically calculate the soil texture classification of your soil sample at the Pedosphere website and look for the American Texture Triangle calculation page: http://www.pedosphere.com/resources/bulkdensity/triangle_us.cfm

Soil Texture Test by Sedimentation Bottle and Texture Triangle (Part 2)

Step 7. Use the % separates data with the Soil Texture Triangle. Soils are a combination of sand, silt, and clay particles. The mixture affects the soil classification. The Soil Texture Triangle uses the ratio of sand, silt, and clay to name the soil class.



To Use the Soil Texture Triangle:

Step 1. Use the % Sand from your sample. Find the % on the Sand Separate scale and follow the diagonal lines going up to the left in the chart.

Step 2. Use the % Silt from your sample. Find the % on the Silt Separate scale and follow the diagonal lines going down to the left in the chart.

Step 3. Use the % Clay from your sample. Find the % on the Clay Separate scale and follow the horizontal lines going across the chart.

Step 4. Read the name of the soil type where the 3 lines intersect.

Example: A soil sample is 40% sand, 40% silt, and 20% clay. This soil is a Loam.

5.0 Soil Structure

Texture affects soil structure. Soil structure describes how the soil components (small pieces of rock, air, water, and humus) stick together. This affects the ability of water, air, and plant roots to move through the soil. If the spaces are too big, the soil cannot hold enough water for plants to grow. If the spaces are too small, the roots cannot get through the soil to get water, air and nutrients.

There are numerous ways to test soil structure. [**Note:** You need to know the soil texture before doing any soil structure tests.] This paper presents two types of tests for soil structure: the crumb tests and the compaction tests. At the same time, you can do an earthworm census (a surrogate soil chemistry test) and a simple percolation test (for soil compaction).

Advisory Note: The subsurface sampling portion of the crumb test for soil structure requires digging a hole 30 cm / 12 inches deep. Ten tests can be done using the same hole. However, these tests need to be coordinated (see Appendix2 for more details) and many can be done at different depth zones for the same hole.

1	Earthworm Census	5	Crumb Bottle Test	9	Finger Rub
2	Soil Moisture by Feel	6	pH Test	10	Percolation
3	Temperature	7	Color		
4	Crumb Diameter	8	Soil Ball		

5.1 Crumb Tests: Soil particles naturally clump together. This is a 3-step process to assess the soil structure. First, check a surface sample. Second, dig a hole for subsurface samples. Last, do a bottle test to see how well the crumbs hold up under water.

Materials	Equipment		Knowledge / Skills
• Plastic Tarp (3 ft x 3 ft) • Soil sample • Water	• 2 clear plastic cups • Shovel and hand trowel • Ruler or short	• measuring tape • Pencil / eraser • notepad	• Able to follow instructions • Careful observation and note taking

5.1.1 Crumb Test for Surface Samples

Visual / Tactile Procedure	**The soil…**	Soil Structure
Step 1. Pick up a handful of soil.	Retains shape; doesn't get powdery	Good Structure
Step 2. See how it crumbles in your hand	Crumbles easily	
Step 3. Compare the results to the table and record the results in your notebook.	Get dusty or powdery	Poor Structure
	Forms big clumps; resists crumbling	

5.1.2 Crumb Tests for Subsurface Samples

Crumb Diameter

Step 1. Dig a hole about 30 cm / 12 inches deep.
Step 2. Put the soil on a tarp or in a bucket. (***This is a good time for the worm census***.)
Step 3. Use the hand trowel to scrape soil samples from various depths from the side of the hole. Keep records about the depth for each sample.
Step 4. Examine the samples. Soil crumbs come in various sizes but are *not* discrete or separate objects like a marble. They may appear to be more like a piece of moist cake. You are looking for large crumbs about 1-3 mm / 1/32 - 1/8 inch in diameter.
Step 5. Observe and record the soil color.
Step 6. Check and record the soil moisture.
Step 7. Count the worms in the soil from the hole (See Step 2). Record the count.
Step 8. Record any other comments you have.

Crumble Bottle Test:
You will need 2 clear cups for a test.
Step 1. Carefully put a handful of the soil crumb sample into each cup. One cup will remain dry. This is the control sample. The second cup is the test sample.
Step 2. Hold the test sample cup at an angle, and gently pour the water down the inside of the cup. ***Be careful not to pour the water directly on the soil crumbs***.
Step 3. Put the two cups next to each other and compare the wet soil crumbs to the dry sample. If the wet crumbs hold together as the dry ones, the soil structure is good. If the wet crumbs "melted", turned to mud, and did not keep their shape, the soil has poor structure.
Step 4. Record the results.

Worm Count	Depth		% Moisture	Temp	Crumb Diam	Crumb Bottle		pH	Color	Texture	Percolation
	cm	in		☐ºF ☐ºC	☐ mm ☐ in	Good	Poor		(LMD)		☐Good ☐Poor
	7.5	3									Total Hrs
	15	6									
	22.5	9									
	30	12									

5.2 Soil Compaction: Here are 3 simple tests for soil compaction: 2 soil probe methods (push rod, garden fork) and a percolation test. Soil compaction is the indicator of how tightly packed the soil particles are on your site. Highly compacted soils do not let water, air, or plant roots penetrate through it. It is a good idea to keep good records of the test results to monitor change over time.

Materials	Equipment	Knowledge / Skills
• Plastic Tarp (3 ft x 3 ft) • Clean water	• Push Rod, Garden Fork, Shovel • Tape measure • 1 Gallon water container • Watch or clock • Pencil / eraser / notepad	• Able to follow instructions • Make linear measurements • Measure time • Careful observation and note taking

5.2.1 Soil Probe Tests

<table>
<tr><th colspan="3">Push Rod Method</th><th colspan="2">Garden Fork Method</th></tr>
<tr><td colspan="3">Use a steel rod 46 cm /18 in long, 7 mm / 1/4 inch diameter as a soil probe.</td><td colspan="2">This is similar to the push rod test but uses a garden fork as a soil probe.</td></tr>
<tr><td colspan="5">Step 1. Find a place you want to test for soil compaction.</td></tr>
<tr><td colspan="5">Step 2. Hold the soil probe perpendicular to the soil surface.</td></tr>
<tr><td colspan="3">Step 3. Slowly, firmly, and gently push the rod into the soil until you feel resistance or until you see the rod begins to bend. Stop pushing before you bend the rod. If you haven’t hit a rock, mark the rod at the soil surface.</td><td colspan="2">Step 3. Slowly, firmly, and gently push the garden fork into the soil. If you haven’t hit a rock, mark the blade of garden fork at the soil surface.</td></tr>
<tr><td colspan="5">Step 4. Measure and record how deep the soil probe went into the soil. The root zone for most garden plants is about 15-30 cm / 6-12 in deep.</td></tr>
<tr><td colspan="2">…the push rod did not penetrate to root zone without starting to bend.</td><td>Soil is compacted if…</td><td colspan="2">…you have to stand on the garden fork or it won’t go all the way in,</td></tr>
<tr><td colspan="2">…the push rod penetrates to root zone easily</td><td>Soil is NOT compacted if…</td><td colspan="2">…you can push the garden fork all the way to the full length of the tines without standing on it.</td></tr>
<tr><td rowspan="2">Modifier</td><td colspan="2">Depth of Push Rod Penetration</td><td colspan="2">Relative Rating</td></tr>
<tr><td>Firm</td><td>Stable</td><td>Paths / Trails*</td><td>Garden Beds**</td></tr>
<tr><td>Very</td><td>~7.62 mm
~ 0.3 in</td><td>~ 12.7 mm
~ 0.5 in</td><td>Excellent</td><td>Poor</td></tr>
<tr><td>Moderately</td><td>> 7.62 & < 12.7 mm
> 0.3 & < 0.5 in</td><td>> 12.7 mm & < 25.4 mm
> 0.5 & < 1.0 in</td><td>Fair</td><td>Fair</td></tr>
<tr><td>Not</td><td>> 12.7 mm
> 0.5 in</td><td>> 25.4 mm
> 1.0 in</td><td>Poor</td><td>Good</td></tr>
<tr><td colspan="5">* Paths and trails for loaded wheelbarrows should be tested with a rotational penetrometor (e.g. a 20 cm diameter pneumatic wheel, under constant pressure of 18 kg / 40 lbs of force and rotated 90°. This test will reveal the firmness and stability of the path surface to withstand use.</td></tr>
<tr><td colspan="5">** Push rod penetrations in gardens of 15 – 30 cm / 6-12 inches (approximate root zone depth) are Excellent.</td></tr>
</table>

5.2.2 Simple Percolation Test: This is a compaction test to see if you have soil drainage problems. (Be sure you completed the subsurface crumb test and the earthworm census before doing the percolation test.)

Step 1. Dig a hole 30 cm (1 foot) deep, 15 cm (6 inches) wide.
Step 2. Fill the hole with water and let it drain completely.
Step 3. As soon as the water from Step 2 has drained, fill the hole with water again.
Step 4. Record the time it takes for the water to completely drain from the hole. If it takes more than 8 hours, the soil is compacted and has poor drainage.

Easy Ways to Break Up Compacted Soil

- Adding compost to attract earthworms
- Cover bare soil with mulch
- Sheet compost compacted bare soil
- Double dig raised garden beds on the compacted area
- Use a garden fork to periodically aerate the soil. Push the fork into the compacted soil and rock the blades back and forth. Pull out the fork. Do this 2-3 times a season to help break up compacted soil.

Easy Ways to Prevent Compacting the Soil

- Avoid working, tilling or walking on wet soil
- Avoid walking on planted areas
- Keep traffic off planted areas
- Avoid frequent plowing or roto-tilling

Descriptive terms for the infiltration rates are show in the table on USDA Soil Permeability Classes. In most cases, permeability classes of very slow, slow, rapid and very rapid are considered poor for irrigation.

USDA Soil Permeability Classes

Classification	Infiltration Rate cm / hr	Infiltration Rate in / hr
Very Slow		< 0.06
Slow		0.06 – 0.2
Moderately Slow		0.2 – 0.6
Moderate		0.6 – 2.0
Moderately Rapid		2.0 – 6.0
Rapid		6.0 – 20.0
Very Rapid		> 20.0

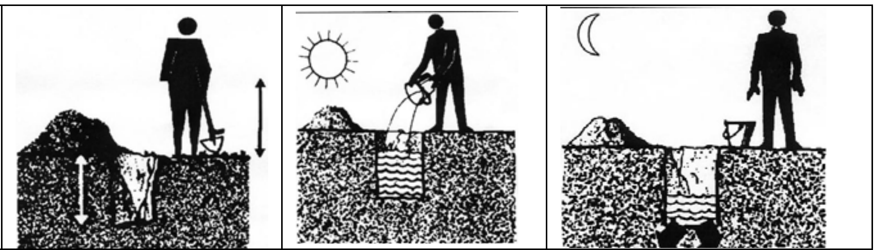
5.2.3 Pond Site Percolation Test

Now you should make a second test to be sure that the soil is good. Repeat this once you dig out the pond. Do this test at the very bottom of the pond.

Dig a hole as deep as your waist

Early in the morning fill it with water. Fill it to the top

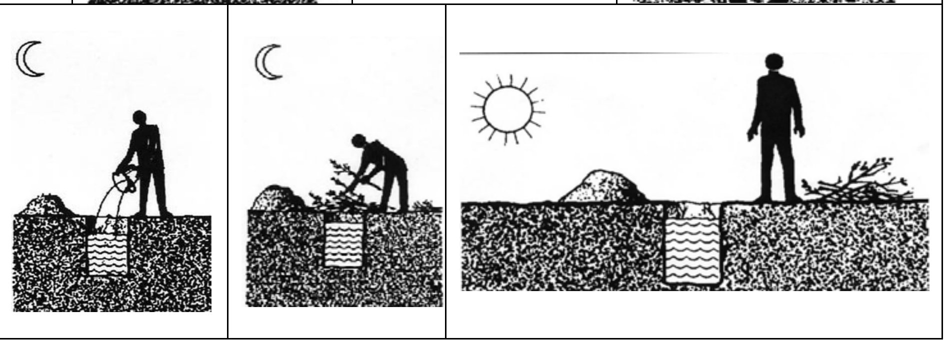
By evening some of the water will have sunk into the soil.



Then fill the hole with water again. Fill it to the top.

Cover the hole with boards or leafy branches

The next morning if most of the water is still in the hole, the soil will hold enough water to build a fish pond there.



6.0 Soil Chemistry

It all begins with water. Plants mostly live on a liquid diet. They use water to get the soil nutrients. People commonly talk about soil fertility and think it means soil chemistry. Soil fertility is a bit more complex. It actually refers to the ability of plants to get to the soil nutrients and not the actual chemical condition of the soil. Chemical testing of soils is complex and requires specialized equipment and procedures that are beyond the scope of this paper. You will learn three simple tests:

- Soil moisture tells you how much water is available in the soil for plants to use.
- The pH test is a direct measurement of the acid or alkali condition of the soil.
- The earthworm census is an indirect measurement of soil health.

6.1 Soil Moisture: When soil moisture in the root zone (about 15 cm / 6 in deep) is less than 50%, most garden plants will be stressed. Plants begin to wilt if soil moisture drops below 5% for sandy soils to 15% for clay soils. Soil texture and soil structure all affect soil moisture. Be sure you have completed the soil texture and soil structure tests before starting the soil chemistry tests.

6.1.1 Soil Moisture by Touch or Appearance

Soil moisture is the water in the soil that is available for plants to use. You should check the soil moisture in the root zone (about 15 cm / 6 in deep).

Available soil moisture	Light Texture	Medium Texture	Heavy Texture
	Sandy	Loamy	Clayey
0-25%	Dry; loose; flows through fingers	Powdery dry; sometimes slightly crusted but easily broken to powder	Hard; baked; cracked; sometimes has loose crumbs on surface
25%-50%	Looks dry; will not form ball	Somewhat crumbly but holds together from pressure.	Somewhat pliable; will for ball under pressure
50%-75%	Tends for form ball under pressure but seldom holds shape	Forms a ball; somewhat plastic; will sometimes slick with pressure	Forms a ball; ribbons out between fingers
75% to 100%	Forms weak ball; breaks easily; will not slick	Forms a ball; is very pliable; slicks readily if relatively high in clay	Easily ribbons out between fingers; has slick feeling
100% (Field Capacity)	No free water appears with squeezing; but leaves wet outline on hand		
Saturated	Water appears on ball and hand.		

Notes:

- Make a Soil Ball: Squeeze a handful of soil firmly.
- Make a Soil Ribbon: Start with a soil ball. Then use your thumb to push the soil ball out of your hand against the side of your index finger.

Source: Soil Conservation Service Bulletin No. 199

Use mulch to cover bare soil to improve moisture retention. Adding compost helps sandy soils retain moisture and helps loosen tight clay soils. Raised beds help improve drainage for wet conditions.

6.1.2 Gravimetric Method of Soil Moisture Analysis: This method requires soil samples to be collected and sealed in plastic bags (with as much air removed as possible). The "wet" sample from the field is weighed and the data recorded before the sample is dried. After sufficient drying, the difference weight between the wet and the dry samples is expressed as a percentage.

6.1.2.1 Oven Drying: This method may take at least 24 hours to complete.

<table>
<tr><td colspan="3">Soil moisture is the water in the soil that is available for plants to use. You should check the soil moisture in the root zone (about 15 cm / 6 in deep).</td></tr>
<tr><th>Materials</th><th>Equipment</th><th>Knowledge / Skills</th></tr>
<tr><td>• Soil sample</td><td>• Oven
• Oven proof drying dish
• Scale</td><td>• Able to measure weight
• Able to measure temperature
• Able to calculate percentages</td></tr>
<tr><td colspan="3">Step 1. Pre-heat oven to 105º C / 221º F
Step 2. Weigh empty oven proof drying dish and record weight on data log sheet.
Step 3. Place soil sample in oven proof drying dish. Weight and record the combined weight of the dish and soil sample on data log sheet.
Step 4. When oven is at the proper temperature, place the dish with the soil sample into the oven and close the door. Note the time on the data log sheet.
Step 5. Let the sample oven dry overnight. Then remove the dish with the dried soil sample and weigh it. Record the dry weight on the data log sheet.
Step 6. Subtract the combined dish / soil dry weight from the combined dish / original soil sample weight. Record the combined dish / soil weight difference on the data log sheet.
Step 7. Divide the combined dish / soil weight difference by the combined dish / original soil sample weight x 100 to calculate the % soil moisture content. Record the result on the data log sheet.</td></tr>
</table>

6.1.2.2 Air Drying: This method is very similar to the Oven Drying method described above except the soil sample is dried on newspaper.

<table>
<tr><td colspan="3">Soil moisture is the water in the soil that is available for plants to use. You should check the soil moisture in the root zone (about 15 cm / 6 in deep).</td></tr>
<tr><th>Materials</th><th>Equipment</th><th>Knowledge / Skills</th></tr>
<tr><td>• Soil sample
• Newspapers
• Facial tissue</td><td>• Scale</td><td>• Able to measure weight
• Able to calculate percentages</td></tr>
</table>

Step 1. Weigh the soil sample from the field and record its weight.
Step 2. Spread the soil on some newspaper and set it aside to dry in a place where it will not be disturbed.
Step 3. When you think the soil sample is dry, test it by pressing a facial tissue to the soil to detect any moisture.
Step 4. When the soil sample is dry, weigh it.
Step 5. Subtract the dry weight from the moist weight and record the difference.
Step 6. Divide the difference by the original moist weight x 100 to get the % soil moisture content. Record the result on the data log sheet.

6.2 Soil pH Test: Using strips pHydrion test paper is an easy way to get a general idea of soil acidity (acid) or alkalinity (base). The pH scale goes from 1 (acid) to 14 (alkali) with 7.0 as neutral. Most soil nutrients are more soluble (able to be dissolved) when the soil pH is about 6.5 – 7.0. This is also close the good pH range for many soil organisms, such as earthworms and bacteria (6.0-8.0). Knowing the soil pH of your site will help you select plants that will flourish better in your habitat.

This simple Soil pH test can be done in the field if you have the proper equipment.			
Materials	**Equipment**		**Knowledge / Skills**
• Soil sample • PHydrion test paper • Distilled water	• 1 clean plastic cup • 1 old tablespoon	• Watch or clock • Pencil / eraser / notepad	• Able to follow instructions • Careful observation and note taking
Step 1. Put about 1 tablespoon of soil in a clean container. **Step 2.** Add distilled water and stir until the sample is as thick as a milkshake. **Step 3.** Let it stand for 1 hour. Check it periodically and add water if needed. **Step 4.** Put a piece of test paper in the solution. Leave it in for about 1 minute. **Step 5.** Take the test strip out and rinse it with distilled water. **Step 6.** Match the color of the test strip to the standard color chart that came with the test paper. Record of your test results.			
Soil is too Acid (pH low)		**Soil is too Alkali** (pH high)	
This means	Corrective Action	This means	Corrective Action
Phosphorus, calcium, magnesium are less available to plants	Add calcitic or dolomitic limestone Add compost and use mulch	Iron and manganese are less available to plants	Add various forms of sulfur or acidic organic matter (peat moss or pine needles

The pH Scale

Soils		pH			
	Acid	0			
		1	Battery acid		Acid rain
		2	Lemon juice	Adult fish die	Acid rain
Extreme Acid Peat Soils		3	Vinegar, cola, beer, apples	Adult fish die	Acid rain
		4		Fish reproduction affected	Normal rain
Common extreme range of most soils; Range of humid soils; Fertile Agricultural Soils		5	Black coffee, carrots	Fish reproduction affected	Normal rain
Common extreme range of most soils; Range of humid soils; Fertile Agricultural Soils		6	Saliva; Milk	Normal Stream water	Normal rain
Common extreme range of most soils; Range of humid soils		7	Blood	Normal Stream water	
Common extreme range of most soils; Range of arid soils		8	Sea Water	Normal Stream water	
Common extreme range of most soils		9			
		10			
Extreme Alkaline Soils		11	Ammonia		
		12			
		13	Oven cleaner		
	Alkaline	14			

6.3 Earthworm Census: This is an indirect indication of good soil chemistry. Earthworms are small organic tractors that move tremendous amounts of soil in a year. The more biological activity in the soil, the more earthworms you will find. Adding compost and organic materials to the soil is the easiest way to provide "food" for earthworms. In that sense, they are like people. Feed them, and they will come. Note: To save time, you can also do the subsurface crumb test and bottle crumb tests.

Earthworms effectively move about 1,363 kg of soil per 4,047 sq m (15 tons of soil per acre). The worm castings (solid wastes) add about 727 kg of soil per 4,047 sq m (8 tons of soil per acre). They make miles of tunnels that help air, water, and roots penetrate more readily throughout the soil. They also move soil and nutrients vertically in the soil column. Mulching and composting provide organic matter in soil that feeds earthworms. Earthworms (different from red worms used in worm composting) prefer 10°C (50°F) temperatures, slightly moist soils, and calcium (and therefore a neutral soil pH). During winter in mid-latitude zones, earthworms can tunnel down 1-2 m (3-6 ft) to escape the cold.

Pesticides, herbicides, and the highly soluble salts in synthetic fertilizers easily kill them. This is another good reason to reduce or eliminate these from your habitat. Besides, it's also much safer and healthier for you and your family, too.

<table>
<tr><td colspan="6">Soil chemistry is a very complex subject. This simple field test gives a general indication of soil chemistry. It is not a substitute for a proper soil lab chemical analysis.</td></tr>
<tr><th colspan="2">Materials</th><th colspan="2">Equipment</th><th colspan="2">Knowledge / Skills</th></tr>
<tr><td colspan="2">• Plastic Tarp 1 m sq (3 ft) or a bucket
• Clean water</td><td colspan="2">• Shovel
• Tape measure
• Pencil / eraser / notepad</td><td colspan="2">• Able to follow instructions
• Make linear measurements
• Count
• Careful observation and note taking</td></tr>
<tr><td colspan="6">Step 1. Take an earthworm census during a cool time of day. This minimizes stress to the earthworms.
Step 2. Pick a sample site. Measure a square 30 cm / 1 foot on a side. Dig down about 30 cm / 1 ft. Put all soil on a tarp or in a bucket.
Step 3. Count the number of earthworms in the soil sample.
Step 4. Interpret the results using the table below. Keep records of your results.</td></tr>
<tr><th colspan="6">Earthworm Census Rating Scale</th></tr>
<tr><td colspan="2">0-3 = Poor soil</td><td colspan="2">3-9 = Fair soil</td><td colspan="2">10 or more = Good soil</td></tr>
<tr><td colspan="2">Add organic material.</td><td colspan="2">Can be improved by adding organic material.</td><td colspan="2">Soil in good health.</td></tr>
<tr><td colspan="6">Fertilizers and Soil Amendments: Earthworm Test
Before you add fertilizers or soil amendments to your garden beds, do a simple "taste test" with your earthworms. After all, they will have to eat it. If they don't like it, they will leave. And who wants their hard working garden staff to leave the job site?
Step 1. Put a handful of earthworms on one end of an empty tray.
Step 2. Put a handful of fertilizer or soil amendment on the other end of the tray.
Step 3. Watch to see if the earthworms move toward it (they like it) or not (they don't).</td></tr>
</table>

6.4 Soil Temperature: Insolation at the Earth's surface is absorbed and heat is generated. Although sunlight does not penetrate much beyond 1mm of the soil surface, heat can conduct downward into the soil column. The surface cover affects the soil temperature. Bare soil will have warmer subsurface subsurface temperatures than vegetated areas.

Season variations in soil temperature coinciding to the solstices and equinoxes will usually be delayed about 1 month or more. For example, the June solstice is when insolation in the northern hemisphere is at a maximum. Climatic temperature maxima are recorded about 1 month later. Soil temperatures may reach a maximum about the same time or later.

Soil temperature will be affected by soil depth. The suggested sampling depths are geared to the root zone for most plants. However, if soil temperature data are needed for planning earthen cool storage or solar "air conditioning" systems, deeper depths should be used (e.g. 1-2 m or more) depending on when the soil temperatures are significantly cooler than the ambient air temperatures. [Note: Obtain local climatic summaries to know the seasonal temperature ranges relative to the cooling requirements for food storage or other cooling requirements.]

Soil chemistry is affected by a number of factors, including temperature. Soil temperatures vary seasonally. Measurements should be made at the significant astronomical points (e.g. solstices and equinoxes) and about one month after each event (to allow for time / temperature lags).

Materials	Equipment	Knowledge / Skills
• Pencil / eraser / notepad	• Shovel • Tape measure • Thermometer	• Able to follow instructions • Make linear measurements • Make temperature measurements • Careful observation and note taking

Step 1. Dig a hole about 30 cm / 1 ft deep (or more).
Step 2. Note the temperature reading on the scale, then insert the soil thermometer horizontally into the side of the hole at the suggested depth intervals (see table below).
Step 3. Wait until the thermometer stabilizes (e.g. the temperature no longer changes). Record the temperature for the specified depth.
Step 4. Repeat Steps 2 and 3 until all measurements are made and recorded. [**Note:** If a deeper hole is dug, pick a depth interval for making temperature measurements.]

Worm Count	Depth		% Moisture	Temp	Crumb Diam	Crumb Bottle		pH	Color	Texture	Percolation
	cm	in		□ºF □ºC	□ mm □ in	Good	Poor		(LMD)		□Good □Poor
	7.5	3									Total Hrs
	15	6									
	22.5	9									
	30	12									

Appendix 1: The Soil Profile

The soil profile is one way to examine and characterize the soil at a site. To see the soil profile, you dig a hole or trench in the ground. This often reveals vertical layers in the soil. The exposed layers of soil are called the soil profile. The layers are called horizons.

An easy alternative to digging is to examine road cuts. You may need to cut a fresh “face” to expose the underlying soil.

Simplified Soil Horizons		
Master Horizons	**Named for**	**Note**
0	**O**rganic surface materials	The actual number and thickness of the various soil horizons depends on the climate and terrain conditions for a location
A	**A**bove the uppermost soil layer made from weather parent rock material below the surface.	
E	**E**luviation, the process of water removing soluble minerals and microscopic particles from the A horizon downward through the soil column.	
B	**B**elow the vertical zone where illuviation (deposition) of the soluble minerals and microscopic soil particles occurs.	
C	**C**lasts: A fragment of parent rock material weathered to make smaller soil particles.	
R	**R**egolith; consolidated parent rock material starting to be weathered.	

Organic matter can be chemically deposited and organic sediments are classified on the basis of the mode and source of sedimentation. Highly organic soils are identified because they contain decomposed grass, twigs, leaves, and related plant materials. They have a characteristic dark brown to black color, spongy feel, and a fibrous texture.

CAUTION: Never work alone. Unsupported soil can collapse and trap people in the hole / trench. Plan carefully when digging deep holes and especially trenches.

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Appendix 2:
Basic Recon Soil Survey Methods Summary

Basic Recon Soil Survey Methods Summary (Part 1)			Section	Field		Lab	
				Surface	Subsfc	Surface	Subsfc
Soil color (visual)			3.0	X	S		P
Soil Texture	Soil Ball		4.1.1	X	S		P
	Finger Rub		4.1.1	X	S		P
	Sedimentation Bottle / Texture Triangle		4.1.2			X	▼1 X
Structure	Crumb Tests	Crumble Test (Visual / Tactile)	5.1.1	X			
		Crumb Diameter	5.1.2		▼1 X		P
		Crumb Test Bottle	5.1.2		▼3 X		P
	Soil Compaction	Probe-Push Rod	5.2.1	X			
		Probe-Garden Fork	5.2.1	X			
		Percolation Test	5.2.2		▼4 X		
Chemistry	Soil Moisture	Visual / Tactile	6.1.1	X	S		P
		Gravimetric-Oven Dry	6.1.2.1			X	S
		Gravimetric-Air Dry	6.1.2.2			X	S
	pH Test		6.2	X	▼3 X	S	S
	Earthworm Census		6.3		▼2 X		
	Temperature		6.4		▼3 X		

▼ = Requires a test hole so digging one hole can do these tests following the indicated sequence number.
S = If a test hole is dug, these tests can be done.
P = If soil samples are brought to the lab from the field (sealed in plastic bags with air squeezed out of the bag), these test could be done in the lab to confirm field tests or if no field tests were done.
Reminder: When digging test holes, samples and measurements should be taken at selected depths: 7.5 cm / 3 in; 15 cm / 6 in; 22.5 cm / 9 in; 30 cm / 12 in.

Field Soils Recon Survey Equipment Matrix (Part 1) Before going to the field, look at the field tests to be done and make sure you have all the necessary equipment. Note: LAB test equipment is NOT listed here.			Section	Trowel	Sample Bag	Small Water Bottle	Bucket	Push Rod	Garden Fork	Small Measuring Tape	Shovel	Tarp	Large bottle water	Watch	Distilled water	Clear Cup	Phydrion paper	Thermometer
Soil color (visual)			3.0		X													
Texture	Soil Ball		4.1.1		X													
	Finger Rub		4.1.1		X	X												
	Sedimentation Bottle / Texture Triangle		4.1.2		X					X	X	X						
Structure	Crumb Tests	Crumble Test	5.1.1	X	X					X	X							
		Crumb Diameter	5.1.2	X	X					X	X	X						
		Crumb Test Bottle	5.1.2	X	X	X				X	X					2		
	Soil Compaction	Probe-Push Rod	5.2.1					X		X								
		Probe-Garden Fork	5.2.1						X	X								
		Percolation Test	5.2.2							X	X		X					

Basic Recon Soil Survey Methods Summary (Part 2)			Section	Field		Lab	
				Surface	Subsfc	Surface	Subsfc
Chemistry	Soil Moisture	Visual / Tactile	6.1.1	X	S		P
		Gravimetric-Oven Dry	6.1.2.1			X	S
		Gravimetric-Air Dry	6.1.2.2			X	S
	pH Test		6.2	X	▼3 X	S	S
	Earthworm Census		6.3		▼2 X		
	Temperature		6.4		▼3 X		

▼ = Requires a test hole so digging one hole can do these tests following the indicated sequence number.
S = If a test hole is dug, these tests can be done.
P = If soil samples are brought to the lab from the field (sealed in plastic bags with air squeezed out of the bag), these test could be done in the lab to confirm field tests or if no field tests were done.
Reminder: When digging test holes, samples and measurements should be taken at selected depths: 7.5 cm / 3 in; 15 cm / 6 in; 22.5 cm / 9 in; 30 cm / 12 in.

Field Soils Recon Survey Equipment Matrix (Part 2)

Before going to the field, look at the field tests to be done and make sure you have all the necessary equipment.

Note: LAB test equipment is NOT listed here.

			Section	Trowel	Sample Bag	Small Water Bottle	Bucket	Push Rod	Garden Fork	Small Measuring Tape	Shovel	Tarp	Large bottle water	Watch	Distilled water	Clear Cup	Phydrion paper	Thermometer
Chemistry	Soil Moisture	Visual / Tactile	6.1.1	X	X													
		Gravimetric-Oven Dry	6.1.2.1	X	X					X	X							
		Gravimetric-Air Dry	6.1.2.2	X	X					X	X							
	pH Test		6.2	X	X									X	X	X		
	Earthworm Census		6.3							X	X	X						
	Temperature		6.4	X						X	X	X						X

Digging a Test Hole for Subsurface Soil Sampling

A number of soil tests can be done using the same hole. Do them in this order to economize on time and energy to get optimal results.

- **Earthworm Census:** Dig the entire hole. Put the soil on a tarp and count the earthworms quickly. Then put them back in the ground or cover them with other damp soil. [Note: You need to use the soil removed from the hole for more tests.
- **Soil Moisture by Feel:** Do this quickly before the soil dries out. If possible, do this for the different depth zones.
- **Temperature:** Shade the hole and take the temperatures for the different depth zones.
- **Crumb (Diameter and Bottle Tests):** Do the crumb tests for the different depth zones next or collect samples.
- **pH Test:** Use the wet Crumb Bottle for the pH test.
- **Color:** Record of the soil color for the different depth zones as you collect the samples
- **Texture (Soil Ball and Finger Rub Tests):** Do these tests for the different depth zones or take samples.
- **Percolation Test:** Do this last as filling the hole with water will make it difficult to do other tests.

Appendix 3
Soil Sample Collecting Methods

Soils can be highly variable over very short distances. Soil thickness can range from 6 mm / ¼ in to about 2.1 m / 6 ½ ft. Soils tend to be thicker in low-lying areas where deposition takes place and thinner on slopes where erosion takes place. Any soil sample is taken from a single spot, a limited sample of the entire world. By taking a large number of samples, you increase the chance of adequately characterizing the soils for a particular site. The fewer samples you take, the more likely you may be to be in error.

Plan a soil sampling survey by picking one item from each major category.							
Sampling Depth		**Sampling Type**		**Sampling Distribution**			
				Line Transect		Pattern	
Shallow	Deep	Spot	Aggregated	Regular	Random	Regular	Random
30-45 cm below the surface	45-100 cm or more below the surface	Soil from a single hole is the sample	Soil from multiple holes is mixed to make one sample	Single or multiple lines with a planned orientation	Single or multiple lines with a randomly selected orientation	Regular shape with a planned orientation	Irregular shape with a randomly selected orientation
Details for these soil sampling methods are presented in Appendix 3 of this document.				See the RTC GSM Basic Recon Line Survey Methods paper.			

SAMPLING DEPTH

Pick the sampling depth suitable to the purpose of the survey. For gardens, shallow sampling is adequate. For siting cool storage facilities or ponds, deeper sampling may be necessary.

Shallow: This sampling depth is where most plant roots are found within 30-45 cm below the surface.

Deep: If you go down to 45-100 cm or more below the surface, this is the depth where about 90% of all plants roots reach.

SAMPLING TYPE

Pick the sampling type suitable to the purpose of the survey. After digging the hole, use a hand trowel to cut a vertical slice of soil from the sidewall of the hole to get a clean face to sample. Then get the actual sample by taking another vertical slice for the depth zone you are sampling.

Spot: The soil sample is taken from a single hole. For gardens or sites with a fairly uniform soil distribution, spot sampling may be suitable. Or, a series of spots can be sampled in the same garden (esp. if the soils vary greatly over a short distance, or the site is on a slope).

Aggregated: Soil samples from many holes on a site are mixed together to get an aggregated "average" soil generalization. This could be a reasonable approach for a small garden with variable soils in the small area. Or it could be a way to save time.

SAMPLING DISTRIBUTION (See the RTC GSM Basic Recon Line Survey Methods paper.)

The key consideration is to find a line / pattern to cover the diverse conditions of the study area or site to get a representative sampling to adequate / accurately portray the soil conditions. Here are some guidelines:

- **Survey at right angles to known linear features.** If you have a stream, ridge line, or known natural feature boundary line (e.g. soils boundary, vegetative boundary, geologic fault, etc.), layout the survey lines to cross these at or nearly at right angles. This will give you the sharpest data contrast in the vicinity of the boundary. [**Note:** Some boundary lines may be more realistically termed “zones” that can be rather broad in contrast to your mental image of a “line”.]
- **High to Low:** Layout survey lines that go up / down slopes as vertical zonation can be significant as elevation changes. If near water bodies, lay out survey lines that extend outward from the water (high concentration of water to less). If you have an area of interest, layout survey lines that radiate outward from the area of interest (high interest to less interest).
- **Offset / stagger line intervals on subsequent surveys.** If you are surveying in an area previously surveys, offset or stagger your survey lines to optimize the data sets. Assuming you can get to the other survey data AND combine it you many be “filling in” gaps and developing a more full map.

Appendix 4:
Soil Color Classification Training Ideas

1.0 CREATING A LOCAL SOIL COLOR CLASSIFICATION KEY

1.1 Individual Judgment

Step 1. The best qualified / experienced person collects samples for the local area. Be sure to get a variety of soil sample colors. Label the samples to properly identify its origin / location.

Step 2. Use the simplified color classification key to create a display showing the samples. This will become the basic visual training reference.

Simplified Soil Color Terms		
Light	**Medium**	**Dark**
White, tan, light yellow	Light red/yellow to brown	Dark brown to dark gray to black
When starting to work in a specific area, collect samples and create a "standard" local color key to help speed the training of local workers. Referring to the key frequently will shorten the learning curve and reduce variance in soil color classification.		

1.2 Group Consensus

Step1. All group members bring in soil samples from around the local area. Each sample should be properly identified as to its source location and the person collecting it.

Step 2. Get the group together. If a local soil color key training display is available, briefly describe the color terms. If not, briefly talk about the simplified standard soil color terms.

Step 3. Then set out three boxes, each labeled for one soil color class. The boxes should be covered but allow a person to place a sample in the box without seeing the contents of the box. Ask each person to place their soil sample into the box they think best matches the color of their sample.

Step 4. Divide the trainees into 3 groups. Each group takes one of the soil color classification boxes. Each group will then examine the samples in the box and separate the samples into one or more groups. The first group is the samples they feel properly match the simplified soil color group. For those not believed to be properly classed, the group should decide which other simplified soil color class should be used.

Step 5. Round 1. Share the results of the 3 groups. This involves a number of discussion rounds. First round, each group presents their findings of the samples they feel truly fit the simplified color class. They are proposing these samples become the local soil color key references. After each group has done this, everyone will vote to agree or disagree with the group consensus. This is the end of Round 1.

Step 6. Round 2. Each group will then share the samples they did NOT include and explain why those samples should go into another simplified soil class. After each group has presented its results, everyone votes, and the samples are put into the "approved" soil color class.

Step 7. Additional discussion rounds can be added as needed until a group consensus produces a local simplified soil color classification reference (standard). [Note: Make use of RTC Learning Logs (See Appendix 5) to get people to focus, reflect and internalize their learning. The Learning Log also gives trainees a chance to ask specific questions about training items they do not clearly understand.

Soil color classification is very subjective. The group consensus training method gives trainees an opportunity to practice interpersonal communications and teamwork. There are so many variables affecting soil color. It is hard to tell what is absolutely correct. So instead of focusing on "correctness", the consensus method results in a simplified standard local soil color classification that may be more "consistent." If at a later date professional soil scientists (agronomists) classify the local soils, any differences in the simplified soil color classes will be more easily resolved.

2.0 SOIL COLOR CLASSIFICATION TRAINING

All training in local soil color classification is based on having a local soil color key. RTC training follows the community-based education method integrating academics, job preparation, practical applied lessons, and teaching back. At the end of each training session (or day), have the participants submit a learning log. Then have the trainers read / review the learning logs with their training team before ending the training session. This is more fully covered in the RTC Community-based Education Guidebook.

2.1 Individual Mentoring: This is a one-on-one trainer / trainee situation.

Step 1. Explain the simplified local soil color classifications using the display samples.

Step 2. Take out past soil samples and have the trainee sort them into the 3 simplified soil color classes. When they can get 70%+ of the samples correctly classified, they can start to collect samples in the field. [**Note:** The trainee should study the misclassified samples in order to improve their proficiency.]

Step 3. The trainee can get soil samples alone on with an experienced trainer. In both cases, they must properly identify the sample origin / location, and attempt to assign a simplified soil color classification to the sample.

Step 4. A more experienced worker reviews the samples with the trainee present. It is important to give "instantaneous" feedback. Discuss any reclassifications with direct reference to the local simplified soil color display. Scores of 70%+ enables the trainee to assist in field projects. Scores of 80-90%+ qualifies them to teach back to others.

2.2 Group / Team Training: There should be a maximum of 10 trainees to 1 trainer. It would be better to limit to 5 trainees to 1 trainer. Dividing a larger group into smaller training teams increases the interaction of all individuals. Participants who are friends / partners should be separated during training. Set up a schedule to also rotate trainers among the trainees. The idea is to get people to mix so as to expand network contacts and encourage diversity. At the end

Step 1. Meet and Greet. Introduce the training staff and have the trainees briefly introduce themselves. Give a brief orientation to the facilities. Summarize the training schedule and reinforce the key training goals. Set up the training teams.

Step 2. Present the Simplified Soil Color Classification. This can be a presentation and discussion an already created local simplified soil color classification, or the stage can be set for creating one by group consensus.

Step 3. Practice Classifying Samples. Have each group practice simplified soil color classification using previously collected samples. When each person on a team scores 70%+, the team goes to the field to collect their own samples.

Step 4. Field Soil Color Classification. In the field, team members each collect soil samples, properly identify the sample's origin / location, and attempts to classify the color. They can discuss among themselves, but only 1 soil color class can be assigned to each sample.

Step 5. Compare to Local Soil Color Reference Display. The group reviews and examines each sample with the local soil color key. If the group scores 70% or more, they have successfully completed the training. Scores of 80-90%+ indicates they are able to train others. Be sure the Learning Logs are completed and reviewed.

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Community-based Education

Appendix 5: Learning Log

Activity: Page __ of __

Community-based Education for Self-Sufficiency and Sustainability for Small Rural Family Farms

Name: ____

Training Topic	What did I learn that was new that I didn't know before? How will I make use of this information? What didn't I understand about this lesson?	Date Reviewed by
Training Topic	What did I learn that was new that I didn't know before? How will I make use of this information? What didn't I understand about this lesson?	Date Reviewed by
Training Topic	What did I learn that was new that I didn't know before? How will I make use of this information? What didn't I understand about this lesson?	Date Reviewed by
Training Topic	What did I learn that was new that I didn't know before? How will I make use of this information? What didn't I understand about this lesson?	Date Reviewed by

Name: ____

Training Topic	What did I learn that was new that I didn't know before? How will I make use of this information? What didn't I understand about this lesson?	Date Reviewed by
Training Topic	What did I learn that was new that I didn't know before? How will I make use of this information? What didn't I understand about this lesson?	Date Reviewed by
Training Topic	What did I learn that was new that I didn't know before? How will I make use of this information? What didn't I understand about this lesson?	Date Reviewed by
Training Topic	What did I learn that was new that I didn't know before? How will I make use of this information? What didn't I understand about this lesson?	Date Reviewed by
Training Topic	What did I learn that was new that I didn't know before? How will I make use of this information? What didn't I understand about this lesson?	Date Reviewed by

Lithosphere: Soils

Appendix 6:
Field Recon Soil Survey Data Log

Community-based Education for Self-Sufficiency and Sustainability for Small Rural Family Farms

Location:					Date:
Collected by			Sample: ☐ Spot ☐ Aggregated		
Slope	Angle	Aspect	☐ Line ☐ Reg ☐ Irreg		Length:
GPS:	Lat	Long	☐ Pattern	☐ Reg	Shape
	Alt	EPE		☐ Irreg	Length

Surface Sample		Color	Texture	Structure	Chemistry
☐ Bag	ID	Visual	Finger Rub / Rope	Crumble ☐ Gd ☐ Pr	Feel %
		☐ Lt ☐ Md ☐ Dk		Compaction	pH

Subsurface Sampling

Worm Count	Depth cm	Depth in	% Moisture	Temp ☐ºF ☐ºC	Crumb Diam ☐ mm ☐ in	Crumb Bottle Good	Crumb Bottle Poor	pH	Color (LMD)	Texture	Percolation ☐Good ☐Poor
	7.5	3									Total Hrs
	15	6									
	22.5	9									
	30	12									

Note: Identify subsurface samples by the hole location and sample depth.
Be sure to have enough soil for gravimetric moisture *and* sedimentation bottle texture tests.
Squeeze out as much air as possible and seal the sample bag tightly. Keep the samples cool and out of the direct sunlight.

Location:					Date:
Collected by			Sample: ☐ Spot ☐ Aggregated		
Slope	Angle	Aspect	☐ Line ☐ Reg ☐ Irreg		Length:
GPS:	Lat	Long	☐ Pattern	☐ Reg	Shape
	Alt	EPE		☐ Irreg	Length

Surface Sample		Color	Texture	Structure	Chemistry
☐ Bag	ID	Visual	Finger Rub / Rope	Crumble ☐ Gd ☐ Pr	Feel %
		☐ Lt ☐ Md ☐ Dk		Compaction	pH

Subsurface Sampling

Worm Count	Depth cm	Depth in	% Moisture	Temp ☐ºF ☐ºC	Crumb Diam ☐ mm ☐ in	Crumb Bottle Good	Crumb Bottle Poor	pH	Color (LMD)	Texture	Percolation ☐Good ☐Poor
	7.5	3									Total Hrs
	15	6									
	22.5	9									
	30	12									

Note: Identify subsurface samples by the hole location and sample depth.
Be sure to have enough soil for gravimetric moisture *and* sedimentation bottle texture tests.
Squeeze out as much air as possible and seal the sample bag tightly. Keep the samples cool and out of the direct sunlight.

Location:					Date:
Collected by			Sample: ☐ Spot ☐ Aggregated		
Slope	Angle	Aspect	☐ Line ☐ Reg ☐ Irreg		Length:
GPS:	Lat	Long	☐ Pattern	☐ Reg	Shape
	Alt	EPE		☐ Irreg	Length

Surface Sample		Color	Texture	Structure	Chemistry
☐ Bag	ID	Visual	Finger Rub / Rope	Crumble ☐ Gd ☐ Pr	Feel %
		☐ Lt ☐ Md ☐ Dk		Compaction	pH

Subsurface Sampling

Worm Count	Depth cm	Depth in	% Moisture	Temp ☐ºF ☐ºC	Crumb Diam ☐ mm ☐ in	Crumb Bottle Good	Crumb Bottle Poor	pH	Color (LMD)	Texture	Percolation ☐Good ☐Poor
	7.5	3									Total Hrs
	15	6									
	22.5	9									
	30	12									

Note: Identify subsurface samples by the hole location and sample depth.
Be sure to have enough soil for gravimetric moisture *and* sedimentation bottle texture tests.
Squeeze out as much air as possible and seal the sample bag tightly. Keep the samples cool and out of the direct sunlight.

Location:					Date:
Collected by			Sample: ☐ Spot ☐ Aggregated		
Slope	Angle	Aspect	☐ Line ☐ Reg ☐ Irreg		Length:
GPS:	Lat	Long	☐ Pattern	☐ Reg	Shape
	Alt	EPE		☐ Irreg	Length

Surface Sample		Color	Texture	Structure	Chemistry
☐ Bag	ID	Visual	Finger Rub / Rope	Crumble ☐ Gd ☐ Pr	Feel %
		☐ Lt ☐ Md ☐ Dk		Compaction	pH

Subsurface Sampling

Worm Count	Depth cm	Depth in	% Moisture	Temp ☐ºF ☐ºC	Crumb Diam ☐ mm ☐ in	Crumb Bottle Good	Crumb Bottle Poor	pH	Color (LMD)	Texture	Percolation ☐Good ☐Poor
	7.5	3									Total Hrs
	15	6									
	22.5	9									
	30	12									

Note: Identify subsurface samples by the hole location and sample depth.
Be sure to have enough soil for gravimetric moisture *and* sedimentation bottle texture tests.
Squeeze out as much air as possible and seal the sample bag tightly. Keep the samples cool and out of the direct sunlight.

Lithosphere: Soils

Appendix 7:
Soil Survey Lab Data Log

Community-based Education for Self-Sufficiency and Sustainability for Small Rural Family Farms

Location:				Date:
Sample ID:			Collected by	
Sample Type: ☐ Surface ☐ Subsurface	Depth		:	
Lab Work Requested for	Color	Texture	Structure	Chemistry
	☐ Field not done ☐ Confirm field test	☐ Field not done ☐ Confirm field test	☐ Field not done ☐ Confirm field test	☐ Field not done ☐ Confirm field test
Lab Results	L M D		☐ Good ☐ Poor	pH % Moisture

Texture				Structure		Chemistry	
Soil Ball				Crumb Diameter	Crumb Bottle ☐ Good ☐ Poor	pH	
Finger Rub						Moisture	
Sedimentation Bottle						Feel	
Time Estimate	Sediment Layer	Thickness ☐ mm ☐ in	% of Sample			Gravimetric Moisture	☐ Oven Dry ☐ Air Dry
1-2 days	D. Total ht		100%			Dry wt	
	C. Clay					Wet wt	
1-2 hrs	B. Silt					Diff	
1-2 min	A. Sand					% Moisture	

Notes:

Appendix 8: Soil Fines Sample Card

Soil fines (e.g. sand, silt, and clay particles) indicate something about the weathering conditions that helped make the soil.

Term	Description	Process	Some Locations
Angular	Flat sides, sharp corners,	Relative young material separated from parent material.	Mountains and arid regions
Subangular	Flat sides, corners not pointed	Exposed to some weathering but for a short time or infrequent exposure.	Talus slopes
Subrounded	Sides not so flat, corners rounded	More exposure to weathering	Flood plains
Rounded	No flat sides, no corners	Usually due to flowing water	River channels
Well Rounded	Almost spherical	Usually due to wave action.	Lake shores or coasts

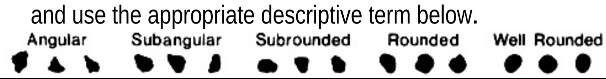
Soil Fines Sample Card

Site Location: Date

Collected by

Step 1. Get a sample of dry surface fines and glue it to card.
Step 2. Record the sample location within the Study Site.
Step 3. Classify the soil texture by touch.
Step 4. Classify the general soil color.

Step 5. Note the grading of the sample.
Step 6. Use a magnifying glass to examine the particle shapes and use the appropriate descriptive term below.



Sample A	Sample B	Sample C	Sample D	Sample E
Location	Location	Location	Location	Location
☐ Sand ☐ Silt ☐ Clay	☐ Sand ☐ Silt ☐ Clay	☐ Sand ☐ Silt ☐ Clay	☐ Sand ☐ Silt ☐ Clay	☐ Sand ☐ Silt ☐ Clay
Color:☐ Lt ☐ Md ☐ Drk	Color:☐ Lt ☐ Md ☐ Drk	Color:☐ Lt ☐ Md ☐ Drk	Color:☐ Lt ☐ Md ☐ Drk	Color:☐ Lt ☐ Md ☐ Drk
☐ Sorted ☐ Unsorted	☐ Sorted ☐ Unsorted	☐ Sorted ☐ Unsorted	☐ Sorted ☐ Unsorted	☐ Sorted ☐ Unsorted
☐ Angular ☐ Subangular ☐ Subrounded ☐ Rounded ☐ Well-rounded	☐ Angular ☐ Subangular ☐ Subrounded ☐ Rounded ☐ Well-rounded	☐ Angular ☐ Subangular ☐ Subrounded ☐ Rounded ☐ Well-rounded	☐ Angular ☐ Subangular ☐ Subrounded ☐ Rounded ☐ Well-rounded	☐ Angular ☐ Subangular ☐ Subrounded ☐ Rounded ☐ Well-rounded