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STUDY #286: Selected Physical Properties of California Soils Prior to Broadcast or Bedded Fumigation Treatments

July 2013

Introduction

Fumigation of agricultural fields involves introduction into the soil of volatile pesticides. Common fumigation methods include injection using steel shanks or in solution through drip irrigation. These applications create ground-level area sources that emit fumigants into the atmosphere. After application of a fumigant, flux density follows a typical pattern. An initial and relatively abrupt increase is followed by a long tailing decrease. This pattern is affected by the type of pesticide applied, micro-meteorological weather conditions, diurnal temperature changes, soil physical and chemical properties, as well as soil management practices (Sullivan and Ajwa, 2011; Yates et al., 2011).

Variables such as soil bulk density, porosity, and water content are used as initial condition parameters in mechanistic models, i.e. HYDRUS 2D/3D (Šimůnek et al., 2011). This model is designed to predict soil, water, or soil air fumigant concentrations based on the physical-chemical properties of a soil fumigant (Spurlock et al., 2013). The HYDRUS 2D/3D model is capable of simulating 2- or 3- dimensional fumigant fate and transport in complex geometrical domains, and can simulate multiple volatilization boundary conditions (Kandelous et al., 2011). In a model validation where 1,3-dichloropropene and chloropicrin were shank-applied in three nearby fields, HYDRUS 2D/3D realistically characterized fumigant dispersion in the vadose zone and provided adequate estimates of both maximum period and cumulative flux densities (Spurlock et al. 2013).

As DPR staff gain confidence in the use of HYDRUS 2D/3D, the model will be used for estimating flux under conditions which vary from those conditions used to validate the model. For example, Spurlock (2013) used HYDRUS 2D/3D to estimate the effect on chloropicrin flux density of greater injection depth, post-application irrigations and strip versus broadcast tarp. The conditions used for these simulations largely reflected the conditions found in the Lost Hills study. However, some sensitivity analysis by Spurlock (2013) led to the conclusion that the impact of depth on flux density depended on initial soil water content.

A single modeling scenario should not be used to represent the many diverse conditions present during fumigant applications in California fields. This is especially true if decisions based on modeling will be made for buffer zone distances, buffer zone duration and related restrictions on the use of fumigants. Such restrictions must ensure a high level of safety over many different field conditions. On the other hand, the multitude of possible parameter variations representing the varying fumigant application conditions is nearly limitless.

The sensitivity of HYDRUS 2D/3D flux density estimates was studied in relation to various partition coefficients, diffusion coefficients, activation energies, temperature amplitudes, degradation rates, bulk density, initial soil water content and saturated water content (Spurlock et al. 2013). The most sensitive variables for shank broadcast or bed applications were saturated soil water content, initial soil water content and bulk density (Spurlock et al. 2013). For drip applications, simulated flux densities were also sensitive to saturated hydraulic conductivity.

This study will sample the range of initial soil water and bulk density conditions in fields that have been prepared for either shank broadcast applications or bedded fumigations, for either drip or shank injection. Broadcast and bedded applications pose different sampling problems and will be described in different sections. The common goal for both bedded and broadcast applications is to describe the variability in application conditions and the resulting variability in flux density patterns.

The variability will be described using conventional descriptive statistical methods such as estimation of mean, variance and fitting distributions to measured values. These initial soil water and bulk density conditions will be modeled using HYDRUS 2D/3D in order to also assess the resulting variability in flux density estimates. Quantifying the flux density variability will help set a lower bound on the variability one could expect in commercial applications. Soil water content, bulk density and particle density are the measured variables and will be used for modeling by calculating saturated water content as a proxy for total void space.

$$\theta_{sat} = 1 - \frac{\rho_{bd}}{\rho_{pd}}$$

where θ_{sat} is the saturated pore volume, ρ_{bd} is bulk density and ρ_{pd} is the particle density. Particle density for a mineral soil is usually estimated at 2.65 g/cm3 (Freeze and Cherry 1979). Variability in ρ_{pd} and the resulting variability in θ_{sat} will be estimated in this study.

Soil water content at time of application and saturated soil water content (total pore space) both had larger impacts on flux density estimates by HYDRUS 2D/3D (Spurlock et al. 2013). .

Johnson and Spurlock (2009) found that most fumigant applications in California are in just four similar texture classes: loam, loamy sand, sandy loam and sand. While it would be desirable to ensure sampling from all four texture classes, the sampling logistics may limit the texture classes sampled.

Objectives

Phase I

The main objective of the Phase I portion of the study for both broadcast and bedded applications is to sample soil from fields which have been prepared for fumigant

applications and measure soil bulk density, initial water content and the derived parameter of saturated water content. Additional sampling at a more aggregated scale will occur for soil texture class and particle density by depth for each sampled field. Descriptive information about the intended application will also be collected. This descriptive information is detailed below.

Phase II

For this phase of the study, the main objective is to create a standard modeling scenario with HYDRUS 2D/3D which utilizes the sampling data from Phase I. Each simulation will reflect a sampling location as defined by the measured initial water contents, bulk densities and saturated water content. The variability in resulting maximum six hour flux and cumulative fluxes will be determined. The between field and within field variability will be estimated.

Analysis objectives include (1) characterizing the distributions of soil bulk density (2) saturated water content (3) initial water content and the HYDRUS modeling derived distributions of (4) maximum period flux density (5) cumulative flux density.

A secondary analysis objective will be to compare within field to between field variability, both for the bulk density, initial water content and saturated water content. Analogously, the between- and within-field variance of maximum flux densities and cumulative flux densities will be compared. For the bedded applications, there are several hypotheses to test: (1) is the bulk density in the center of the bed different than the bulk density closer to the edge (2) is the bulk density on the bed surface different than in the interior (3) is the bulk density in the furrow different than the bulk density in the bed.

Additional statistical questions may arise which reflect groupings based on the descriptive information that will be collected for each field. For example, broadcast application fields may be classified based on the depth of application because there are obvious differences between these fields.

Personnel Responsibilities and Timeline

The Environmental Monitoring (EM) Branch will conduct this study, under the overall supervision of Randy Segawa and Pam Wofford, following the timeline reported in the table below.

Tasks	Timeline	Personnel by task
Soil sampling†	May-July 2013	Bruce Johnson, Fabio Sartori, and Atac Tuli
Laboratory analyses	September-October 2013	Fabio Sartori
Data analysis and simulation modeling	November 2013-February 2014	Bruce Johnson and Frank Spurlock
Report Preparation	March 2014-June 2014	Bruce Johnson, Fabio Sartori, and Frank Spurlock

†Sampling will be conducted in groups of two people (three crews), and each group will always include one of the listed personnel.

Dr. Bruce Johnson will act as project leader and Dr. Fabio Sartori as field and laboratory coordinator. Drs. Fabio Sartori, Bruce Johnson, and Atac Tuli will lead the sampling effort of three two-people field crews: each of them will be assisted by another field worker from EM branch during sampling. Dr. Fabio Sartori will perform most of the laboratory analyses with the assistance of a scientific aid from the EM Branch. Drs. Bruce Johnson and Frank Spurlock will be responsible for data analyses and simulation modeling. Please direct questions regarding this study to Pamela Wofford (e-mail: Pam.Wofford@cdpr.ca.gov).

Study Plan

Soil Sampling

For each category of fields, i.e. bedded or non-bedded fields, twenty or more agricultural fields will be sampled. Non-bedded field should be completely prepared and ready to be fumigated. Most bedded applications are generally tarped. For shank-bedded applications the tarping is applied during application. For drip applications, the field is prepared with or without beds, drip lines and tarp. The application may or may not have taken place when the soil sampling commences. For both kinds of bed applications, this study may require a sacrificial blank row, which has no fumigant applied. For drip applications, there should be no drip line in this blank row, but should otherwise be tarped and prepared like the beds that will be applied. For shank bedded applications, the only difference between the blank and treated beds will be the lack of fumigant injection in the blank (e.g. the shank(s) should be dragged through the bed with no injection, but the other bed forming and tarping procedures will be the same as in the treated beds). The soil sampling will be accomplished with the assistance of the County agricultural commissioners within the Central California Coastal Valleys where dominant soil orders are Alfisols, Entisols, Mollisols, and Vertisols, and the Sacramento and San Joaquin Valleys (Alfisols, Aridisols, Entisols, Mollisols, and Vertisols) (USDA-NRCS, 2006).

Computer Modeling

For broadcast applications, a modeling scenario will be constructed including daily temperature, depth of application, a generic fumigant, and related variables. This scenario will be modified by using the measured bulk densities, soil moisture and the derived variable saturated water content. Each sampling location will be simulated and two particular resulting estimates will be analyzed: maximum 6 hour flux and cumulative flux. For bedded applications, the bed geometries resulting from the sampling will be used to construct a standard bed modeling scenario. This standard bed scenario will be modified using the measured bulk densities, soil moisture and derived saturated water content parameters measured at each location. The resulting maximum 6 hour flux and cumulative flux estimates will be analyzed.

Field Information

The following information about site history, characteristics, and management will be collected for each field (bedded and non-bedded).

1. Date of soil sampling

2. Intended date of fumigation

3. Crop to be planted

4. Field size

5. GPS coordinates of corners for each field

6. Tillage operations (e.g., combination of ripper/chisel/disk).

7. Depth of cultivation

8. Last irrigation and amount

9. Bedded or broadcast application

10. Drip or shank application

11. Other relevant past management practices

12. For bedded applications only, further information will be recorded:

- Bed dimensions: bottom and top width, height, and center-to-center distance (Fig. 1)
- Tuck in depth (depth of tarp edge into soil)

Application Information

The following information about the specific application (bedded and non-bedded) will be collected for each field.

13. Fumigant (formulated product)

14. Intended application rate

15. Depth of application

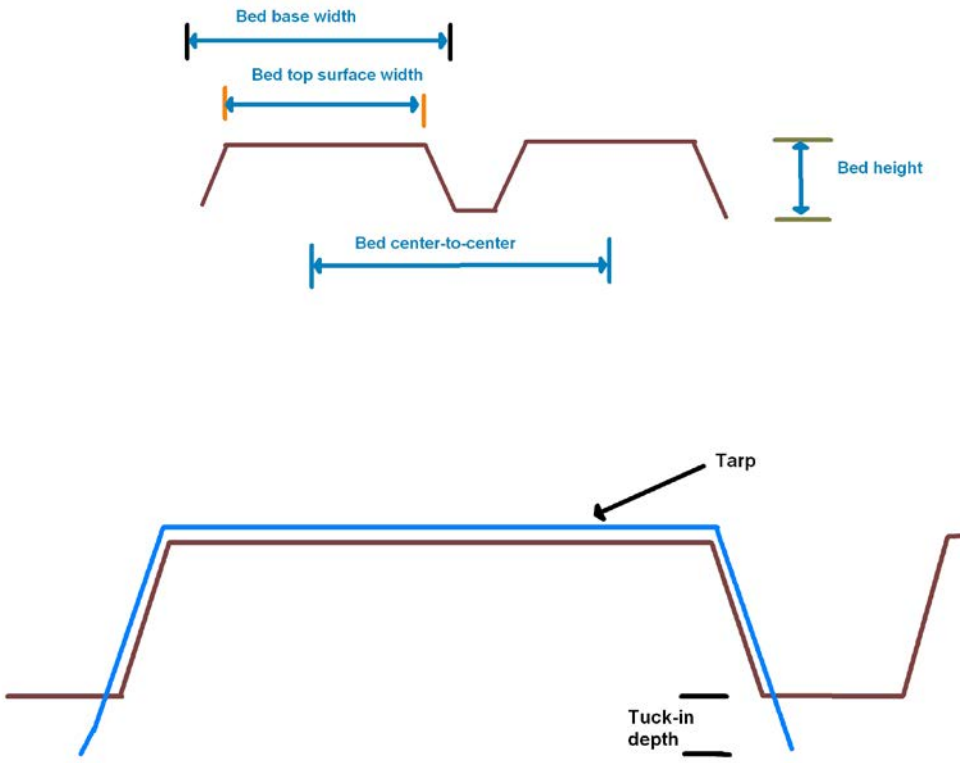
16. For shank applications, number and spacing of shanks

17. Tarp type

18. For broadcast applications only, further information will be recorded (if available)

- Intended tarp width
- Intended tarp glued seam width

Figure 1. Schematics of the bed dimensions of interest for site description information.



Soil Sampling and Laboratory Analyses

Broadcast (non-bedded) Fumigations

Each broadcast field will be divided into approximately four equal quadrants (Fig. 2): Two sets of soil samples representative of three depth increments will be collected in two randomly selected sampling points of each quadrant. Each sampling point will be geo-referenced for comparison to the corresponding USDA NRCS soil maps. Appendix 1 details the procedures for field delineation and determination of sampling locations within the field.

On the day before application, soil samples (first set) will be collected using a 5-cm diameter by 5-cm high brass core from each selected location vertically centered within the 0- to 10-, 10- to 30-, 30- to 50-cm depth increments ($n = 8 \times 3$ per plot, resulting in 24 samples per plot). Near one of the two sampling points within each quadrant, mineral soil samples (second set) will be collected, split, and composited by depth increment ($n = 4 \times 3$ per plot, resulting in 3 composited samples per plot), using a 6.7-cm diameter stainless steel soil probe with internal liner and slide hammer. Two or three additional locations per field may also be sampled to gather a sufficient soil mass for laboratory analyses, if the soil bulk densities of the selected fields are relatively low. Appendix 2 provides detailed information on soil sampling both for bulk density and bulk samples.

The first will set will be returned to the laboratory to estimate bulk density and initial soil-water content after drying at 105 ºC to constant weight. The second set will be returned to the laboratory under ice, air dried, and passed through a 2-mm sieve prior to analysis to determine soil particle size analysis, using the hydrometer method (Gee and Or, 2002), and particle density using the volumetric flask method (Flint and Flint, 2002). The remainder of bulk samples after analysis will be archived for future studies.

Bedded Fumigations

For bedded fumigations, an extra bed may need to be created in which no fumigant is applied and which has been cultivated and tarped and shaped identical to the other beds. Generally, for shanked bedded applications, tarping and bed shaping occur with the application. Hence, sampling of the soil will have to occur after the application. For bedded drip applications, soil sampling may occur before or after the application since the start of application occurs after the beds have been formed and the tarp has been laid down. It would be preferable to sample before the application. In either case, a blank bed which has been prepared identically to the treatment beds may need to be provided in order to allow for the destruction of the tarp and bed due to the soil sampling.

Soil sampling of the beds will follow a similar procedure as described before, although modified to capture the properties of the soil material at bed sides, collecting two sets of soil samples. The bed to be sampled will be divided into approximately four equal lengths. Within each quarter, a transect will be randomly located (Fig. 3). In each transect, samples representative of the 0–10 cm, 10–30 cm, and 30–50 cm depth increments will be collected using a 5-cm diameter by 5.1-cm high brass core (first set) in three locations: (1) center of the bed, (2) one-fourth of the distance from center to edge, and (3) center of the furrow. In addition, two samples, one for each side, will be taken perpendicular to the side surface of the bed at about the midpoint representative of the 0-10 cm depth from the tarp surface towards the bed interior (11 samples per transect × 4 locations = 44 samples per field). Soil samples will also be collected using a 6.7-cm diameter stainless steel soil probe with internal liner and slide hammer (second set) from near each of the four transects at the center of the bed and representative of the same depth increments. These four bulk samples will be composited by depth increment (3 composited samples per field). Two or three additional locations per field may also be sampled to gather a sufficient soil mass for laboratory analyses, if the soil bulk densities of the selected fields are relatively low. (A closed bucket auger may be used in place of the soil probe as described in Appendix X.) The first and second sets will be returned to the laboratory and analyzed as described for the broadcast case.

Figure 2. Schematics of the soil sampling scheme in non-bedded agricultural fields (top), and of the corresponding sampling depth increments (bottom).

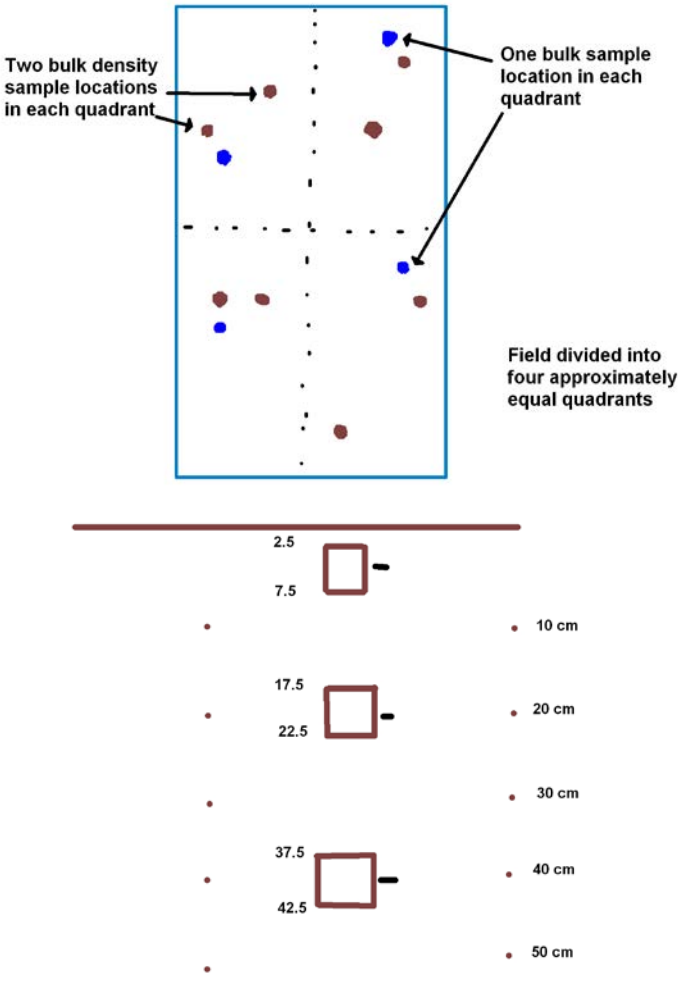
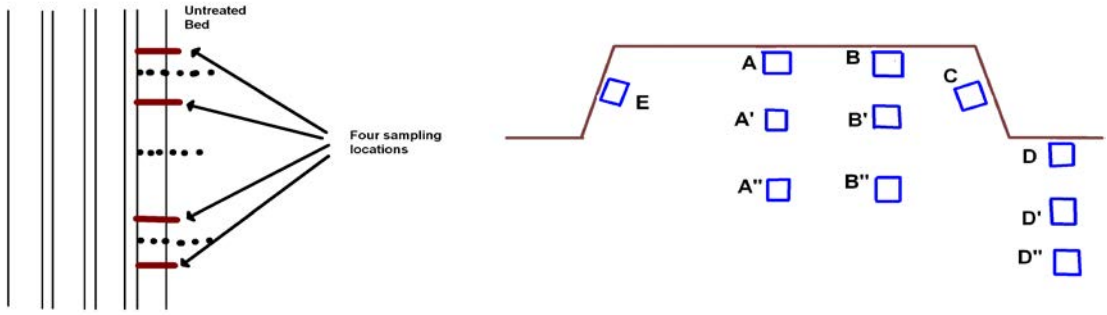


Figure 3. Schematics of the sampling transects (left) and corresponding sampling points at different depths (left) for the soil sampling scheme in bedded fields. Dotted lines on left represent division of bed into four approximately equal lengths and solid lines are randomly selected sampling locations within each quarter bed.



Data Analysis and Simulation Modeling

The primary statistical focus will be characterizing the distribution of soil moisture, bulk density and saturated water content. Additional ANOVA statistical analysis will be used to compare between- and within-field variability and address specific hypotheses. Retrospective analysis may be used to investigate relationships between recorded additional information and the measured soil variables.

For broadcast field sampling, a mixed model ANOVA in SAS PROC MIXED will be used to quantify the mount of variation due to (1) field to field (2) quarter to quarter (3) sample to sample and the impact of depth on bulk density, soil moisture and the derived variable of saturated water content (Willits, 2013). Field, quarter and sample are random effects. Depth is a fixed effect.

For the bedded field sampling, an initial analysis will determine if the measurements satisfy the assumptions of normality and constant residual variance. Assuming these assumptions can be satisfied, then a similar mixed analysis (SAS PROC MIXED) will be used to test differences among measured variables at the five surface sampling locations (A,B,C,D,E), differences between the three mid-deep samples (A',B',D'), differences between the deepest samples (A'',B'',D'') and then a factorial structure for the effects of location and depth (AA'A'', BB'B'', DD'D''). The field effect and quarter bed are random effects. Surface locations, mid-depth and deepest depth locations, and depth are fixed effects.

For both broadcast and bedded applications, the texture analysis will be compared to soil survey data. The particle density variability will also be analyzed. Each field (either broadcast or bedded) will yield 3 particle density estimates, one for each depth. This analysis will be a non-replicated field x depth.

For the broadcast (non-bedded) samples, the HYDRUS 2D/3D model will be used to simulate each vertical sample location consisting of three depths and the associated bulk density, saturated water content and initial water content. The maximum 6 hour flux density and cumulative flux fractions will be analyzed. As in the case of the soil measurements, the primary focus will be characterizing the variability of these two flux measures. For the bedded samples HYDRUS 2D/3D will be used to simulate a standardized bedded scenario. The measured bulk densities, soil moistures and derived saturated water content measures at each sampling location will be incorporated and modeled. The maximum 6 hour flux density and cumulative flux fractions will be analyzed. A mixed model ANOVA will be used, similar to that in Phase 1, except that the analysis will be simplified to field x location since the various localized individual measurements will be integrated by HYDRUS to produce the volatilization estimate at each location. In this case, the variability at the hierarchical level (broadcast: field, quarter, location; bedded: field, location) will be calculated. The between field vs. within field variability will be tested. Retrospective analysis may be used to look for relationships between the two flux measures and the supplementary field information.

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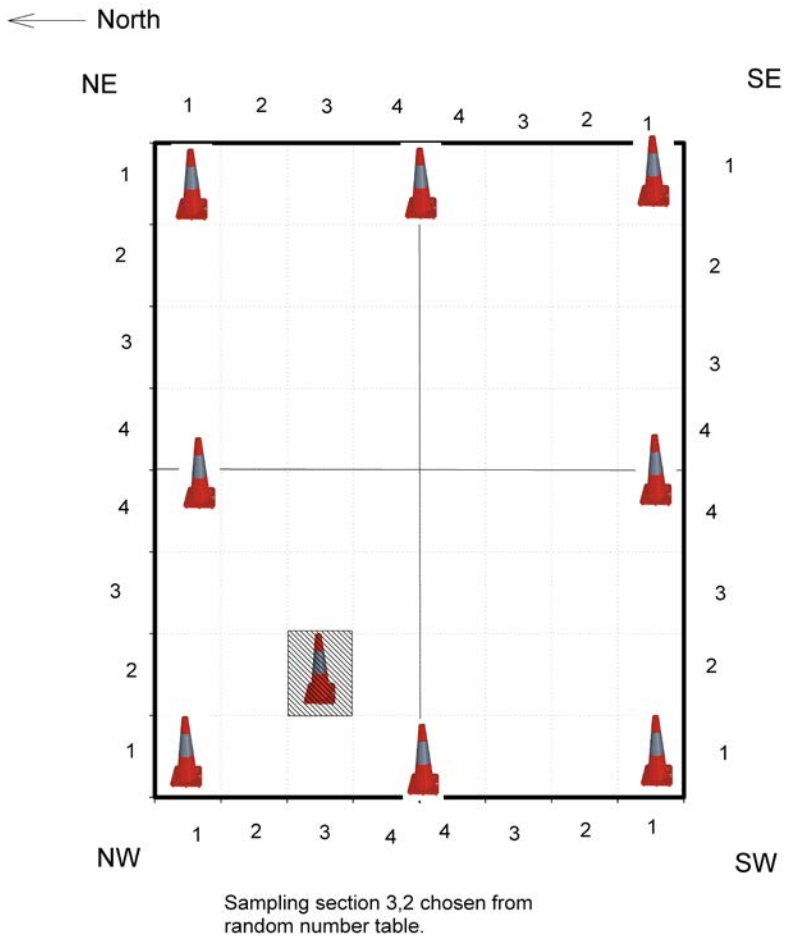
Appendix 1. Narrative for field delineation and location of samples within field for non-bedded applications (rev 130626).

1. Fill out the data sheet as much as possible before sampling.
2. Drive to a field corner and orient yourself with respect to North/South, East/West.
3. Place a bright orange cone on the field near the corner.
4. Record the GPS location in UTM (see other side).
5. Drive towards the next corner and judge the half-way point. At the half-way point, set a bright orange cone on the field near the road to mark the halfway point of that side.
6. Continue to the corner. Set a bright orange cone near the corner and record the GPS location in UTM.
7. Drive toward the next corner and set a cone at the half way point.
8. Continue to the third corner and set a cone there and record the GPS location.
9. Continue this procedure until you return to the first corner. You should have recorded a GPS location for each of four corners and 8 cones placed at the corners and at the midpoints of the sides of the field.



Sampling section 3,2 chosen from random number table.

10. At the first corner, consult the random number table (pairs of digits, each digit is from 1 to 4) and select a pair, say based on the date: eg. If sampling on the 16th day of June, chose the 16th pair and for the next location on that sampling day chose the 17th pair, and the 18th pair for the next location and so on. The date just gives you a starting point in the table. Cycle up to the top if you're at the end of the table.
11. Mentally divide the distance to each of the side midpoints into four equal lengths, and mentally number them 1 2 3 4. Using the coordinates 1-4 along each side of this quadrant, go out to the point in the field based on the random digits, set down a cone (or wooden stake) and record the GPS location.
12. Obtain the bulk density/soil moisture and bulk samples near this stake.

13. Obtain the next random number pair from the table, and go to that rectangle within the same quadrant, mark with a cone or stake, and record the GPS location and obtain bulk density/soil moisture samples near this stake (2 bulk density/soil moisture samples and 1 bulk sample per quadrant).
14. Return to the vehicle, make sure you retrieve all of your equipment (especially small pins, soil knives), drive to the next corner and repeat this process, moving from quadrant to quadrant.
15. After taking all soil samples, drive back around the field to retrieve the cones.

Random Number Table

Day	1st Ran Num	2nd Ran Num
1	3	2
2	1	2
3	4	1
4	2	4
5	4	2
6	2	2
7	1	1
8	4	1
9	3	1
10	2	4
11	1	4
12	4	1
13	4	2
14	3	2
15	3	2
16	1	2
17	2	4
18	1	4
19	3	1
20	1	2
21	2	4
22	1	2
23	4	1
24	2	3
25	4	3
26	4	1
27	3	4
28	4	4
29	2	2
30	2	3
31	2	4

The **Garmin GPSmap76S** should be set up showing units in meters, 24 hour time, UTM coordinates ("UTM UPS" in the options), and the WGS84 datum. If you think these are not the current settings, get someone who knows the machine to set it up with those options.

Here are the steps to getting a reading.

1. Turn on (red button lightbulb icon)
2. Press "Page" key until you get to screen that will probably say "Acquiring Satellites" (see figure below).
3. Point unit to sky.
4. Eventually, you should get set of symbols and numbers at the bottom below the date/time (in the Figure these are dashes before position is acquired). The symbols and numbers will look like this:

   10 S 0604328
   UTM 4265721

5. It's possible that there will be an "11", instead of a "10". The "S" does NOT stand for south, but it will always be an S (for California locations). The first number is the easting in meters and the second number is the northing in meters.
6. When you record the first GPS location for a field (say a corner), write down the 10 S (or 11 S). But after that, you only need to record the

When initializing the receiver or trying to receive satellite signals, orient the GPSMAP 76S so the top of the unit points toward the sky. If the unit is held with the top of the unit pointed toward the horizon, satellite reception may be severly degraded.

showing there.

e in on an odd screen, press "MENU" twice, uter", press "ENTER" and then "PAGE" to get to TM coordinates.

ff, press and hold the red lightbulb icon key.

Appendix 2. Detailed soil sampling instructions.

Soil Sampling Protocol for Soil Variability Study

Below is a summary of the important points to remember when collecting soil samples using the soil bulk density sampler, the direct push probe with slide hammer, or the closed bucket auger.

Bulk Density Sampling

From each of the selected 8 locations (2 per quadrant), collect a 5-cm diameter by 5-cm stainless steel core vertically centered within the 0- to 10-, 10- to 30-, 30- to 50-cm depth increments (n = 8 × 3 per plot, resulting in 24 samples per plot).

1. Main goal is to collect an intact core that is representative of the 0–10 cm, 10–30 cm, and 30–50 cm depth increment.

2. For this reason, the top edge of the 5-cm long, numbered stainless steel cylinder needs to be driven to a depth of 2.5 cm, 17.5 cm, or 37.5 cm depth, using the closed ring holder connected to the extension with beating handle and the impact-absorbing hammer when necessary.

3. Use the closed bucket auger to dig a borehole to a depth near the desired sampling depth, i.e. 2–3 cm less, and the long shovel to enlarge the hole and create a small soil pit.

4. Repeat step 3 until the desired soil depth is reached and a clear surface at the bottom of the soil pit is obtained.

5. Collect the sample using the bulk density sampler.

6. Repeat steps 1–5 for each sampling depth by selecting, three adjacent sampling points within the same sampling location (within about 50 cm).

7. Always fill in the holes created by the sampling and level the soil surface before moving to the next sampling location.

Soil Probe sampling

Near one of the two sampling locations within each quadrant, collect soil samples composited by depth (n = 4 locations × 3 depths per plot, resulting in 3 composited samples per field), using the 6.7-cm diameter stainless steel soil probe with internal liner and slide hammer.

1. Using a black Sharpie pen, mark on the plastic soil tube liner 10 cm increments from the bottom part of the tube up until 70 cm, and the steel tube at 50 cm depth.

2. Assemble the probe once the sampling point has been identified by connecting (1) the drive head assembly to the steel tube (securing it with the drive head pin), and (2) the slide hammer to the drive head assembly.

3. Drive the probe to 50 cm depth.

4. Retrieve the probe by (1) loosening the soil around it with the long shovel, (2) gently rocking the probe from side to side prior, and (3) pulling it up while the probe is oriented horizontally.

5. Split the collected soil core into the 0–10 cm, 10–30 cm, and 30–50 cm depth increments, by collecting them in reverse order, i.e. starting from the bottom of the plastic liner.

6. Always fill in the holes or pits created by the sampling and level the soil surface before moving to the next sampling location.

Instructions to collect soil samples using a stainless steel closed-bucket auger

Objective of sampling: Collect samples for a general characterization of soil properties (e.g., soil total, organic, and inorganic carbon and textural analysis).

Quality of sampling: This is a rapid sampling method that is suitable when a general characterization of soil properties at a plot level is needed. Other methods are generally required for more specific laboratory soil analysis and sampling designs.

Basic tools and supplies:

- Bucket auger with extension and handle bar
- General purpose tarp
- One-gallon, freezer plastic bags
- Coolers to store samples
- Measuring tape
- Black Sharpie markers
- Adjustable or regular wrench for the auger
- Stainless steel wool pads
- Leatherman multi-tool or equivalent
- Clipboard
- Small backpack
- Ice packages
- Leather gloves
- Long shovel

1. Select the sampling point and unfold tarp in vicinity to form a long tarp strip. Using a Sharpie marker and colored tape mark on the auger bucket and extension the sampling depths of interest, i.e. 0–10 cm, 10-30 cm, and 30–50 cm depth. (Set the reference point at the end of one of the two blades.)

2. Make sure that the tarp is clean without any soil or other materials that may contaminate your samples. Properly label the plastic bags needed using a black Sharpie, indicating date, your initials, site and plot ID, and soil depth increment.

3. Prior to start, gently remove any litter material that is not part of the mineral soil, such as decomposing leaves, stems, or any sort of organic residues.

4. Sample the surface layer (e.g., 0–10 cm) rotating the auger while applying pressure. Generally for a 3 1/4'' diameter auger, three separate, full buckets are required to complete one 0–20 cm depth increment. Use the different marks to identify when you have reached a certain sampling depth.

5. Fill the auger's bucket without overflowing it and avoid any possible loss of sample.

6. Maintain your body in an erect position as much as possible using your legs to avoid injuries to your back.

7. Gently retrieve the auger and move a few feet away from the tarp. Using your hands and/or a stainless steel wool pad, wipe away any soil that has stuck on the outside of the bucket, extension, or handles.

8. Place your sample on the tarp by lowering the auger near the tarp and tapping on the auger's extension. Pour your sample from the top (and/or bottom) of the bucket.


9. Create a small pile of soil corresponding to the 0–10 cm depth increment. Repeat the same procedure for the 10–30 cm and 30–50 cm depth increment, proceeding until the whole 0–20 depth increment has been collected. For each depth increment and maintain sufficient distance among the individual piles to avoid mixing samples from different depth increments.

10. Use your hands to homogenize each pile and obtain a well representative sample. Collect part of the homogenized sample and place it in the corresponding, labeled plastic bag. The collection at each of the desired locations should lead to fill your 1-gal bag from ½ up to a maximum of ¾ its volume. Seal the bag to avoid loss and contamination during transport. Store your samples in a cooler under ice until samples are returned to the lab or in a storage facility to air dry.

11. Fill up completely the hole with the soil remaining on the tarp and make the surface level.


Important Note: After the initial surface sample has been collected, it is important to toss away any soil that has fallen into the hole from higher layers while the auger was either being inserted into or extracted from the hole. For example, while sampling the 30–50 cm depth increment (see adjacent picture), top soil layer inside the bucket (white arrows) fell from the sides and needs to be tossed away, prior to placing the "real" 30–50 cm sample on the tarp.