LTER Resource Gradient Experiment

Decagon soil porewater sampler (lysimeter) installation notes

April 2014
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Updated 27 May 2014
Contents

1. Equipment details
   – Lysimeter specs
   – Sample bottles
   – Access boxes
   – Equipment checklist
2. Experimental design (Resource gradient, plot layouts
   – LTER resource gradient
   – Layout of probes and boxes
3. Installation schematics & calculations
   – How we used the Geoprobe
   – Geometry for each lysimeter depth (3)
   – Birds eye view of plots
4. Step by step instructions
5. Resources
Decagon Devices SIC20

- Chosen for:
  - Long lifetime
  - Not a porcelain cup, which is known for leaching Ca\(^{2+}\).
  - This silicon-carbide cup was recommended for our interest in measuring HCO\(_3^-\), Ca\(^{2+}\), PO\(_4^{2-}\), NH\(_4^+\), (and NO\(_3^-\); most cups are good at measuring—if not designed for measuring—NO\(_3^-\)).
  - $300 each
  - PREPARATION: Before installation all lysimeters were soaked in lab purified DI for 2 days (in a Brute trash can scrubbed with alconox and thoroughly rinsed) then we drew a vacuum (0.5 bar) to saturate cup pores and to confirm water was moving into the cups (saw water moving into the tubing) for at least 3 days prior to installation. They were installed with vacuum released but still holding DI water in tubing (and assuming in the cup) as per instruction manual, will discard first 1000 mL of produced water

### 10.1 Technical specifications

<table>
<thead>
<tr>
<th>Technical Specifications SIC20</th>
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<tbody>
<tr>
<td><strong>Shaft</strong></td>
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<tr>
<td><strong>Extraction tube</strong></td>
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<tr>
<td><strong>Protective tube</strong></td>
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<tr>
<td><strong>Cup type</strong></td>
</tr>
<tr>
<td><strong>Cup size</strong></td>
</tr>
<tr>
<td><strong>Active surface</strong></td>
</tr>
<tr>
<td><strong>Filling volume</strong></td>
</tr>
<tr>
<td><strong>Cup porosity</strong></td>
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<tr>
<td><strong>Pore size</strong></td>
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</table>
Bonnie McGill:
“Bottle dimensions: As you can see from the attached photo from Decagon, the bottles need 11-12" height to accommodate the bending tubing. They are 4" diameter, 1000-mL glass bottles.”

Decagon: Bottle volume should be at least 3X desired water sample volume.

$50 each
Access boxes for sample bottles

- One for each plot
  - ten boxes (see plot map above)
  - Fits three sample bottles
  - Tubing from lysimeters will come up through the bottom of the box
  - Each ~100 lb
- Needs to withstand heavy loads
- Oldcastle model GO5 box and lid:
  - heavy duty; 10.4” ID, ~11” inside ht.
    Cost $63 incl. lid. +shipping, ~$200 for 10 boxes and lids (got them delivered directly to the FSC).
  - Hole for box lined with pea gravel to deter mice
  - Slid PVC over tubing before installing box to protect it from the weight of the box (as it passes under the edge of the box into the inside of the box)
  - $37 per box, $26 per lid = $63 total per unit
Equipment checklist for installation

- Make sure the Geoprobe is available, assembled, and its generator has gas.

Geoprobe equipment:
- 4x 1” outer diameter, 4’ (1.22 m) long extensions (borrowed 3 from Superior Environmental—contact info last slide)
- Driving point
- Pull cap (borrowed from Superior Environmental)
- Hammer cap
- Strap wrenches, wrench, silicon spray in case extensions get stuck together

Sledge hammer (Hamilton lab)

KBS stock room:
- 3x 30 m tapes (stock room)
- 1x metal retractable m tape (stock room)
- 3x Hand trowels
- Plastic pin flags (1 per probe)
- 2x surveying pins

Farming Systems Center (Joe Simmons):
- Ground spray paint & twine (FSC)
- Trench shovels (FSC)—more shovels available from Physical Plant
- Rake
- Hearing protection

Magnetic angle measurer (Kevin Kahmark)

- 3 different colors lab tape for marking extensions and steel rod @ 3 different depths

Work gloves

Cardboard or tarp to lay out soil strata from pits

Black sharpies

Hamilton Lab garage:
- Wooden angle guide for Geoprobe foot (3 pieces)
- Aluminum and Steel rods (20 mm outer diameter)
- Buckets for carrying equipment
- Soil core sleeves and stoppers for transporting lysimeters (scrubbed and rinsed)
- 2x meter sticks

Insertion point coordinates (see table on slide 14)

Lysimeters (prepped—see slide 3)
2. Experimental design

KBS LTER Resource Gradient Experiment

Amount of Nitrogen Applied

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Treatment F1</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
<th>F5</th>
<th>F6</th>
<th>F7</th>
<th>F8</th>
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<tr>
<td>Corn</td>
<td>0</td>
<td>30</td>
<td>60</td>
<td>90</td>
<td>120</td>
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<td>N (kg/ha)</td>
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<td>101</td>
<td>134</td>
<td>168</td>
<td>202</td>
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<tr>
<td></td>
<td>N (lb/a)</td>
<td>N (kg/ha)</td>
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<td></td>
<td></td>
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<tr>
<td>Wheat</td>
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</table>

Lysimeter installation in spring 2014, a CORN year

Each plot is 15’x 90’(4.57 m x 27.4 m)
Established May 2005
Installation layout (boxes outside plots)

- Access boxes are just south of plots, aligned with plot borders
- See following slides for lysimeter depths and locations within plots
- Access boxes (“B” below) are shared by two plots except for plots with 3 bottles.
- Minimized disturbance to center 3 rows of corn that we harvest for biomass measurement (especially needed to be considered during trenching)
Lysimeter locations and depths

- Blocks 2 (rainfed) and 5 (irrigated)
- Treatments F1 – F8 (skipping F9)
- Depths:
  - All plots have 1 lysimeter that is 1.3 m vertical depth (“shallow”)
  - F1 and F8 plots have 2 additional lysimeters at 2.5 m (“mid”) and 3.5 m (“deep”), so these plots have a total of 3 lysimeters
- Boxes (slide 4): 1 box for each F1 and F8 treatment, 1 box shared by neighboring plots for treatments F2-F7.
- Totals: 24 lysimeters, 24 bottles, 16 plots, 10 boxes
Used Geoprobe to make hole for lysimeter

- Mark extension at probe length minus 30 cm stop hammering when mark reaches this point; mark steel rod at probe length, hammer in additional 30 cm till this mark is at this point. Before removing the steel rod, record its angle from the soil surface, length of the hypotenuse of this triangle, and the depth of the insertion point so you can calculate the actual vertical depth of the lysimeter later.

- Soil profile above cup not disturbed

- Geoprobe extension (1 in = 25 mm OD, 1.22 m long per segment)
- Steel or aluminum rod (20 mm OD = lysimeter OD)

* Pit is 18” deep because all equipment needs to be 18” below soil surface to protect it from any future plowing.

See following slides for specific dimensions for the different lysimeter depths...

Soil above tubing was trenched after lysimeters were installed.
3. Installation schematics & calculations

**IN THEORY:**

→ SHALLOW PROBES ARE 1.23m DEEP.

![Diagram showing installation details]

**Drawing not to scale**

- **SOIL SURFACE**
  - 16" = 40.6 cm = minimum depth of all equipment
  - 1.23m = vertical depth of sampler cup

**AFTER INSTALLATION,**

MEASURED DIMENSIONS IN ORANGE TO CALCULATE ACTUAL VERTICAL DEPTH OF CUP.

**Use 2 Geoprobe extensions (22 m each).**

Mark first extension at 1.06m - 0.30 = 0.76m. Attach 2nd ext. to get mark to insertion point. Mark Aluminum rod (20mm O.D.) @ 1.06m, hammer on it to create remaining 30cm of hole needed.
IN THEORY:

→ MID PROBES ARE 2.47m DEEP.

USE 3 GEOPROBE EXTENSIONS:

Mark 2nd extension @ 1.14m:
2.66 - 0.30 = 2.36 length of geoprobe hole
2.36 - 1.22 = 1.14 mark on 2nd ext. stop when this mark reaches the insertion point. (need 3rd ext. on top)

Mark steel rod (20mm O.D.) at 2.66 m. Hammer it in remaining 30 cm.
IN THEORY:

- DEEP PROBES ARE 3.3m DEEP.

Use 4 Geoprobe extensions:
3.72 - 0.30 = 3.42
3.42 - 2.44 = 0.98 - mark on 3rd ext.
Add 4th ext. to get mark to insertion point.
Treatments F2-F7 look like this (or the mirror image) and Treatments F1 & F8 look like this (or the mirror image). Angles offset so the probes are not overlapping.

Numbers outlined in green are the x,y coordinates to use for marking the insertion point in the plot for installation (also see table below).

### Actual coordinates for cups (not insertion point coordinates!)

<table>
<thead>
<tr>
<th>probe</th>
<th>probe length (m)</th>
<th>x coordinate for insertion point</th>
<th>y coordinate for insertion point</th>
<th>x,y hypotenuse</th>
<th>geoprobe angle from baseline</th>
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</thead>
<tbody>
<tr>
<td>shallow</td>
<td>1.06</td>
<td>1.77</td>
<td>2.95</td>
<td>3.44</td>
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<td>mid</td>
<td>2.66</td>
<td>1.08</td>
<td>1.49</td>
<td>1.84</td>
<td>36</td>
</tr>
<tr>
<td>deep</td>
<td>3.72</td>
<td>0.36</td>
<td>0.35</td>
<td>0.5</td>
<td>46</td>
</tr>
</tbody>
</table>
1. Mark insertion points with a pin flags (see table on previous slide for x,y coordinates), use plastic not metal flags.
2. Lay a meter tape from plot corner to flag, this will guide digging the pit and driving the gator to line up the Geoprobe.
3. 12” wide, 18” long along the meter tape, with the pin flag at the far edge of the pit and 18” deep (see diagram A).
4. Mark Geoprobe extension rod (1” outer diameter) at probe length minus 30 cm. Mark steel rod at actual probe length.
   - Deepest probes: 3.72 m, mark steel rod (20 mm OD = same OD as probes) @ 3.72 m, mark Geoprobe extension @ 3.42 m, put the marked rod on third, add fourth extension to get the mark down to the insertion point.
   - Mid probes: 2.66 m, mark steel rod @ 2.66 m, mark Geoprobe extension @ 2.36 m put the marked ext. on second, add third ext. to get mark down to the insertion point.
   - Shallow probes: 1.06 m, mark Aluminum (shorter) rod (20 mm OD = same OD as probes) @ 1.06 m, mark Geoprobe extension at 0.76 m, put marked ext. on first, add second ext. to get mark down to the insertion point.
5. Drive gator into the plot so that the base of the Geoprobe foot is about 1 m from the edge of the pit (see diagram B).
6. GEOPROBE SETUP: Turn on the generator for the Geoprobe on the back of the Gator:
Lift the hydraulic hoses off the generator, pull up choke, turn key, push choke in, pull
throttle knob all the way out (can be difficult, should get much louder), turn the
hydraulic knob to 10:00.

7. Unfold Geoprobe using “unfold” knob and lower the foot onto the wooden angle guide
using “foot ↑↓” knob (see diagram). Attach the magnetic angle measurer’s bottom
surface (see note below) onto the Geoprobe. Use the unfold knob to adjust angle to
51°.

Note: when you attach the angle measurer to a surface, use its bottom to
measure the angle with respect to horizontal, use its side (like in this photo) to
measure its angle with respect to vertical.
9. Put the driving point and the hammering cap on the first extension rod. Put drive point at the insertion point (in the pit below where the flag was). The insertion point is where the top of the probe will eventually sit. Line up the extension rod so that it is parallel with the Geoprobe (see diagram D). Put the magnetic measurer on the extension to get the angle as close to 51° as possible when you lower the Geoprobe onto the cap. Also make sure the extension is still parallel with the Geoprobe. To get the 51° you may need to pull up or push down on the lower part of the extension as the Geoprobe pushes in the first few cm. You may need to fine tune the pit (make wider, etc.).
10. DRIVE EXTENSIONS IN: Use the “probe ↑↓” knob to push the extension in as deep as you can before hammering (usually the first meter or so). When the Geoprobe foot lifts up as you probe down, this means you need to start to hammer. Use the hammer AND the probe down knob simultaneously to get the right balance of speed of hammering and downward movement.

11. When you reach the bottom extent of the Geoprobe, ↑probe, remove hammering cap on the extension, put it on the next extension, screw the next extension onto the top of the first extension. ↓probe over the cap. Repeat steps 10 & 11 until the mark on the extension rod is at the insertion point (you will need one extension on top of the extension with the marking since the insertion point is below the Geoprobe).

- Deepest probes: 3.72 m, mark steel rod (20 mm OD = same OD as probes) @ 3.72 m, mark Geoprobe extension @ 3.42 m, put the marked rod on third, add fourth extension to get the mark down to the insertion point.
- Mid probes: 2.66 m, mark steel rod @ 2.66 m, mark Geoprobe extension @ 2.36 m put the marked ext. on second, add third ext. to get mark down to the insertion point.
- Shallow probes: 1.06 m, mark Aluminum (shorter) rod (20 mm OD = same OD as probes) @ 1.06 m, mark Geoprobe extension at 0.76 m, put marked ext. on first, add second ext. to get mark down to the insertion point.
12. PULL THE EXTENSIONS OUT: Once the mark on the extension rod as reached the insertion point, ↑probe. Remove the hammering cap on the ext., replace with pull cap (see diagram). ↓probe and push the pull cap lift under the pull cap (by hand). ↑probe to pull the extensions out. With each lower ext. that comes out, one person hold it in place while another person unscrews the top ext. so that the lower extension does not fall down into the hole! Put the pull cap on lower extension and ↓probe and put the pull cap lift under the pull cap.
13. **SHUT DOWN GEOPROBE:** Once all the ext.’s are out, probe as low as possible. Use the FOLD knob to fold the Geoprobe back onto trailer. Turn hydraulic knob clockwise all the way. Push the throttle down all the way. Turn key off. Lift hydraulic hoses onto generator. Pull gator ahead and pull wooden guide away from the hole.

14. Lower steel rod into hole. Avoid pushing soil into the hole. Rod should stop with ~ 30 cm between the mark on the rod (for actual probe length) and the insertion point. Use sledge hammer to pound rod so that mark is at insertion point. **Before you pull out the rod** measure the angle of the rod, the distance from the insertion point to the surface (hypotenuse), and the depth of the insertion point to calculate the actual vertical depth of the lysimeter cup later (see yellow triangle on slide 9).
15. Prep lysimeter—DO NOT TOUCH CUP WITH HANDS as oils will clog pores--(for mid and deep lysimeters, screw the two pieces of blue tubing together, screw cap on top, leave some slack in inner tubing but not too much.

15. Push lysimeter into hole. Last 30 cm should be a more snug fit (harder to push but not impossible). If impossible, hole may have caved in or a rock is lodged in the hole. Pull the probe out, hammer rod in again. Re-insert probe. (Fill in pit by strata if you will not be digging trenches right away. If trenching soon, leave pit open!)

16. MARK END OF TUBING FOR WHICH PLOT AND DEPTH IT CORRESPONDS TO.
18. DIGGING TRENCHES: Tubing needs to also lie 18” below the surface, so trenches should be dug to 18”. We rented a Ditch Witch from Tool Time (contact info last slide). It was a stand-on because the smaller walk-behind was not working. The walk-behind is smaller so would have compacted the loose soil less than the big one.

19. Use twine & 2 surveying pins to layout ditch witch path (see diagram). Ditch witch the main path, then will dig trenches by hand to connect main trench to probe insertion point (make ditch witch path about 20 cm from flags). Use ground marking spray paint to paint line on the ground, remove pins and twine.
20. For plots with 3 lysimeters, lay a piece of U-pipe over the tubing at the surface for the mid and deep lysimeters to protect tubing when ditch witch drives over it.

21. One person stands out beyond the end of the path to guide the ditch witch driver. Lower the blade to the soil surface, start turning the blade and continue lowering it into the ground. The person guiding the driver should have a yard stick to check the depth of the trench as the driver drives in reverse as they cut the ditch toward the corner of the plot. The soil will be homogenized by the ditch witch so there is no way to try to return the soil by strata. Continue the ditch to outside the plot.

22. For pairs of plots sharing a box, before digging the second leg of the “V” shaped trench, shovel away the soil from the first trench where the ditch witch will be driving over it.

23. Dig remaining trench at 18” depth connecting top of lysimeter to main trench. Be careful when digging near tubing, use a trowel.

24. Once you have checked that the entire trench is 18”, double check that you have correctly labeled the ends of the tubing before laying the tubing into the trench. Be sure to leave slack so that as soil settles there will not be tension on the lines. Re-fill the trenches, tamping down the soil as you go. The ditch witch pulls soil toward the edge of the plot, so you will have to shovel soil from the edge toward the pit.
25. Do not fill in the trenches at the end where the box will be. Leave the trench open (so that you can see the tubing at the 18” depth) so that when you dig the holes for the boxes the tubing is already at the proper depth.

26. The tubing will come up into the boxes from below. A custom made concrete bottom was made for the boxes to sit on. It is a ring shape, with a piece of approx. 2” diameter PVC running through it, so the sampler tubing can slide in through there, rather than sit directly under the weight of the box. Brandon and Justin Mezo and Terry Tilley made these.

27. Joe Simmons has a lot of prior experience installing boxes so that they: keep rodents out, don’t flood, their tops are level with the soil surface, and are located in the proper place (directly in line with the N-S plot boundaries). He instructed us to surround the bottom and sides of the boxes with several inches of pea gravel to prevent rodents digging in. Terry Tilley dug most of the holes.
Resources

- For ordering boxes: Gary Putrow
  - Michigan Pipe & Valve – Lansing Inc.
  - 517-322-0300 Ph
  - 517-322-4037 Fax
  - Gary.putrow@michiganpipe.com
- Decagon Devices
  - Sales: Nick Mower
    - 2365 NE Hopkins Ct, Pullman, WA 99163, Direct: 509-332-5563, Main: 509-332-2756, mover@decagon.com
    - Hydrology Product Manager: Leo Rivera, leo@decagon.com
- Borrowed geo-probe extensions from Dave Hill
  - Drilling/Field Services Manager
  - Superior Environmental Corp
  - 1128 Franklin Street
  - Marne, MI 49435
  - o 616.667.3637
  - c 616.318.5586
  - f 616.667.3666
- Rented trencher (ditch witch) from Tool Time (Steve) 269-381-9372, $135 per day, free delivery; 4” wide blade, blade length 3’.—recommended company by Kevin Kahmark