Chapter 8

Single-ring infiltrometer (for water infiltration)

Infiltration rate is a measure of how fast water enters the soil. Water entering too slowly may lead to ponding on level areas or to erosion from surface runoff on sloped areas. A Single-ring infiltrometer provides a *relative* indication of infiltration capacity under saturated conditions.

Infiltration cannot be measured with this method on very rocky/gravelly sites, steep slopes or areas with dense root mats at the surface.

Materials

- The same transect(s) used for Line-point and Gap intercept
- Six infiltrometer rings (see Appendix A, diameter = 12.5 cm)
- Six 25 x 50 cm (10 x 20 in) terrycloth towels
- Two 370 ml (12.5 oz) cups*
- Two 30 x 30 cm (12 x 12 in) sheets of plastic (e.g., grocery bags)
- Five gallons of water
- One 15 cm (6 in) ruler
- Stopwatch
- Six infiltration bottles full of water (diameter = 8.7 cm) (see Appendix A for construction instructions)
- Clipboard, Single-ring Infiltrometer Data Forms and pencil(s)

*Based on volume required for 3 cm depth in a 12.5 cm diameter ring. For other ring diameters, volume = 9.4 x r^2, where radius equals one-half the diameter ($r = {}^1/_2\ d$).

Standard methods (rule set)

1. Determine locations for the tests.

Rules

1.1 Randomly select points along the transects used for Line-point and Gap intercept (Fig. 8.1).

1.2 Record sampling locations (positions) on the data form in the "Position on line" column.

1.3 If you are also making vegetation measurements, move the infiltration measurements at least 1 m (1 yd) from the transect, and move the infiltration measurement at least 1 m from any penetrometer measurement(s).

2. Record the vegetation class for the sample point in the "Veg class" column of the Single-ring Infiltrometer Data Form.

Rules

2.1 Lay down the infiltrometer ring on the sample point and record the dominant cover class for the sample area:

NC = no perennial grass, forb, shrub or tree canopy cover
G = perennial grass canopy and grass/shrub canopy mixture
F = perennial forb canopy
Sh = shrub canopy
T = tree canopy

2.2 If the soil surface is protected by a rock or embedded litter that prevents ring insertion, select another sample point 1 m (1 yd) down the transect and note the move.

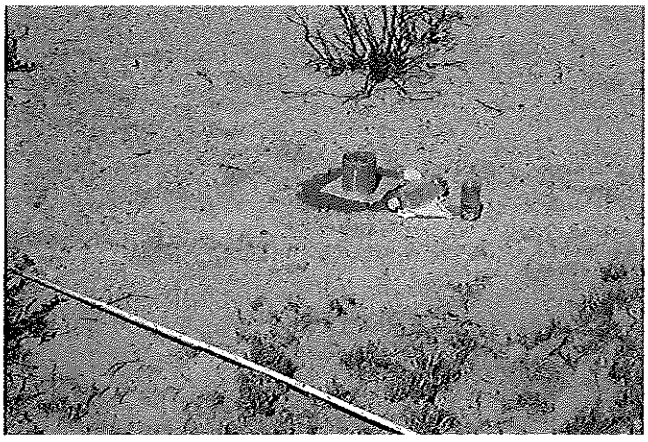

Figure 8.1. Infiltrometer supplies and sample location.

3. **Remove the aboveground vegetation (Fig. 8.2).**

Rules

3.1 If the sample point is located on a plant, carefully remove aboveground vegetation to within 1 cm of ground level, using a serrated knife and cutting with a sawing motion.

3.2 Do not disturb the soil crust in or around the plant.

3.3 Gently remove loose (not embedded) litter obstructing the edge of the ring.

3.4 In areas with duff (e.g., under coniferous trees), clearly define a standard depth to which litter will be removed, based on soil and litter characteristics (e.g., depth at which there is 80 percent mineral soil by volume), *OR* leave litter in place and insert ring to standard depth in the mineral soil, *OR* exclude these areas. If pieces of litter create a visible hole in the soil when the ring is inserted, select another sample point at least 1 m (1 yd) down the transect and note the move. This is necessary because the ring will not seal.

3.5 Clearly record which of the three options in rule 3.4 was applied.

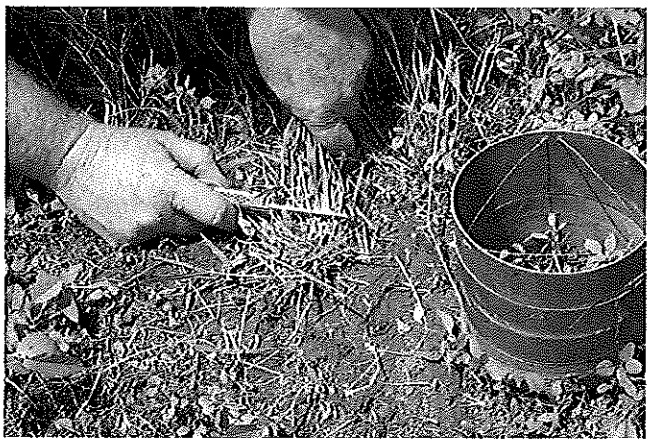

Figure 8.2. Remove aboveground vegetation.

4. **Pre-wet the soil to a depth of at least 4 cm (1.5 in) (Fig. 8.3).**

Rules

4.1 Fold a moistened towel in half and lay over the sample area.

4.2 Using the 370 ml cup, pour water slowly on the towel in a series of applications.

4.3 Wait several minutes between applications.

4.4 Minimize water runoff from under the towel.

4.5 Continue adding water until soil is wet to 4 cm (1.5 in). The required volume varies with soil texture and structure, but should be approximately 740 ml (25 oz), or two cupfuls.

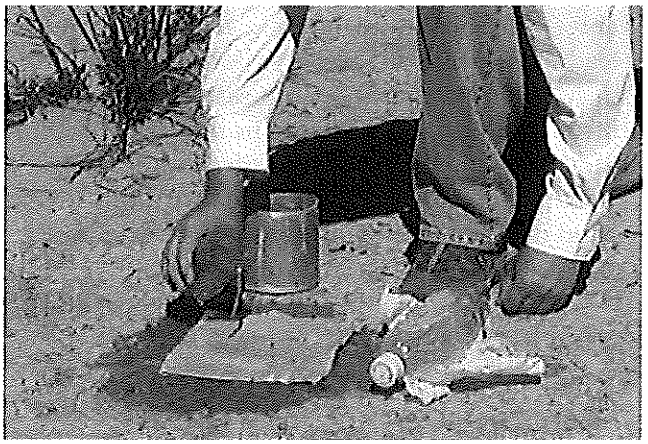

Figure 8.3. Pre-wet the soil to a 4 cm depth.

5. **Insert the infiltration ring to a depth of 3 cm ($1^{3}/_{16}$ in) (Fig. 8.4).**

Rules

5.1 Distribute pressure evenly on as much of the ring as possible. If necessary, twist the ring very slightly while pushing.

5.2 Test if the ring is set securely in the soil by gently wiggling the sides. If there is any movement, push the ring into the ground an additional 0.5 cm ($^{3}/_{16}$ in).

Figure 8.4. Insert infiltration ring to 3 cm.

6. **Add water to the ring without disturbing the soil surface (Fig. 8.5).**

Rules

6.1 Line the bottom and sides of the ring with the plastic sheet.

6.2 Pour sufficient water onto the sheet to bring the water depth to approximately 3 cm (1.25 in) and gently pull out the plastic sheet (Fig. 8.5). For a 12.5 cm ring, this is 370 ml water.

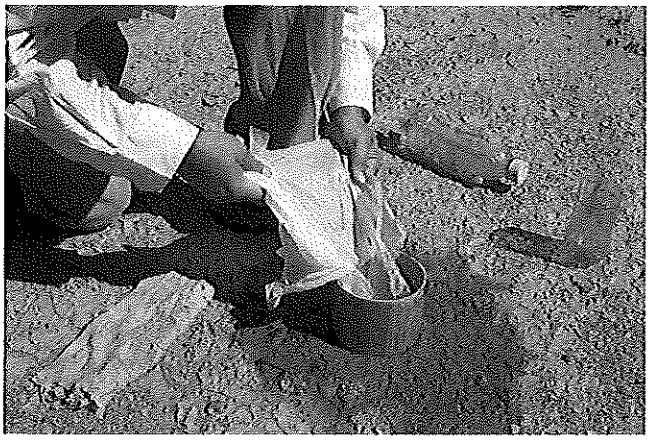

Figure 8.5. Add 370 ml water, using plastic sheet.

7. **Watch for leaks (Fig. 8.6).**

Rules

7.1 Observe the ring, watching for obvious leaks. Wetting at the soil surface around the ring is normal and does not constitute a leak.

7.2 Water should not pond on the soil surface or glisten around the outside edge of the ring (Fig. 8.6). If either of these occurs, the ring is leaking.

7.3 If a leak occurs, gently push the ring in 0.5 cm ($^3/_{16}$ in) more and see if the leak stops.

7.4 If the leak persists, remove the ring and relocate the sample at least 1 m (1 yd) away in the same vegetation class (up or down the transect line). Note the move.

8. **Place bottle in ring (Fig. 8.7).**

Rules

8.1 Push the infiltration pipette almost all the way into the bottle.

8.2 Open the cap on the bottle so that water will come out when it is upside down, but the cap will not fall off. The cap should be very loose.

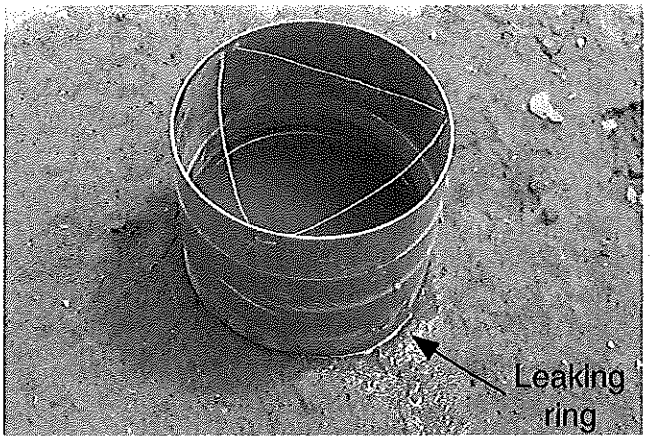

Figure 8.6. Water leaking from the ring.

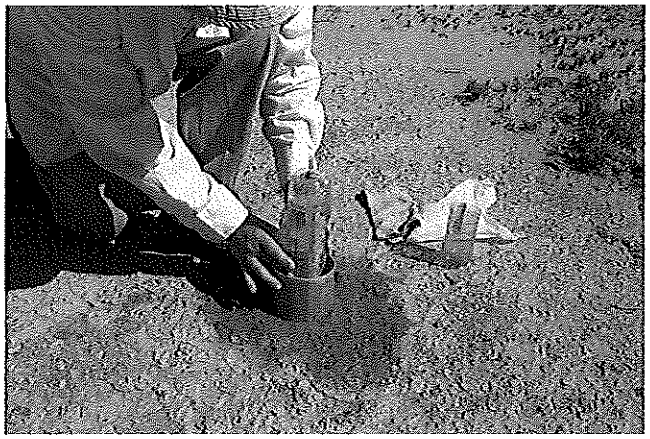

Figure 8.7. Suspend bottle inside the ring.

8.3 Gently place the infiltration bottle in the ring so the silicone beads on the bottle catch on the ring suspension wires.

8.4 The bottle should be suspended in the ring with the cap end completely submerged *but not touching the soil surface.*

9. **Adjust the pipette to maintain the water in the ring at 3 cm (1.25 in) depth (Fig. 8.8).**

Rules

9.1 It is crucial to keep the water level inside the ring at 3 cm ($1^3/_{16}$ in) or a similar standard depth, such as 5 cm (2 in). For 3 cm, a range of 2.5 to 3.5 cm is allowed. The bottle will do this automatically after the pipette is adjusted. *To increase depth* follow rules 9.2 through 9.6. *To reduce depth* follow rules 9.7 through 9.11.

9.2 *To increase the depth,* raise the pipette. Supporting the bottle carefully with one hand, gently twist and pull the pipette upwards with the other hand until air bubbles come from the lower end of the pipette.

9.3 At this point, stop pulling up on the pipette and start pushing down a tiny distance, until the bubbles stop. This often amounts to less than 1 mm of movement.

9.4 Wait several seconds for the bubbles to start again. Bubbles should emerge at a constant rate within 10 seconds to one minute.

9.5 If no bubbles appear within one minute, slowly pull the pipette upwards and readjust its level (i.e., repeat 9.2 through 9.4).

9.6 Measure water depth. If too shallow, repeat 9.2 through 9.6. If too deep, follow 9.7 through 9.10.

9.7 *To reduce water depth,* push the pipette down. Supporting the bottle carefully with one hand, gently twist and push the pipette downwards. ***Caution: Grasp the side of the pipette only. Do not place your palm on top of the pipette.***

9.8 Wait until bubbles appear. This often takes several minutes, because water must drain from the ring into the soil.

9.9 If no bubbles appear within several minutes, measure the water depth. If the desired depth has been reached, pull the pipette upwards and follow steps 9.2 through 9.6.

9.10 When bubbles appear, measure water depth. If too shallow, repeat steps 9.2 through 9.6. If too deep, follow steps 9.7 through 9.10.

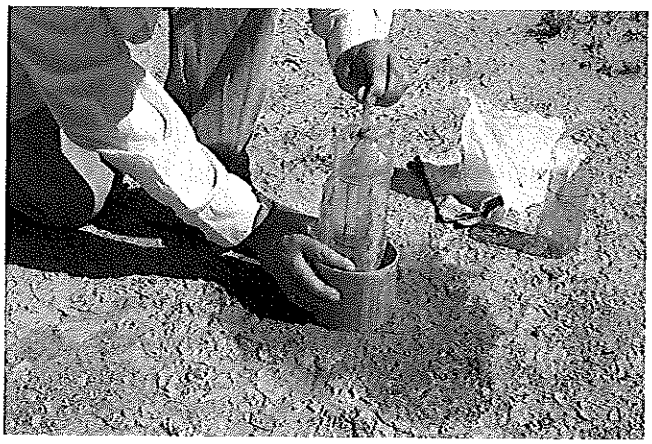

Figure 8.8. Adjust the pipette.

10. Move the rubber band to mark the water level and record the start time (Hours:Minutes:Seconds) in the "Start Time" column.

Rules

10.1 The top of the rubber band should mark the bottom of the meniscus where it intersects the vertical line of the bottle.

10.2 The "meniscus" is the bottom of the curved line formed by the surface of the water inside the bottle.

10.3 Record the start time.

10.4 Check for leaks during the run (defined in 7.2 above).

10.5 If a leak occurs, you must start over.

11. Wait for the water level in the bottle to drop at least 50 mm (2 in).

Rules

11.1 Make sure the water level inside the ring stays at a 3 cm ($1^3/_{16}$ in) depth (± 0.5 cm or $^3/_{16}$ in).

11.2 If water inside the ring drops below the allowable level, carefully pour water into the ring and adjust the pipette if necessary.

12. Record the infiltration end time and measure the distance the water level has dropped.

Rules

12.1 Simultaneously record the infiltration end time and the distance.

12.2 Record infiltration end time as Hours:Minutes:Seconds.

12.3 Record infiltration distance as the distance between the top of the rubber band and the meniscus (in mm or 16^{ths}s of an inch).

12.4 Measure infiltration distance along the straight portion of the bottle only. Use the vertical line on the infiltration bottle as a guide.

12.5 You can safely make measurements as far down the bottle as you like, as long as the final measurement is greater than 50 mm (2 in) and the water level inside the bottle does not go past the curve in the bottle.

Bottleless Infiltration Method (Semi-quantitative Alternative)

Pre-wet sample point, insert ring, and pour water into the plastic bag just as with the standard Single-ring infiltration test (Steps 1-6). Carefully remove bag and record start time. Allow water to infiltrate. When 95% of the soil surface inside the ring is not shining, quickly insert the plastic bag and add another cup of water. Record the start time when the bag is removed. Record the end time when 50% of the soil surface is not shining. The difference between the start and end time is the time required for 3 cm (1.25 in) to infiltrate the soil.

Single-ring infiltrometer indicator calculations

If you use the ring and bottle sizes specified in Appendix A, your correction factor is 0.48 and you may skip to step 4. Otherwise please begin at step 1.

1. Calculate the cross-sectional area of the bottle.

Rules

1.1 The formula for area is: Area = $\pi \times r^2 \approx 3.14 \times r^2$

Area $\approx 3.14 \times (d \div 2) \times (d \div 2)$

r = radius = $^1/_2$ d

d = diameter (width)

1.2 If you don't know the bottle diameter, you can calculate if from the circumference, C.

$d \approx C \div 3.14$

1.3 Record on the Single-ring Infiltrometer Data Form.

2. Calculate the cross-sectional area of the ring (see Step 1).

Rules

2.1 The formula for ring area is: Ring area = $3.14 \times r^2$

or = 3.14 x r x r

or = $3.14 \times (d \div 2) \times (d \div 2)$

2.2 Bottle area = $3.14 \times r^2$

2.3 Record on the Single-ring Infiltrometer Data Form.

3. Calculate the correction factor for the difference between the area of the bottle and the area of the ring.

Rules

3.1 Correction factor = bottle area ÷ ring area.

3.2 Record on the Single-ring Infiltrometer Data Form.

4. Calculate the infiltration time in hours.

Rules

4.1 Subtract the end time from the start time.

4.2 Record in "Total time (min)."

4.3 Convert to hours by dividing by 60.

4.4 Record in "Total time (hr)."

4.5 Example: Start time = 12:55:01, End time = 1:04:31. Time elapsed (min) = 1:04:31 – 12:55:01 = 9.5 min. Time elapsed (hr) = (9.5 min) ÷ (60 min/hr) = 0.1583 hr.

5. Calculate the bottle infiltration rate in mm/hr.

Rules

5.1 Infiltration rate = distance the water dropped (in mm) divided by the amount of time it took to drop (in hours).

5.2 Record the bottle infiltration rate in "Bottle rate" column of data form.

5.3 Example:

Distance traveled was 5.1 cm.

Convert 5.1 cm to mm:

(5.1 cm) x (10 mm/cm) = 51 mm.

Divide distance traveled by time:

51 mm ÷ 0.1583 hr = 322.17 mm/hr.

6. Calculate the soil infiltration rate (corrected for the difference in area between the ring and the bottle).

Rules

6.1 Multiply the infiltration rate (from step 5) by the correction factor (from step 3).

322 mm/hr x 0.42 = 135 mm/hr.

6.2 Record in "Infil rate (mm/hr)" column of data form.

Single-ring vs. double ring infiltrometers

While double ring infiltrometers are sometimes recommended, it has been clearly shown (both theoretically and experimentally) that they provide little advantage over single-ring infiltrometers (Bouwer 1986), and the measurements take much longer. The best way to improve the accuracy of ponded infiltration measurements is to increase ring diameter, provided that this does not increase the risk of leaks (e.g., in soils with gravel or woody litter).

Example

Infiltration Data Form

Monitoring plot: East Pasture 1 **Date:** 15 September 2003

Observer: Tara North **Recorder:** Tim White

Veg Class:

NC = No perennial canopy
G = Perennial grass or grass/shrub mix
F = Perennial forb
Sh = Shrub
T = Tree

Soil moisture (circle one for each depth):

Surface	(Dry)	Moist	Wet
0-5 cm	(Dry)	Moist	Wet
5-10 cm	(Dry)	Moist	Wet
10-15 cm	(Dry)	Moist	Wet
15-20 cm	(Dry)	Moist	Wet
20-25 cm	Dry	(Moist)	Wet

Ring diameter: 12.5 Bottle diameter: 8.7 **Correction factor (CF):** 0.48
CF = Bottle area ÷ ring area

Ring area: 122.7 Bottle area: 59.4 Ring insertion depth (cm): 3

Record time to the nearest second.

Line	Position on line	Veg class	Begin time	End time	Distance (mm)	Total time (min)	Total time (hr)	Bottle rate[1]	Infil rate[2] (mm/hr)
1	2.5	G	12:55:01	13:04:31	52	9.5	0.16	328	158
1	12.5	NC	12:58:05	13:12:02	48	13.9	0.23	206	99
1	22.5	NC	13:01:29	13:16:59	55	15.5	0.26	213	102
1	32.5	G	13:04:53	13:11:33	60	6.7	0.11	540	259
1	42.5	T	13:08:24	13:19:30	58	11.1	0.19	314	150
1	49.5	NC	13:11:05	13:25:05	50	14	0.23	222	107

Average infiltration rate (sum all numbers in column ÷ number of measurements): 146

[1] Bottle rate = Distance (mm) ÷ Total time (hours)
[2] Infil rate = Bottle rate x Correction factor

Notes:

Infiltration Data Form

Monitoring plot: _____ **Date:** _____

Observer: _____ **Recorder:** _____

Veg Class:

NC = No perennial canopy
G = Perennial grass or grass/shrub mix
F = Perennial forb
Sh = Shrub
T = Tree

Soil moisture (circle one for each depth):

Surface	Dry	Moist	Wet
0-5 cm	Dry	Moist	Wet
5-10 cm	Dry	Moist	Wet
10-15 cm	Dry	Moist	Wet
15-20 cm	Dry	Moist	Wet
20-25 cm	Dry	Moist	Wet

Ring diameter: ☐ Bottle diameter: ☐ **Correction factor (CF):** ☐
CF = Bottle area ÷ ring area

Ring area: ☐ Bottle area: ☐ Ring insertion depth (cm): ☐

Record time to the nearest second.

Line	Position on line	Veg class	Begin time	End time	Distance (mm)	Total time (min)	Total time (hr)	Bottle rate[1]	Infil rate[2] (mm/hr)

Average infiltration rate (sum all numbers in column ÷ number of measurements): ☐

[1] Bottle rate = Distance (mm) ÷ Total time (hours)
[2] Infil rate = Bottle rate x Correction factor

Notes: