



Environmental Analysis Program

Pomona College
Biogeochemistry Laboratory

SOP-F406

Soil Respiration Chambers (Field Static Chamber Method)

Standard Operating Procedure

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1. Purpose

This SOP describes the deployment and operation of static (closed, non-flow-through) chambers for manual measurement of soil CO₂ efflux in the field. Static chambers are a simple, low-cost method for quantifying soil respiration across treatments, land uses, or seasonal gradients when the Picarro CRDS automated system ([SOP-F504](#)) is not available or when additional spatial replication is needed. The method captures headspace gas samples at timed intervals, which are analyzed for CO₂ concentration using a portable infrared gas analyzer (IRGA), syringe samples returned to the

lab, or soda-lime traps (Hutchinson & Mosier, 1981; Livingston & Hutchinson, 1995; Parkin & Venterea, 2012).

The static chamber method remains one of the most widely used approaches for point-scale soil CO₂ flux measurement because of its simplicity and low cost, though it is subject to known biases from headspace concentration buildup and pressure artifacts (Pumpanen et al., 2004; Rochette & Eriksen-Hamel, 2005). At a global scale, soil respiration represents one of the largest fluxes in the terrestrial carbon cycle, and small changes can have significant implications for atmospheric CO₂ concentrations (Davidson et al., 2000; Raich & Schlesinger, 1992).

2. Scope

- **Applies to:** Manual static chamber measurements of soil CO₂ efflux at EA Program field sites; applicable to grasslands, agricultural plots, restoration sites, and forest soils
- **Does not apply to:** Automated dynamic chambers with the Picarro CRDS analyzer (see [SOP-F504](#)); eddy covariance or gradient flux methods; aquatic CO₂ flux measurements; N₂O or CH₄ flux measurements requiring GC or CRDS analysis (though the same chambers can be used with different analytical endpoints)
- **Location:** All EA Program terrestrial field sites

3. Responsibilities

Role	Responsibility
PI / Field Lead	Approve chamber design and deployment plan
Trained Personnel	Install collars, deploy chambers, collect gas samples
New Students	Complete training before independent use

4. Definitions

- **Basal soil respiration:** CO₂ efflux from undisturbed soil at ambient temperature and moisture without addition of labile substrate; reflects the combined metabolic activity of the soil microbial community and root respiration.
- **CO₂ efflux (soil respiration rate):** The flux of CO₂ from the soil surface to the atmosphere, expressed in $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ or $\text{g C m}^{-2} \text{ d}^{-1}$; the primary field measurement made with a closed or open dynamic chamber system.
- **Closed dynamic chamber:** A chamber placed over the soil surface in which headspace CO₂ concentration rises over time as CO₂ is released from the soil; flux is calculated from the rate of concentration increase, chamber volume, and collar area.
- **Collar:** A short ring of PVC or metal inserted several centimeters into the soil before measurement to create a gas-tight seal with the chamber; installed at least 24 hours before measurements to allow soil disturbance effects to dissipate.
- **Heterotrophic respiration:** CO₂ produced by soil microorganisms decomposing organic matter; one component of total soil respiration along with autotrophic (root and rhizosphere) respiration.

- **LI-COR analyzer (LI-8100A / LI-8150):** A portable infrared gas analyzer system used for automated soil CO₂ flux measurement; calculates flux from the exponential rise in headspace CO₂ concentration over a defined measurement period.
- **Q₁₀ coefficient:** The factor by which soil respiration rate increases for a 10 °C rise in temperature; typically 1.5–3.5 for mineral soils; used to temperature-normalize measurements made under different field conditions.
- **Rhizosphere priming:** Enhanced decomposition of soil organic matter stimulated by root exudates; inflates field respiration measurements relative to bare-soil or root-exclusion treatments.

5. Safety and Hazards

Hazards

- **Physical:** Driving collars into soil with a mallet poses impact injury risk. Carrying chambers and equipment over uneven terrain.
- **Heat:** Southern California field sites can exceed 40 °C. Metal chambers become extremely hot in direct sunlight; handle with gloves.
- **Chemical:** Soda-lime (NaOH/Ca(OH)₂) is corrosive and causes burns on skin and eye contact. Concentrated NaOH solutions used for soda-lime traps are hazardous. Handle with gloves and safety glasses.

5.1. Required PPE

- ☐ Closed-toed shoes or field boots
- ☐ Nitrile or leather gloves
- ☐ Safety glasses (when handling soda-lime or driving collars)
- ☐ Sun protection (hat, sunscreen)

5.2. Related SOPs

Refer to [SOP-F001 Field Safety](#) for general field safety procedures.

6. Equipment and Materials

Item	Notes
PVC or metal collars	Installed in the soil at least 24 hours before measurement
Chamber lids	Opaque (dark) for total respiration; clear for net CO ₂ exchange
Rubber mallet	For installing collars
Sealing material	Closed-cell foam gasket or water trough on collar rim

Item	Notes
Syringes (30–60 mL)	For headspace gas sampling (syringe method)
Evacuated vials (Exetainer)	For storing gas samples for lab analysis
Portable IRGA (optional)	For real-time CO ₂ concentration readings
Soda-lime (optional)	For absorption-based CO ₂ measurement
Timer or stopwatch	For tracking deployment intervals
Thermometer or soil temp probe	For concurrent soil temperature
Soil moisture probe (optional)	TDR or capacitance sensor
Ruler or tape measure	For measuring headspace height
Field data sheet	For recording deployment times and readings
GPS unit or smartphone	For recording chamber locations

7. Procedure

7.1. Collar Installation

1. Install PVC or metal collars into the soil to a depth of approximately 5 cm at least 24 hours (preferably 48 hours) before the first measurement to allow the soil to recover from disturbance.
2. Do not sever major roots during installation; if roots are encountered, reposition slightly.
3. Measure and record the collar inside diameter and the height of the collar above the soil surface on at least two sides. These dimensions are needed to calculate headspace volume.

7.2. Chamber Deployment

1. Record the start time, soil temperature (at 5 cm depth), and soil moisture at each collar location.
2. Place the chamber lid on the collar, ensuring a gas-tight seal (foam gasket compressed or water trough filled).
3. If using the syringe method, collect a headspace sample immediately after sealing (time zero), then at regular intervals (e.g., 10, 20, 30, and 40 minutes). The choice of deployment interval (typically 20–45 minutes) represents a trade-off: shorter deployments reduce the concentration-feedback bias that suppresses diffusion as headspace CO₂ rises, but longer deployments provide a more detectable concentration change in low-flux soils (Hutchinson & Mosier, 1981; Pumpanen et al., 2004).
4. If using a portable IRGA, connect the chamber to the analyzer and record CO₂ concentration continuously or at 1-minute intervals.
5. If using soda-lime traps, weigh the pre-dried soda-lime, place it inside the sealed chamber, and retrieve it after a fixed deployment period (typically 24 hours). Re-dry and reweigh to determine CO₂ absorbed.

7.3. Ending the Measurement

1. Remove the chamber lid at the end of the measurement period.

2. Record the end time.
3. Transfer syringe samples to evacuated vials (Exetainers) for transport to the lab if not using IRGA.

8. Quality Control and Acceptance Criteria

8.1. Flux Calculation

Linear method (syringe or IRGA):

$$F = \frac{\Delta C}{\Delta t} \times \frac{V}{A} \times \frac{P}{RT}$$

where F = CO₂ flux (micromol m⁻² s⁻¹), $\Delta C/\Delta t$ = rate of change in headspace CO₂ concentration (ppm s⁻¹), V = headspace volume (m³), A = collar area (m²), P = atmospheric pressure (Pa), R = ideal gas constant (8.314 J mol⁻¹ K⁻¹), and T = air temperature (K).

Soda-lime method:

$$F = \frac{(M_f - M_i) \times 1.69}{A \times t}$$

where M_f and M_i are the final and initial soda-lime masses (g), 1.69 is the stoichiometric correction factor, A = collar area (m²), and t = deployment time (hours).

8.2. QC Requirements

- Deploy at least three replicate chambers per treatment or land use.
- Inspect collar seals before each deployment. Soil settling or animal disturbance can break the seal.
- Record soil temperature and moisture alongside every flux measurement; these are the primary drivers of soil respiration. Soil respiration typically increases exponentially with temperature, with Q₁₀ values of 2–3 (Bond-Lamberty & Thomson, 2010; Raich & Schlesinger, 1992). Reporting concurrent soil temperature and moisture allows flux values to be normalized or modeled across campaigns and sites.
- Reject any measurement where the R² of the linear regression (concentration vs. time) is below 0.90, unless the flux is near zero.
- Avoid measuring during or immediately after rainfall, as water pooling on the collar disrupts gas exchange.

9. Waste Disposal

Waste Type	Disposal Method
Used soda-lime	Allow to dry; dispose as solid waste (non-hazardous once fully carbonated)
Syringe needles	Sharps container
Used gloves	Standard trash

10. References

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11. Related SOPs

SOP	Title	Relationship
F001	Field Safety	Required prerequisite
F005	Random Sampling Design	Chamber placement design
F400	Soil Sampling	Companion soil samples
F504	Picarro GHG Analyzer	Automated alternative

SOP	Title	Relationship
L400	Soil Moisture	Moisture alongside flux
L408	Solvita CO ₂ Burst	Lab respiration complement

12. Training Record

Before deploying soil respiration chambers independently, personnel must:

1. Read this SOP and [SOP-F504](#) in full
2. Demonstrate proper collar installation and headspace volume measurement
3. Perform a supervised syringe sampling or IRGA measurement at one site
4. Calculate flux from field data and demonstrate agreement with the trainer's calculation
5. Be signed off by the PI or field lead