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# Decomposition rate protocol

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# Why measure this?

Decomposition rate tells you how quickly dead plant material is being broken down and recycled into the soil. It reflects the combined activity of soil organisms, physical environment, and litter quality – and is one of the first biological indicators expected to respond positively in the years following restoration (Toro et al. 2025; Serra et al. 2021).

## What it captures

Decomposition rate quantifies how quickly leaf litter (or a standard substrate) loses mass after burial. The process integrates soil biological activity, microclimate, and litter chemistry. Higher rates generally indicate greater nutrient cycling and are associated with gains in soil organic matter and aggregate stability – both key indicators of soil health.

## Sampling

See the Sampling Protocol(00) for general plot layout and replication guidance. Protocol-specific details:

- Use at least three replicate plots per site or treatment, with a minimum of five litterbags per replicate.
- Install bags during the growing season (or wet season in the tropics), when soil biological activity is highest.
- Collect bags after approximately 60 days (primary collection). For a decomposition time series, add optional collections at 30, 120, 180, and 365 days.
- Capture variation across sites, soil types, moisture gradients, or regeneration stages where possible.
- Use intact, unbroken leaves only. Fragmented leaves bias mass-loss measurements.
- Plot size depends on the experimental design (commonly 5 x 5 m or 25 x 25 m).

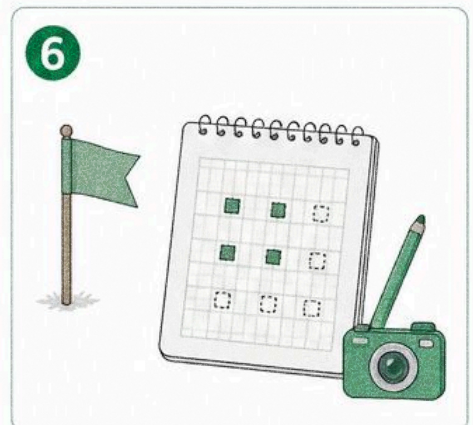
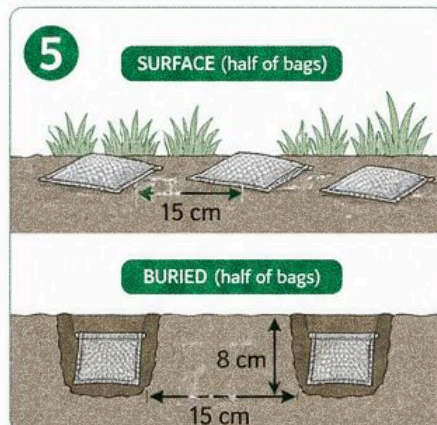
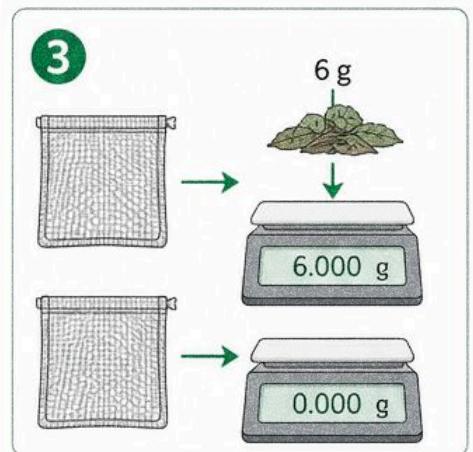
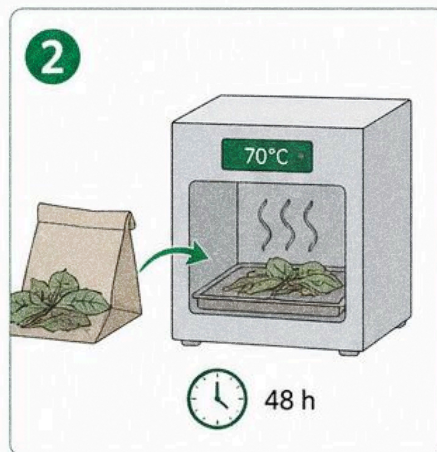
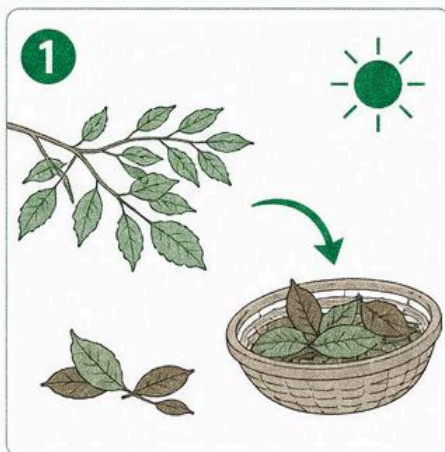
## Materials needed

**For the simplest method skip to the “Tea Bag Alternative” section below**

- Decomposition mesh bags (nylon, ~2 mm mesh) or tea bags (nylon, ~0.25 mm mesh)
- Newly shed leaf litter (mixed or separated by species) or commercially available tea
- Permanent marker
- Colorful marking tape
- Nylon rope or plastic line
- Shovel or soil core
- Scale with 0.001 g (milligram) precision
- Ziploc bags
- Visible stick or flag
- Field notebook
- GPS
- Oven
- Pen or pencil
- Paper bags
- Aluminum trays
- Paintbrush (dry, soft-bristled)

# Procedure

1. Collect recently shed, intact leaves. Time collection for the dry season when freshly fallen litter is abundant.
2. Dry the foliage in paper bags or on trays at 70 °C for 48 hours.
3. Prepare nylon mesh bags (10 x 10 cm or 20 x 20 cm, mesh ~2 mm). Fill each bag with 6 g of dried litter. Record the weight of the litter and the empty bag separately.
4. Label each bag with a permanent marker. Attach a nylon rope or plastic line for retrieval.
5. At the study plot, clear loose organic matter and place half the bags directly on the soil surface (15 cm spacing). Surface placement captures the soil surface decomposition rate, which is the primary indicator of litter turnover. Bury the other half in 8 cm deep holes (~15 cm apart) to capture subsurface decomposition. Keep labels above ground.
6. Mark each installation point with a stick or flag. Sketch the layout and photograph the site.
7. Record the installation date, GPS coordinates, and site information (soil type, land use, forest age, canopy cover, vegetation type).
8. Collect bags after approximately 60 days. Carefully dig out buried bags and retrieve surface bags. Gently remove soil clinging to the mesh in the field.
9. Place each bag in an individual ziploc bag. Note any damaged or disturbed bags.
10. In the lab, remove bags from the ziploc bags. Brush off adhering soil and root particles with a dry, soft-bristled paintbrush. Do not use water.
11. Dry the bags at 70 °C for 48 hours (or sun-dry for 3–4 days in a dry environment).
12. Remove the remaining litter from the bag, place it on a tared tray, and weigh it to 0.001 g.
13. Calculate mass loss and mass loss rate (see Calculating results below).





## Calculating results

Report both metrics:

**Mass loss (%)** = [(Initial dry litter mass – Final dry litter mass) / Initial dry litter mass] × 100

Where:

- Initial dry litter mass = Weight of filled bag before burial – Weight of empty bag
- Final dry litter mass = Weight of dried litter removed from bag after collection

**Mass loss rate (% per day):** Mass loss (%) / Number of days in the field

## Important considerations

- Use native litter when possible to capture a representative sample of the plant community. If using native litter, decide at the start whether to use a single dominant species or a standard mix, and maintain that choice across all sampling campaigns and sites. Document the species and proportions used.
- If using tea bags, see the Tea bag alternative section below.
- Avoid compacting the soil and reduce disturbance where bags will be buried.
- Record the start and end date of the experiment.
- Do not use water to clean bags – it causes material loss.
- Expect higher mass loss with fine-textured leaves and biologically active soils.
- Install bags in the order of planned sequential retrieval to allow easy identification if labels are lost.
- Sketch the layout and photograph the site before leaving.

## Tea bag alternative

The tea bag index method (Keuskamp et al. 2013) is a low-cost, standardized alternative that eliminates the need to collect native litter. It is especially useful for cross-site comparisons.

1. Purchase nylon-mesh tea bags of a single brand and type. Record the brand, type, and mesh size (typically 0.25 mm).
2. Weigh each tea bag before burial. Standard fill is 1.6–1.8 g per bag.
3. Follow steps 5–13 of the main procedure above, substituting tea bags for native-litter bags.
4. Calculate the tea bag index and decomposition rate constant ( $k$ ) following Keuskamp et al. (2013).  $k$  is the decomposition rate constant (per year). Higher  $k$  = faster decomposition. Typical values for tropical forests: 2–6 per year. Values below 1 suggest slow decomposition (e.g., waterlogged or nutrient-poor soils). See also: <https://www.teatime4science.org/method/stepwise-protocol>

### See also

Sampling Protocol (00), Macrofaunal Abundance Protocol (06). Macrofauna drive decomposition; their abundance is linked to litter turnover rates.

## References

Keuskamp, J.A., et al. (2013). Tea Bag Index: A novel approach to collect uniform decomposition data across ecosystems. *Methods in Ecology and Evolution*, 4(11), 1070–1075. doi: 10.1111/2041-210X.12097

Martins, N. P., et al. (2024) Fine root presence and increased phosphorus availability stimulate wood decay in a central Amazonian rainforest. *Oikos*, 2024(2), 1–12, doi:10.1111/oik.09996, 2024.

Martins, N. P., et al. (2021) Fine roots stimulate nutrient release during early stages of leaf litter decomposition in a Central Amazon rainforest. *Plant and Soil* (469), 287-303. doi:10.1007/s11104-021-05148-9, 2021.

Powers, J. S., et al. Decomposition in tropical forests: a pan-tropical study of the effects of litter type, litter placement and mesofaunal exclusion across a precipitation gradient, *Journal of Ecology* (97) 801–811, doi:10.1111/j.1365-2745.2009.01515.x

Toro, L., et al. (2025). Integrating belowground recovery into tropical forest restoration design and monitoring. *BioScience*. <https://doi.org/10.1093/biosci/biaf097>

## Useful resources

Tea Time 4 Science – step-by-step protocol and global network: <https://www.teatime4science.org/method/stepwise-protocol/>

Teabag method video – <https://www.youtube.com/watch?v=z4GHxrQCT7c>

ClimEx Handbook – foliar litter decomposition methods:  
<https://climexhandbook.w.uib.no/2019/11/06/foliar-litter-decomposition/>

## Questions or Feedback?

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