



02

Aggregate stability protocol

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Why measure this?

Aggregate stability tells you whether your soil can resist erosion and absorb rainfall. It increases as fine root biomass and soil organic carbon recover during forest succession (Xiao et al. 2020), making it a direct indicator that restoration is working. The test can be completed at home or at a field station with a smartphone and the free SLAKES app (Flynn et al. 2020).

What it captures

This soil property helps track water infiltration rates, erosion rates, soil health (e.g., nutrient cycling and biological activity), and how a soil responds to disturbances. Aggregate stability is the ability of clusters (i.e., aggregates) of soil particles to resist being broken apart. Therefore, soils with high aggregate stability experience lower erosion, are less compacted, and have high infiltration rates and biological activity.

Sampling

Collect soil samples from a depth of 0 to 10 cm. See the Sampling Protocol (Protocol 00) for general guidance on plot layout and replication. Collect from at least 3 locations per plot.

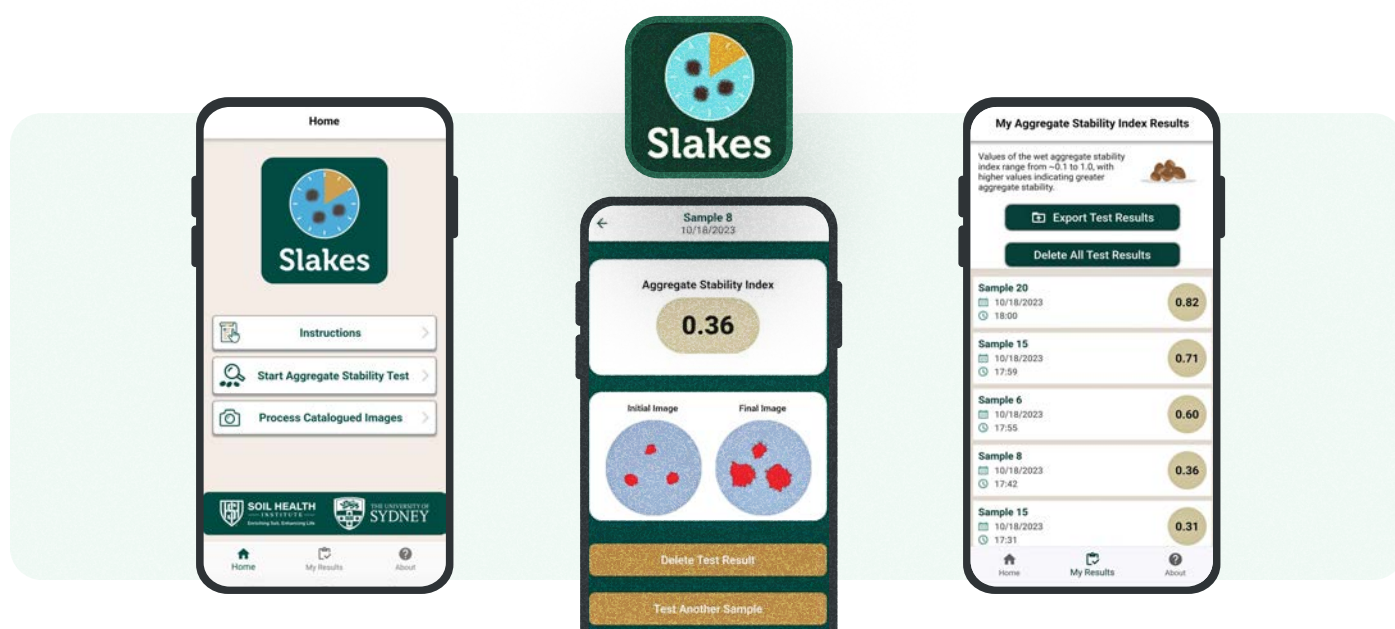
For each sample, analyze **at least** 3 technical replicates (plates), each with 3 soil aggregates per plate, for 9 aggregates total per sample.

Materials needed

- Shovel, soil corer, or knife
- Android or iOS smartphone
- SLAKES app (free app - <https://soilhealthinstitute.org/our-work/initiatives/slakes>; see References)
- Paper bags (optional, for air-drying)
- Clear plastic petri dishes or glass containers
- Scale
- White sheet of paper (for contrast) or light pad (ideal)
- Tap water (preferably deionized water if available)
- Smartphone mount
- Field notebook
- Pen or pencil

Procedure

1. Remove an intact clod of soil from the 0-10 cm surface layer. Gently break apart the clod along natural planes of weakness to release aggregates 4-8 mm in diameter. Do not sieve the soil – sieving disrupts aggregates. Discard aggregates with flat faces created during extraction.
2. Air-dry enough soil to yield at least 15 suitable aggregates per sample. Weigh the fresh soil and air-dry until mass is relatively stable for 24 hours. Paper bags work well for drying.
3. Place a white sheet of paper on a flat surface to provide a high-contrast background.
4. Mount the smartphone exactly 12 cm (about 5 inches) above the paper surface. This distance is critical for accurate image analysis.
5. Place an empty clear petri dish on the paper, centered under the smartphone camera.
6. Select 3 aggregates (4-8 mm diameter, roughly symmetrical or round if possible) and place them in the dish. Note their orientation.
7. Open the SLAKES app. Tap “Start Aggregate Stability Test” and enter the sample ID.
8. Use the slider so that the red outline only captures the surface area of the aggregates, and not any shadows or parts of the petri dish, then take a photo of the 3 air-dry aggregates.
9. Fill a second clear petri dish with enough water to fully submerge the aggregates. Swap it into the position of the first dish.
10. Gently transfer the aggregates to the water-filled dish in the same orientation and take a photo to start the timed test. Adjust the slider for shadows again, as above, if needed and take another photo.
11. Wait 10 minutes. The app will automatically capture the final image and calculate the aggregate stability index.
12. Repeat steps 5-11 for each technical replicate (3 replicates of 3 aggregates = 9 aggregates per sample). Add technical replicates if the results are highly variable.
13. Go to the “My Results” tab and tap “Export Test Results.” Upload to a computer and record geographic location, soil management history, and restoration treatment. Average the valid technical replicates for each sample.



Interpreting results

The SLAKES app produces an aggregate stability index ranging from 0 to 1:

Index range	Interpretation
0	Very low stability – aggregates disintegrate rapidly; high erosion risk
1	Maximum stability – strong aggregate structure; low erosion risk

Track changes over time. An increasing index indicates improving soil structure and is evidence of restoration progress.

Important considerations

- Use clear and clean plastic or glass containers.
- Select symmetrical aggregates about 4-8 mm in diameter.
- Aggregates from soils with poor structure will break apart in water. If aggregates break during handling prior to submersion, the initial image of air-dry soil is no longer valid, and the procedure must be repeated for that replicate.
- Be careful not to accidentally measure rocks instead of soil; if the slaking index is suspiciously high or greater or equal to one, the “aggregate” might be a rock.
- Repeat this measure over time. Compare samples from the same seasons or time periods each year to control for normal intra-annual variation

References

Flynn, K. D., et al. (2020). Evaluation of SLAKES, a smartphone application for quantifying aggregate stability, in high-clay soils. *Soil Science Society of America Journal*, 84(2), 345-353.

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

Fajardo, M. et al. (2025). Measuring soil aggregate stability with mobile phones, lessons, challenges, and future work. *Scientific Reports*, 15, 24536. <https://doi.org/10.1038/s41598-025-09925-9>

SLAKES app download: <https://soilhealthinstitute.org/our-work/initiatives/slakes/#download>

See also

Sampling Protocol (00), Bulk Density Protocol (01). Aggregate stability and bulk density are negatively affected by compaction and covary with infiltration and water-holding capacity).

Useful resources

- SLAKES app download and instructions:

<https://soilhealthinstitute.org/our-work/initiatives/slakes/#overview>

- SLAKES app tutorial / aggregate stability test demonstration -

<https://www.youtube.com/watch?v=14ekNUUGq20>

Questions or Feedback?

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