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Soil Science Challenge Grants Program

Queensland University of Technology

Keeping soil carbon in grasslands through drought: project summary

Project period: June 2022 to December 2025

Introduction

Grasslands across northern and eastern Australia play an important role in storing carbon in the soil. They also support Australia's livestock industry. These areas often experience long dry periods, strong sunlight and unpredictable rainfall. This project investigated whether soil carbon can survive drought, and what conditions help it stay in the soil over the long term. Rather than only measuring whether soil carbon increased or decreased during the study, researchers looked at the processes that determine whether carbon is likely to remain stored in the soil over the long run.

Findings

Overall, the amount of soil carbon stayed about the same during the study, even during drought. Although the amount of carbon in the soil appeared to stay the same, important changes were happening that were not obvious at first. These changes affected how carbon moved through the soil system and reveal valuable information about the soil's long-term resilience and risk of carbon loss. This information cannot be identified by standard soil carbon tests alone.

One of the biggest changes was in plant growth. At the driest sites, grasses put more energy into growing roots instead of leaves. This allowed plants to keep supplying carbon to the soil, even when growth above the ground slowed down. This response was much stronger than that seen in cooler grasslands overseas. It suggests, Australian grasslands are naturally well adapted to drought and can continue adding carbon to the soil during dry periods.

What really happens to carbon after it enters the soil is just as important. The study found that drought changed the way new carbon was stored. During drought, more carbon ended up in forms that break down quickly instead of forms that remain in the soil for longer. In other words, drought did not reduce the amount of carbon entering the soil. Instead, it made that carbon more likely to be lost over time.

The study also found that grazing management made a difference. Under conventional grazing, drought caused more carbon to move into less stable forms. Under time-controlled grazing, these changes were not seen. More stayed on pathways linked to long-term storage. This shows that grazing management affects more than pasture growth. It also influences how soil stores carbon, especially during drought. From a practical perspective, this means that good grazing management can help buffer soils against drought-driven carbon vulnerability even when rainfall is limited.

Further testing confirmed these results. Under drought and conventional grazing, dead plant material was less likely to become stable soil carbon. Under time-controlled grazing, carbon remained more stable. Importantly, these changes happened even though the total amount of soil carbon did not change. This suggests that warning signs of future carbon loss appear before overall soil carbon levels begin to decline.

The project also looked at more extreme conditions, including long dry periods, intense sunlight and rainfall after drought. Researchers found that sunlight changed plant material by causing carbon to be lost quickly when the soil became wet again. This process, called photopriming, happens separately from plant growth and soil biology. As climate change increases, so may the number of extreme drought and heavy rainfall events. This process may become more important, particularly in grasslands with long dry seasons. Modelling helped show what these findings could mean for the future. When only increased root growth was considered, soil carbon increased slightly over time. When only the effects of photopriming were included, soil carbon declined.

Although these effects were modelled separately, the results show that drought creates both positive and negative effects on soil carbon. In the future, these effects may balance each other, but more severe or frequent droughts could shift that balance towards carbon loss.

Publications

This project has resulted in peer review journal papers currently in preparation or in review. This section will be updated once papers are published.

More information

Learn more about the Soil Science Challenge Grants Program.

Contact the project lead, Professor David Rowlings.

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