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Soil Science Challenge Grants Program

The University of Sydney

Diversity and spatial distribution of soil viral communities across Australia: project summary

Project period: June 2022 to December 2025

Introduction

This project investigated the diversity and spatial distribution of soil viral communities across Australia through a coordinated program of field sampling, laboratory protocol development, high-throughput sequencing, and integrated bioinformatic and spatial analyses.

The project progressed from a pilot study in New South Wales to a continental-scale sampling campaign. In parallel, robust protocols for soil nucleic acid – deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) – preservation and extraction were developed, enabling reliable recovery of viral genetic material from remotely collected samples. A national sampling framework was established along the 500 mm to 600 mm rainfall isohyet that represents Australia's major agricultural regions from which soils spanning diverse soil types, environmental conditions and land-use systems were collected. Using shotgun metagenomic and meta transcriptomic sequencing, one of the most comprehensive continental-scale soil viral datasets to date was generated. In the process, over 680,000 DNA viral operational taxonomic units and more than 13,000 novel RNA viruses were identified, 86% of which are assigned to the microbe-associated phylum Lenarviricota.

Findings

Through integrative analyses combining pedometric approaches with biomolecular data, the project revealed that variation in annual precipitation is the primary driver of soil viral diversity at the continental scale, with viral diversity exhibiting a distinctive inverted U-shaped relationship with soil pH. The way environmental selection process's structure bacterial and fungal distributions across the continent was characterised. A scale assessment of microbial functional groups, including antibiotic resistance genes and microbial growth strategies in relation to soil carbon cycling, was also conducted.

The comprehensive datasets generated in this study provide a valuable national reference resource for future investigations of soil biodiversity and will support evidence-based soil management, sustainable agriculture and environmental monitoring across Australia.

Publications

This project has published the following papers with additional papers currently in preparation or in review. This section will be updated once additional papers are published.

Du, M, Xue, P, Minasny, B, Jang, HJ & McBratney, A 2026, [Macroecological processes impact Australian soil resistomes, and climatically stable regions with anthropogenic activities serve as ARG hotspots](#), *The ISME Journal*, vol. 20, no. 1, wrag079, DOI: 10.1093/ismejo/wrag079

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Du, M, Xue, P, Minasny, B, McBratney, A, Fajardo Pedraza, M, Pino, V, de Caritat, P, He, J, Chen, Q & Bissett, A 2025b, [Soil microbial blueprint: predicting soil dominant bacterial genera distribution across Australia](#), *Molecular Ecology*, vol. 34, no. 21, e70135, DOI: 10.1111/mec.70135

Du, M, Xue, P, Minasny, B, McBratney, A & Tang, Y 2025, [Patterns, processes, and predictions: soil bacteria unique habitats along a megametre transect in Eastern Australia](#), *Soil Ecology Letters*, vol. 7, no. 3, 250313, DOI: 10.1007/s42832-025-0313-3

Du, M, Xue, P, Minasny, B, McBratney, A & Tang, Y 2026, [Abundant microbial taxa are more sensitive to land-use intensification than their rare counterparts](#), *Applied Soil Ecology*, vol. 220, 106899, DOI: 10.1016/j.apsoil.2026.106899

Du, M, Xue, P, Minasny, B, McBratney, A & Tang, Y 2026, [Soil bacterial, fungal, and protistan assembly processes across a 1300 km climate and land-use transect](#), *Catena*, vol. 262, 109609, DOI: 10.1016/j.catena.2025.109609

Sadiq, S, Xue, P, Tang, Y, Du, M, Van Brussel, K, McBratney, AB, Holmes, EC & Minasny, B 2026, [Limited effect of short- to mid-term storage conditions on an Australian farmland soil RNA virome](#), *Journal of Virology*, vol. 100, no. 2, e01459-25, DOI: 10.1128/jvi.01459-25

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Xue, P, Minasny, B, Román Dobarco, M, Wadoux, AMJ-C, Padarian Campusano, J, Bissett, A, de Caritat, P & McBratney, AB 2025, [The biogeography of soil bacteria in Australia exhibits greater resistance to climate change than fungi](#), *Global Change Biology*, vol. 31, no. 6, e70268, DOI: 10.1111/gcb.70268

Xue, P, Minasny, B, Wadoux, AMJ-C, Román Dobarco, M, McBratney, AB, Bissett, A & de Caritat, P 2024, [Drivers and human impacts on topsoil bacterial and fungal community biogeography across Australia](#), *Global Change Biology*, vol. 30, no. 3, e17216, DOI: 10.1111/gcb.17216

More information

Learn more about the [Soil Science Challenge Grants Program](#).

Contact the project lead, [Professor Budiman Minasny](#).

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**Australian Government****Department of Agriculture, Fisheries and Forestry****Acknowledgement of Country**

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