



The Ground We Stand On

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The ground is the foundation of our daily lives – we walk around on it, build our homes on it, and travel huge distances across it - but there's far more to it than just being the structure that holds us all up. This lecture can't cover everything that happens underground, but will be built around two pillars:

- Our footprint (the amount of ground we need to live) is far larger than many of us realise.
- The ground is an active part of our world, exchanging water, carbon, heat and life with the atmosphere, ocean, biosphere and ice above.

What is the ground?

We are taught to think of the ground mostly in terms of geology, and rocks are certainly very important. The rocks at Earth's surface are very different in different places, made from very varied combinations of atoms. The British Isles have an exceptionally broad range of rocks and features in a relatively small area, covering almost every stage of Earth's history. But there's more to the ground than solid rock. There are pores and cracks in many rocks that are usually filled with liquid water, and 30.1% of all of Earth's freshwater is stored in these underground crevices. This makes it a very significant water reservoir; in some places on Earth that water would create a pool more than 50 metres deep if it was moved up to sit on the surface. Life also exists down here in the dark, even life that needs to breathe oxygen. A recent discovery showed that oxygen can be produced in very deep groundwater (> 200m down), without photosynthesis, so these regions have rich and varied microbiomes.

The very top layer of the ground is often soil, which is starting to receive much more attention as it becomes apparent that it's effectively a non-renewable resource that we are using up. Soil is an incredibly complex structure of solid, liquid, gas and life, which is hydrologically and chemically very active.

What does the ground do?

We rarely say it out loud, but we grow up with the knowledge that soil is a fantastic medium for recycling – almost anything organic that's buried will be recycled very quickly. But it's very important for the way our world is that this recycling is not instant. Instead, dead organic matter often gets either partially processed, or turned into molecules that are fairly resistant to being consumed themselves. This is what gives us the organic matter of the soil: humus. If full recycling happened immediately, microbes would consume all the soil organic matter and breathe out carbon dioxide, returning that carbon to the atmosphere. This doesn't happen, so the soil is an important *store* of organic carbon. However, in a warming world, where microbial degradation can happen more quickly, it's possible that more efficient recycling could release more carbon to the atmosphere.

The ground is also important as a store for heat. In the top few metres this can be a store of energy that came from the Sun relatively recently. But the more important heat gradient represents the slow flow of

heat out of the very hot centre of the Earth. About half of this is heat left over from the formation of Earth, and half is the heat from radioactive decay in the Earth's mantle and crust. On average, the temperature goes up by about 30°C per kilometre of depth, but in some places this gradient is much steeper near the surface. This means that you don't need to go down as deep to get to the same high temperature, which is potentially very useful for technologies like ground source heat pumps and geothermal energy.

Is the ground changing?

The ground is continually changing naturally, but we will focus on the additional changes to its shape, its biota, and the nature of the top few metres, that are caused by human actions. NASA has just launched a new satellite mission called NISAR, which is designed to monitor very small changes over time in the shape of the Earth's surface, along with many other parameters.

Humans have had an extraordinarily large influence on the Earth's surface, mostly due to clearing and modifying land for food production. There are still large natural forests, and large areas of ice and snow, but our food production takes up around 45% of all the land that isn't glaciers or barren. Many of the ideas for future technologies (especially those for mitigation of or adaptation to climate change) involve using land for new purposes, or changing its current use. But we only have a finite amount of land, so we have decisions to face.

The future

We want to do more and more, but we do not have more and more land to accommodate expansion. We are also realizing that the future of land is not just about what we do at the surface, but about what is happening underneath, and whether we enable or obstruct those processes. Plenty of what the ground does underneath us provides the environment that we take for granted up above, so this cannot just be a question of ownership. Maybe we can be smarter, using land for multiple purposes (for example, grazing sheep on land that's partly covered by solar panels), or fairer in how land use gets decided on. But the ground is more than a surface to stand on. It's part of the biosphere that keeps us alive, and we need to see it in that light.

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References and Further Reading

Introduction

Geindex (British Geological Survey geological map of the UK):
<https://mapapps2.bgs.ac.uk/geoindex/home.html>

What the ground is

Soil Atlas 2024: <https://eu.boell.org/en/SoilAtlas>

Oxygen production in deep groundwater:

Ruff, S. E., Humez, P., De Angelis, I. H., Diao, M., Nightingale, M., Cho, S., ... & Strous, M. (2023). Hydrogen and dark oxygen drive microbial productivity in diverse groundwater ecosystems. *Nature Communications*, 14(1), 3194.

Soil biodiversity: <https://www.pnas.org/doi/abs/10.1073/pnas.2304663120>

The Conversation article on soil biodiversity:

<https://theconversation.com/more-than-half-of-life-on-earth-is-found-in-soil-heres-why-thats-important-2114>
 55

What does the ground do?

Global Carbon Budget: <https://globalcarbonbudget.org/>

Climate change impacts on UK peat:

Ritson, J. P., Lees, K. J., Hill, J., Gallego-Sala, A., & Bebber, D. P. (2025). Climate change impacts on blanket peatland in Great Britain. *Journal of Applied Ecology*, 62(3), 701-714.

Possible loss of soil carbon in a warming world:

García-Palacios, P., Crowther, T. W., Dacal, M., Hartley, I. P., Reinsch, S., Rinnan, R., ... & Bradford, M. A. (2021). Evidence for large microbial-mediated losses of soil carbon under anthropogenic warming. *Nature Reviews Earth & Environment*, 2(7), 507-517.

British Geological Survey geothermal map: <https://ukgeothermalplatform.org/>

Is the ground changing?

How interferometry on the NASA NISAR mission works:

<https://science.nasa.gov/mission/nisar/interferometry/>

British Geological Survey explanation of shrinking and swelling in soils:

<https://www.bgs.ac.uk/geology-projects/shallow-geohazards/clay-shrink-swell/>

Nature paper on invasive earthworm species in North America:

Mathieu, J., Reynolds, J. W., Fragoso, C., & Hadly, E. (2024). Multiple invasion routes have led to the pervasive introduction of earthworms in North America. *Nature Ecology & Evolution*, 8(3), 489-499.

The ground and us

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He, L., Xian, H., Yang, Y., Cao, J., Yang, H., Xie, J., ... & Zhu, J. (2025). Discovery and Implications of a Nanoscale Rare Earth Mineral in a Hyperaccumulator Plant. *Environmental Science & Technology*, 59(48), 25973-25981.

London public land ownership map: <https://apps.london.gov.uk/public-land/>