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What's on Nature's secret plant list?

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Abstract

Picture a meadow or forest full of plants. Did you know that even when it looks wild and healthy, there are many plants missing? Scientists call these "missing species" dark diversity. Our team studied more than 5,000 sites in 119 regions across the globe. Each site was about the size of a classroom. We counted the plants that actually grew there. Then we compared them with the plants that could live there. On average, only about one-quarter of the possible plants were present. The rest were gone, even in places that still look natural. Why? Human activities – like building roads, cities, and farms – make it hard for plants to survive or return. We found that the more people shape the land, the fewer plants remain from the full list of potential species. This hidden loss shows that Nature is emptier around us than it appears. That matters for protecting biodiversity.

Introduction

You probably know about endangered animals, like pandas or tigers. But what about plants? They are the backbone of every **ecosystem** – offering homes, food, shade, and oxygen to other species. When plants disappear, so does much of the life around them.

But here's the tricky part: sometimes a forest or meadow looks healthy. But many of the plants that could be there are actually missing. This is where the idea of **dark diversity** comes in. Dark diversity is like Nature's secret list – the plants that the environment could support, but that we don't see anymore.

The problem is that most of the time, scientists only count the species they see. That number can make a natural area look better than it really is. Dark diversity shows us a hidden loss that's easy to overlook. It also raises important questions. How much of the world's plant life has quietly gone missing? And how much do humans cause that loss?

Methods

Here's how we studied hidden plant loss:

- Picking sites. We chose more than 5,000 natural **vegetation** spots in 119 regions around the world. Each site was 100 square meters (about the size of a classroom). The regions around them were about 300 km² (like a whole city).
- Counting plants. At each site, we listed every species we saw. We call this observed number of species **alpha diversity**.
- Comparing sites. We also looked at how the species lists changed from one site to another in the same region. This is **beta diversity** – it shows how different vegetation is across the region.

- Looking at the bigger picture. Across a whole region, we added together all the species we found. We call this **gamma diversity** – the total "regional library" of plants.
- Finding the missing plants. We calculated dark diversity by counting the plants that were absent but usually grow together with those found at a site. Think of it like a teacher asking, "Which of your classmates are missing today?"
- Making comparisons. The plants present (alpha diversity) plus the missing ones (dark diversity) formed the **species pool**. This is the plant diversity potential of a site. We then calculated **community completeness** – the fraction of the species pool that actually showed up in a site (Figure 1).
- Checking human influence. We used something called the **Human Footprint Index**. It combines things like how many people live in the region and the extent of roads, farmland, and cities. Then we looked at whether higher human impact meant lower biodiversity.

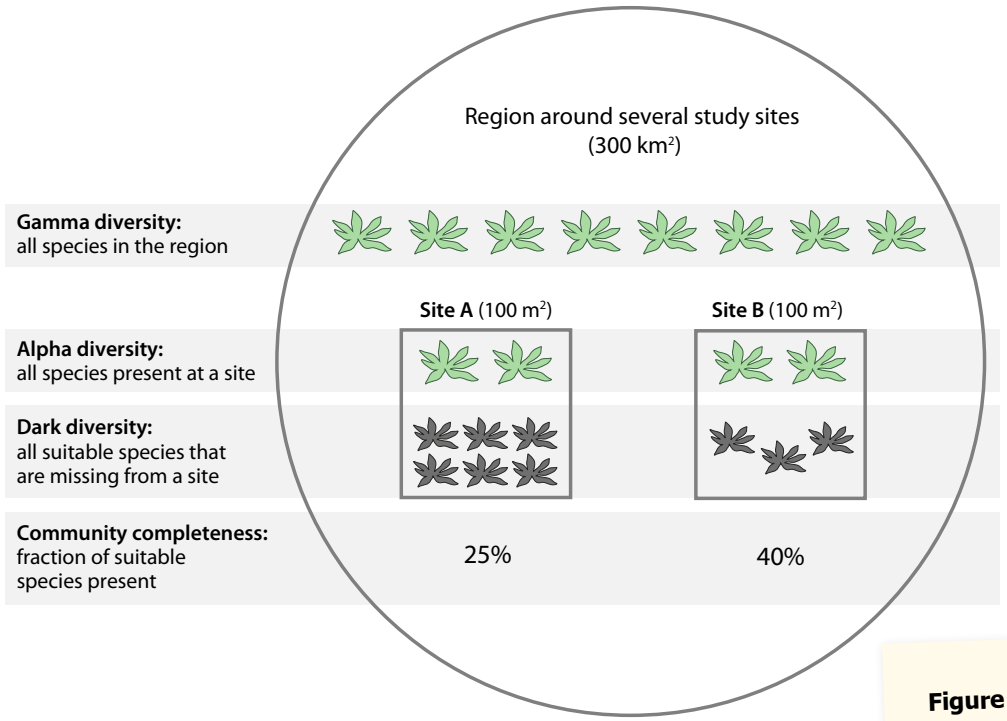


Figure 1: Dark diversity and community completeness.

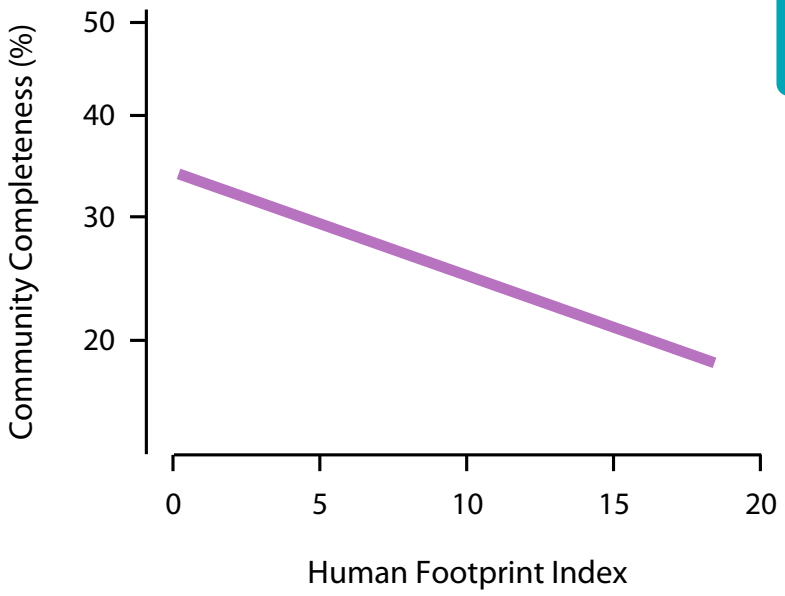
Results

What did we find out? Most sites were missing the majority of their possible plants! On average, only about 25% of the possible plants were present in each spot. That means about three quarters of the plants that could grow there were missing from that site. They still exist in the region, but not in that spot.

In areas with little human activity, about one in three expected species showed up. The rest were likely absent due to natural reasons. In areas with a high human footprint – lots of roads, farms, or cities – only one in five expected species were there (Figure 2).

Just counting plants (alpha diversity) didn't show this problem. This is because different locations have naturally more or fewer species. A meadow might look "full" but still have very low completeness. The hidden loss only became clear when we looked at Nature's secret list of missing plants.

Please see Figure 2 on page 3



How do human activities impact community completeness?

Figure 2: The relationship between human impact and community completeness (percentage of suitable plant species present).

Discussion

So what does this mean for Nature – and for us?

First, ecosystems are much less diverse than they should be. Even places that look wild and healthy have many missing species. This matters because every plant plays a role! That could be feeding insects, enriching soil, or sheltering animals. Fewer plants mean weaker ecosystems.

Second, human influence is a major cause of this loss. Roads cut up habitats, farms replace wildflowers, and cities block plants from spreading. Even if some green patches remain, the overall landscape makes it hard for species to survive or return.

Third, dark diversity shows us a hidden restoration opportunity. The missing plants are often still around somewhere in the region. The plants could come back if we give them a chance! For example, by reconnecting habitats and protecting land from overuse. Protecting biodiversity means giving space for the full cast of plants – both present and absent – to thrive.

Conclusion

Next time you walk through a meadow or forest, look closer. The plants you see may be only part of the story. Hidden in the background is dark diversity – the missing species that *should* be there but aren't. Don't just count the plants that are there. Think about the ones that are missing, too.

Human activity is making this hidden emptiness worse. But that also means we can help. By caring for wild spaces, limiting habitat destruction, and reconnecting natural areas, we can give missing plants a way back. The more plants we recover, the stronger and healthier ecosystems will be – for insects, animals, and people.

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Glossary of Key Terms

Alpha diversity - the number of species you actually see in a single site, for example by counting the plants in a meadow plot.

Beta diversity - the differences in species between sites. It shows how much the species list changes from one place to another.

Community completeness - the fraction of the species pool that is actually present in a site. This tells us how "full" the plant community is compared to its potential. 100% community completeness would mean that all suitable species are present.

Dark diversity - the species that could live in an area but are missing, even though they exist elsewhere in the region.

Ecosystem - a community of living things (including plants, animals, and microbes) and the environment they share.

Gamma diversity - the total number of species across an entire region; the "regional library" of species.

Human Footprint Index - a measure of how much people have changed the land through things like roads, farms, buildings, and population density.

Species pool - all the species that could live in a site, including both those that are present (alpha diversity) and those that are missing but could live there (dark diversity).

Vegetation - a collective word for plants in general or the plants in a particular area.

Check your understanding

1. What is dark diversity, and why is it important?
2. How might connecting two separate forests help reduce dark diversity?
3. Why does human influence affect plant community completeness even in places that look "natural"?
4. Which human activity do you think is most harmful to plant community completeness – building roads, farms, or cities? Why?
5. Imagine you wanted to study dark diversity in your schoolyard. What steps would you take to find out which plants are there and which ones are missing?

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