

Microplastic effects in terrestrial ecosystems and soils

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BBIB

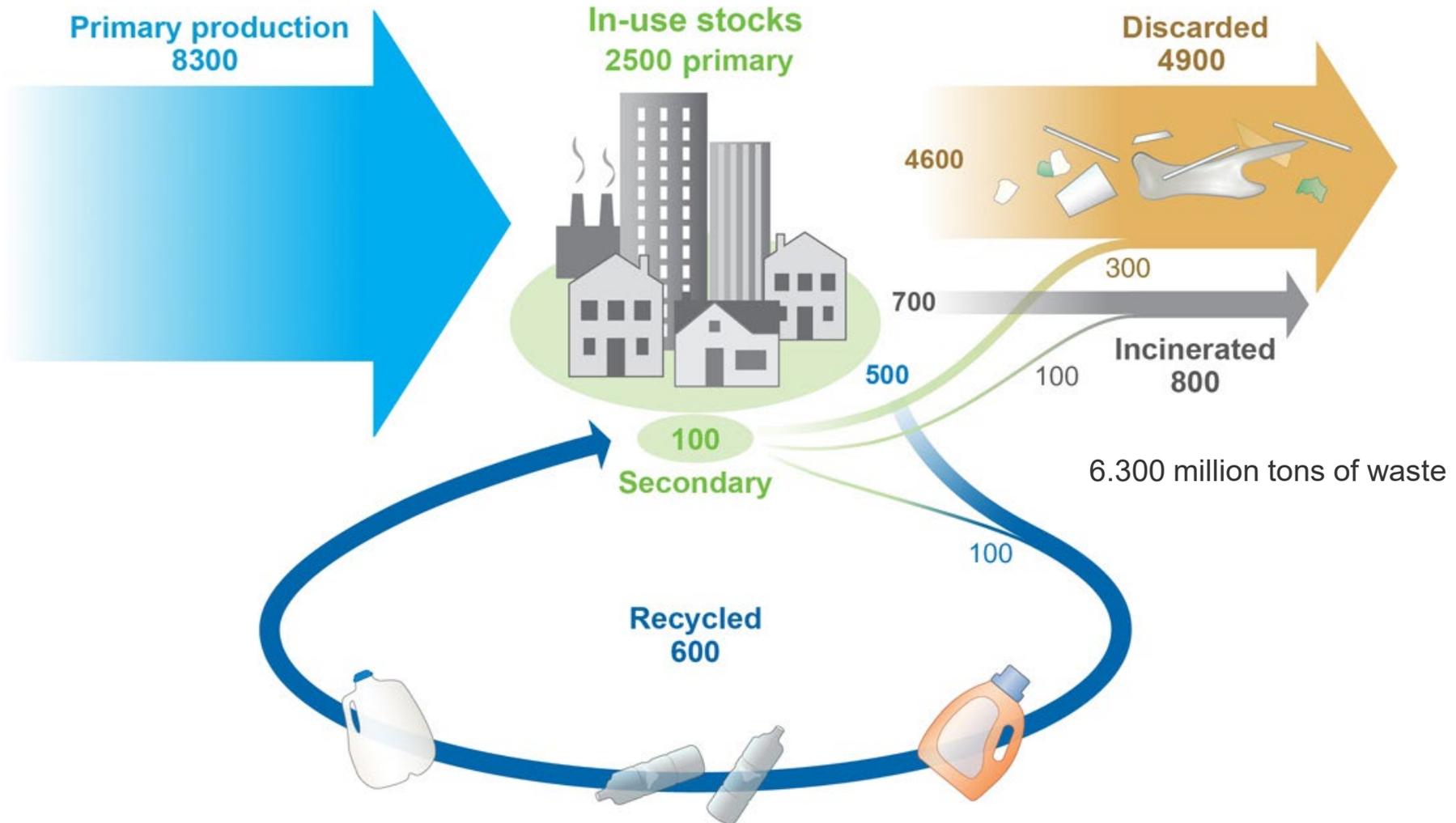
Berlin-Brandenburg Institute of
Advanced Biodiversity Research



In *Life* magazine in 1955, an American family celebrates the dawn of “Throwaway Living,” thanks in part to disposable plastics

<https://www.nationalgeographic.com/magazine/2018/06/>

All plastic ever produced (1950-2015)



Public perception – still more marine focused



Microplastic: plastic particles < 5mm



NOAA's National Ocean Service

Fragmentation or production



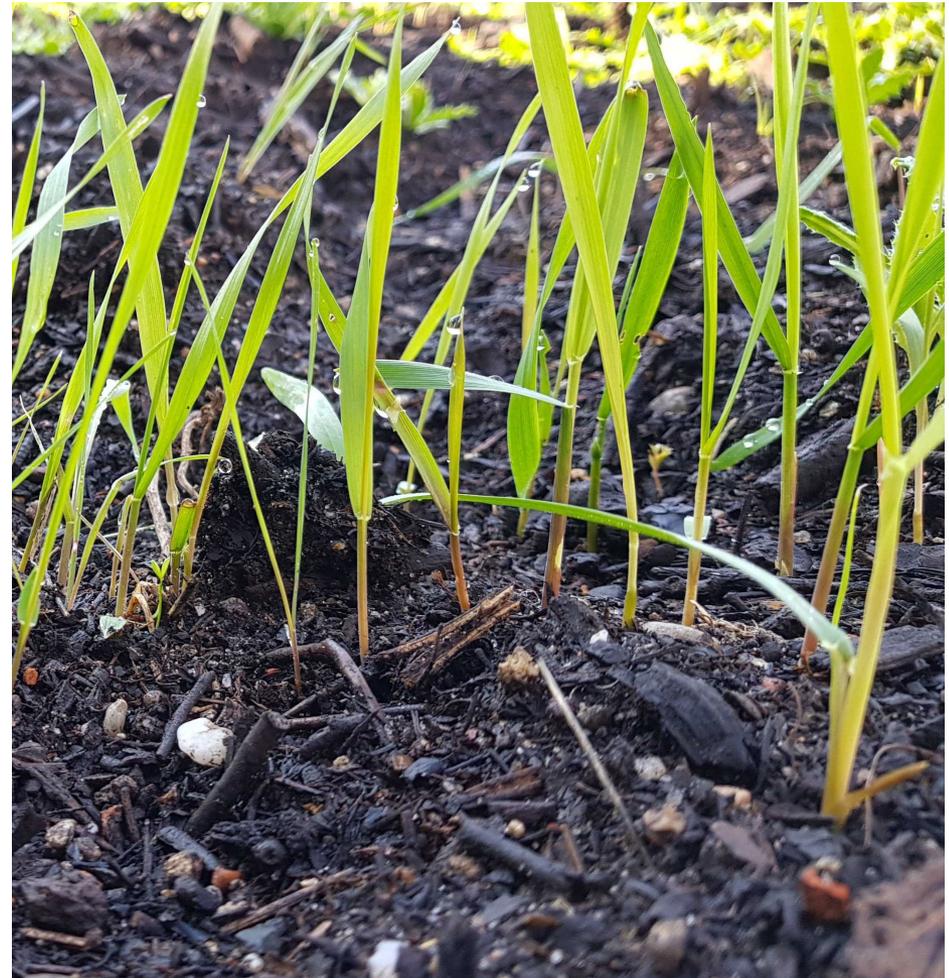
J. Rillig



Phys.org

Multiple input pathways to soils

- Aerial deposition
(Brahney et al. 2020 Science)
- Discarded plastic litter, fragmentation
(Rillig 2012; Kwak and An 2021)
- Plastic mulching, other agricultural products
(Bläsing and Amelung 2018)
- Compost or sewage sludge addition
(Weithmann et al. 2018)
- Roads (tire abrasion)
(Baensch-Baltruschat et al. 2020)



Transport of microplastic into soil

Earthworms efficiently transport various sized microplastic beads down into the soil (10cm depth, 21d)

(Rillig et al. 2017, *Sci Rep*)

Collembola (two spp.) transport microplastic beads horizontally (several cm within days)

(Maaß et al. 2017, *Env Poll*)



Other noteworthy means of transportation:

- Plowing, harvesting
- Root channels
- Movement with water

(Rillig et al. 2017, *Front Plant Sci*)



What are effects? Two vantage points

As a pollutant inducing toxicity (ecotoxicology)

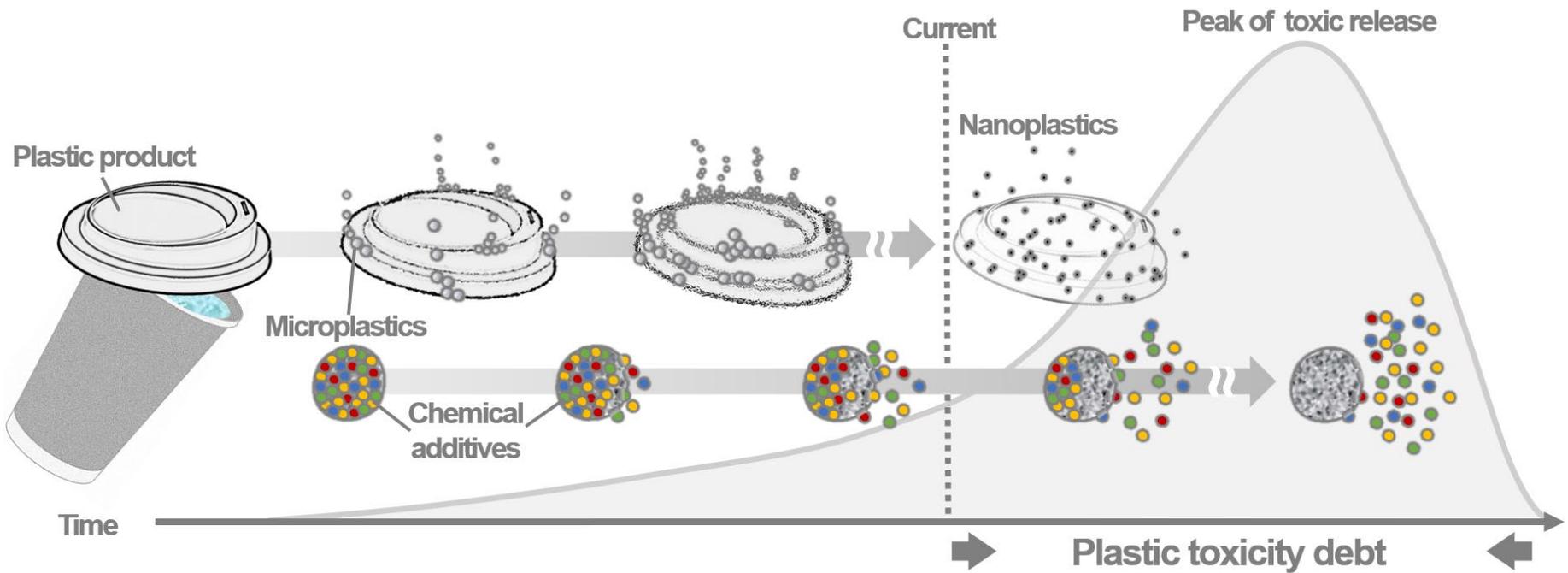
- Focus on *current* contamination levels
 - *Negative* effects
 - Focus on highly controlled experiments
 - Readouts from individual (model) organisms
- long-term effects

As a factor of global change

- Focus on *future* contamination levels
 - *Any* effects
 - Focus on ecological relevance, ecosystems
 - Ecosystem-relevant endpoints; communities
- Earth system feedbacks

Rillig and Lehmann 2020 *Science*
Rillig et al. 2021 *PLOS Biology*, in press
Rillig et al. 2021 *Env Sci Techn*

Global plastic toxicity debt



Microplastic as a factor of global change



Small-scale field experiment

Four different microplastic types

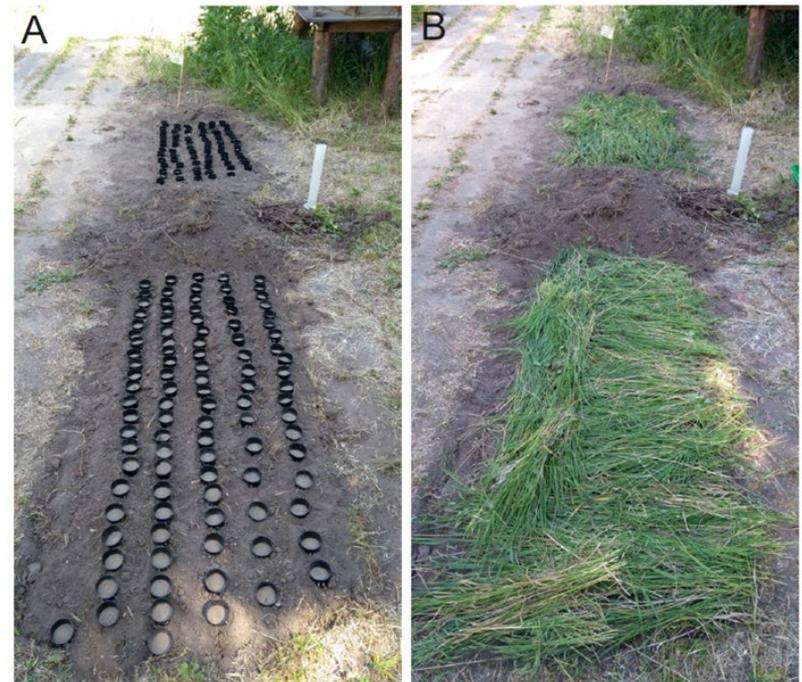
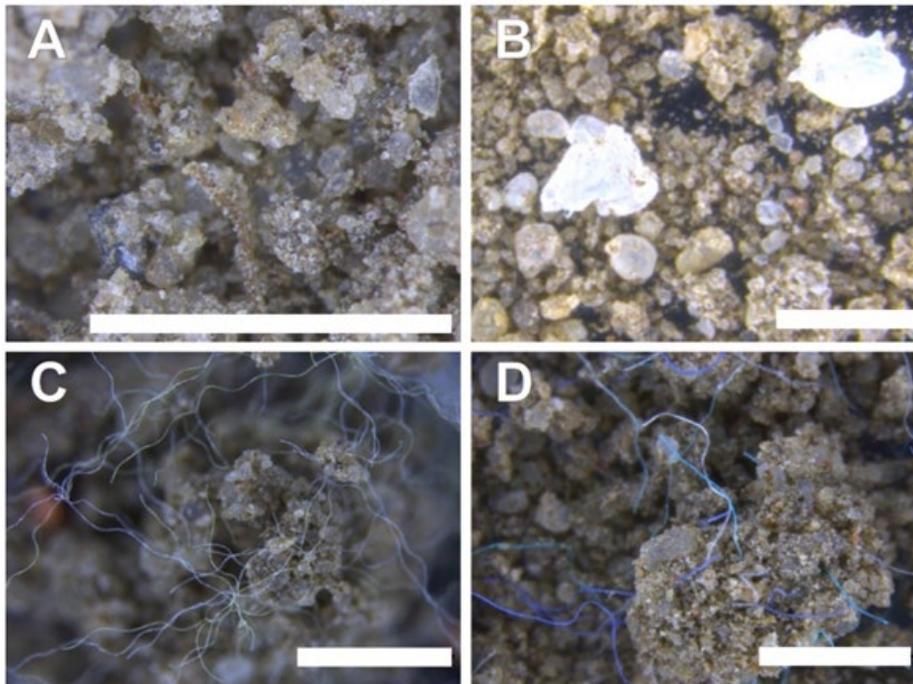
- Polyamide beads
- Polyethylene fragments
- Polyester fibers
- Polyacrylic fibers

Focus on soil physical effects and soil aggregation

Duration 5 wk

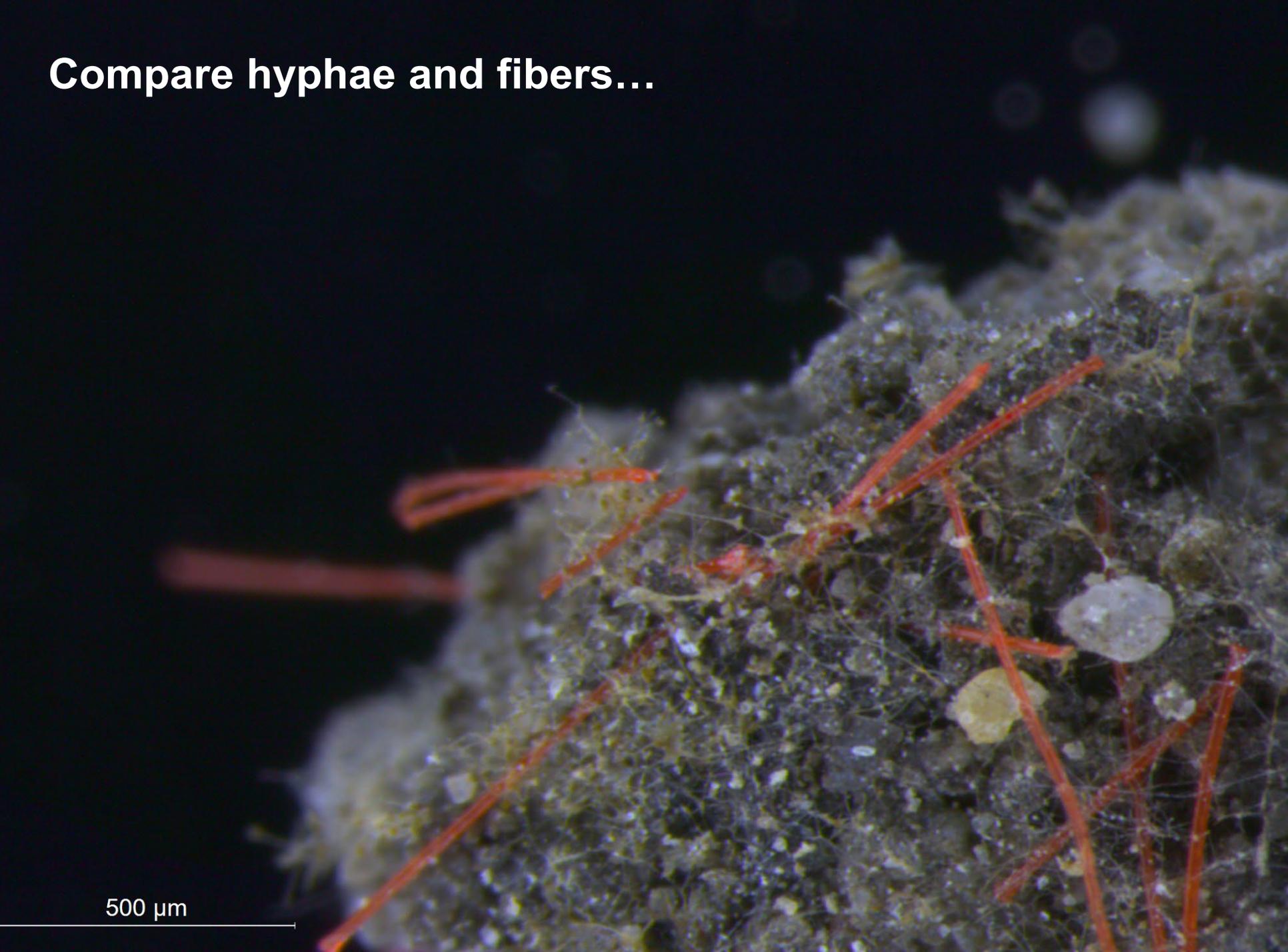
Found strong effects of fibers!

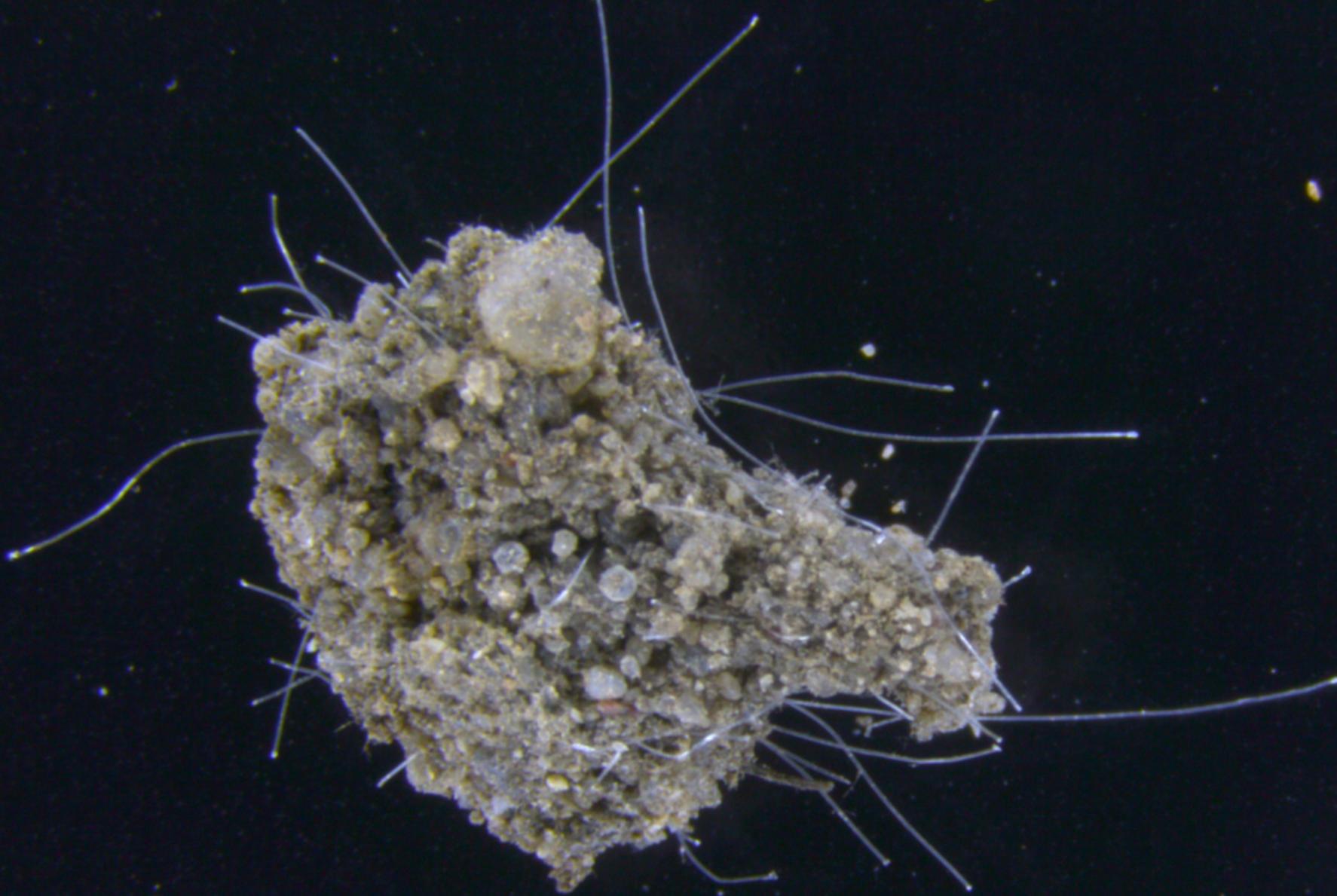
Negative effects on soil aggregation



Compare hyphae and fibers...

500 μm

A scanning electron micrograph (SEM) showing a dense network of fine, greyish hyphae and several thick, orange-red fibers. The hyphae form a complex, interconnected web, while the fibers are thicker and more linear. A scale bar in the bottom left corner indicates 500 micrometers.

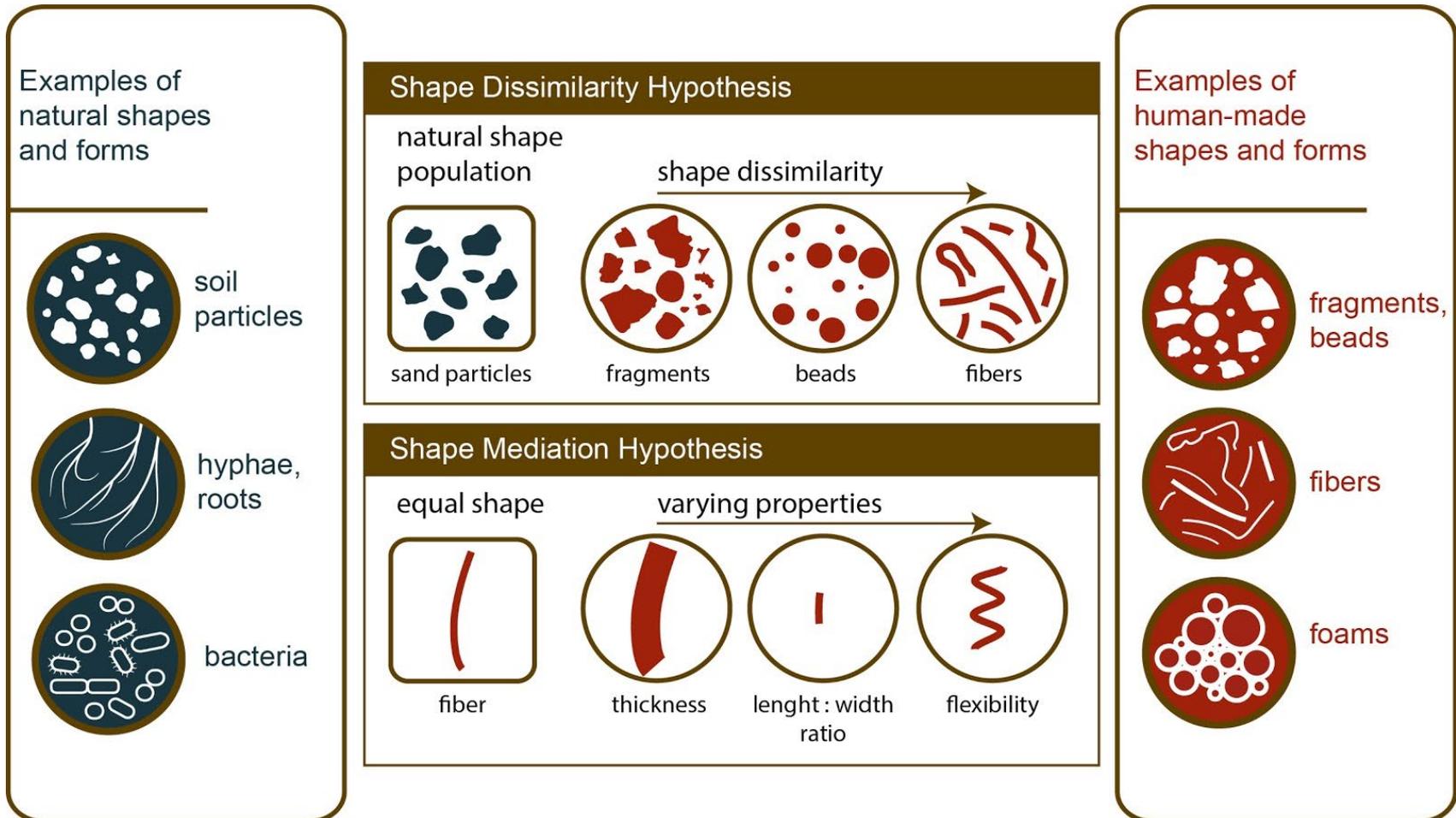


2 mm

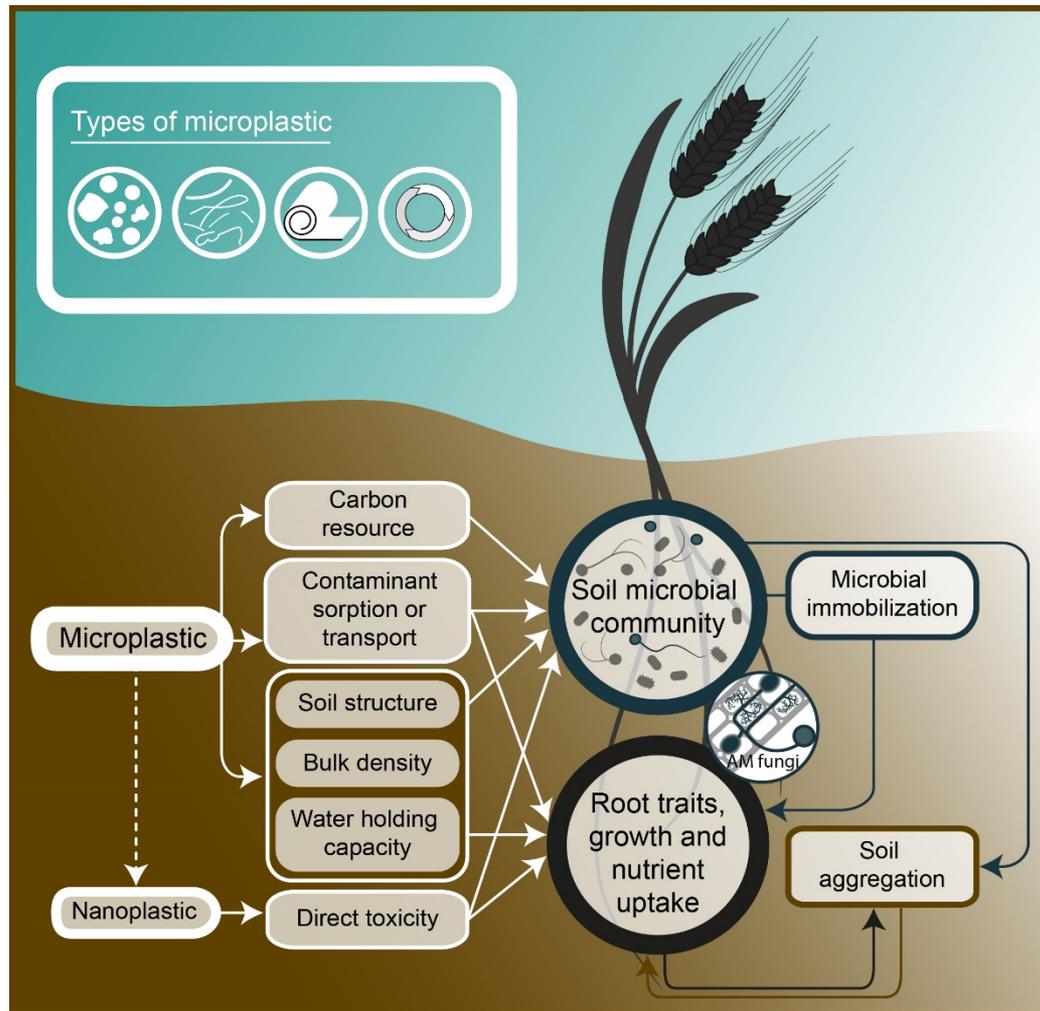
Machado et al. 2018, 2019
Lehmann et al. 2019

Picture by: Dr. Anika Lehmann

The importance of particle shape



How could plants be affected?

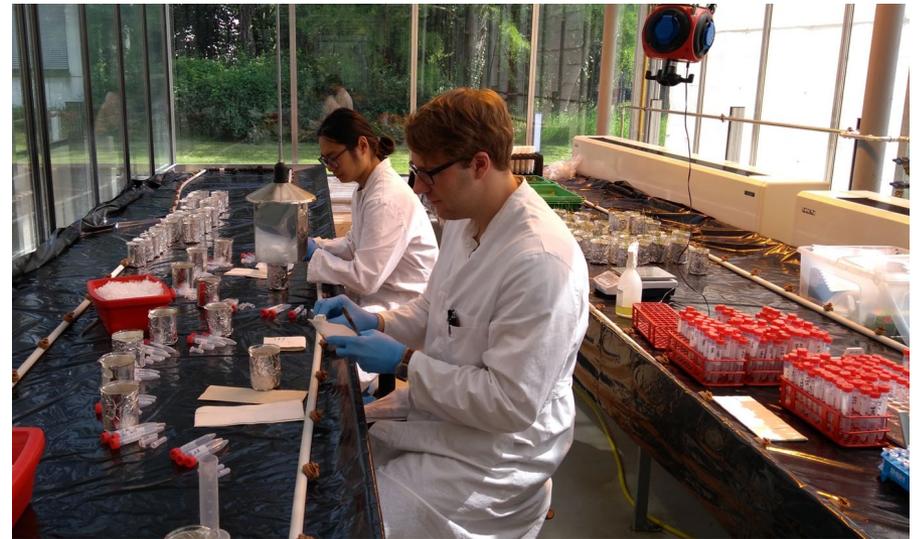


Rillig et al. 2019 *New Phytol*
Rillig 2020 *Nature Sustainability*

Our lab's major findings on plant effects

Neutral or positive effects on plant growth

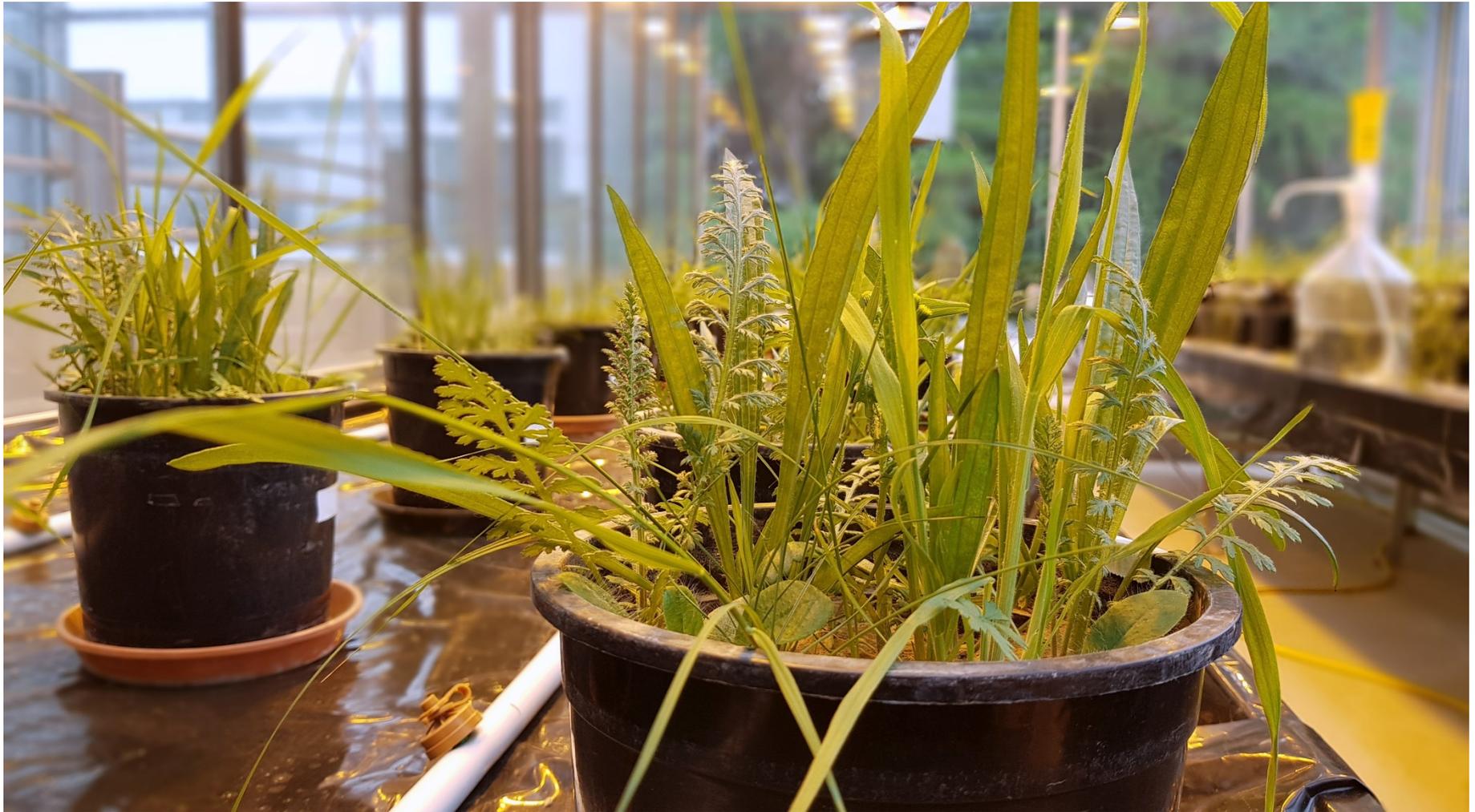
Positive effects on root-colonizing microorganisms (arbuscular mycorrhizal fungi)



Tire-wear particles: negative effects

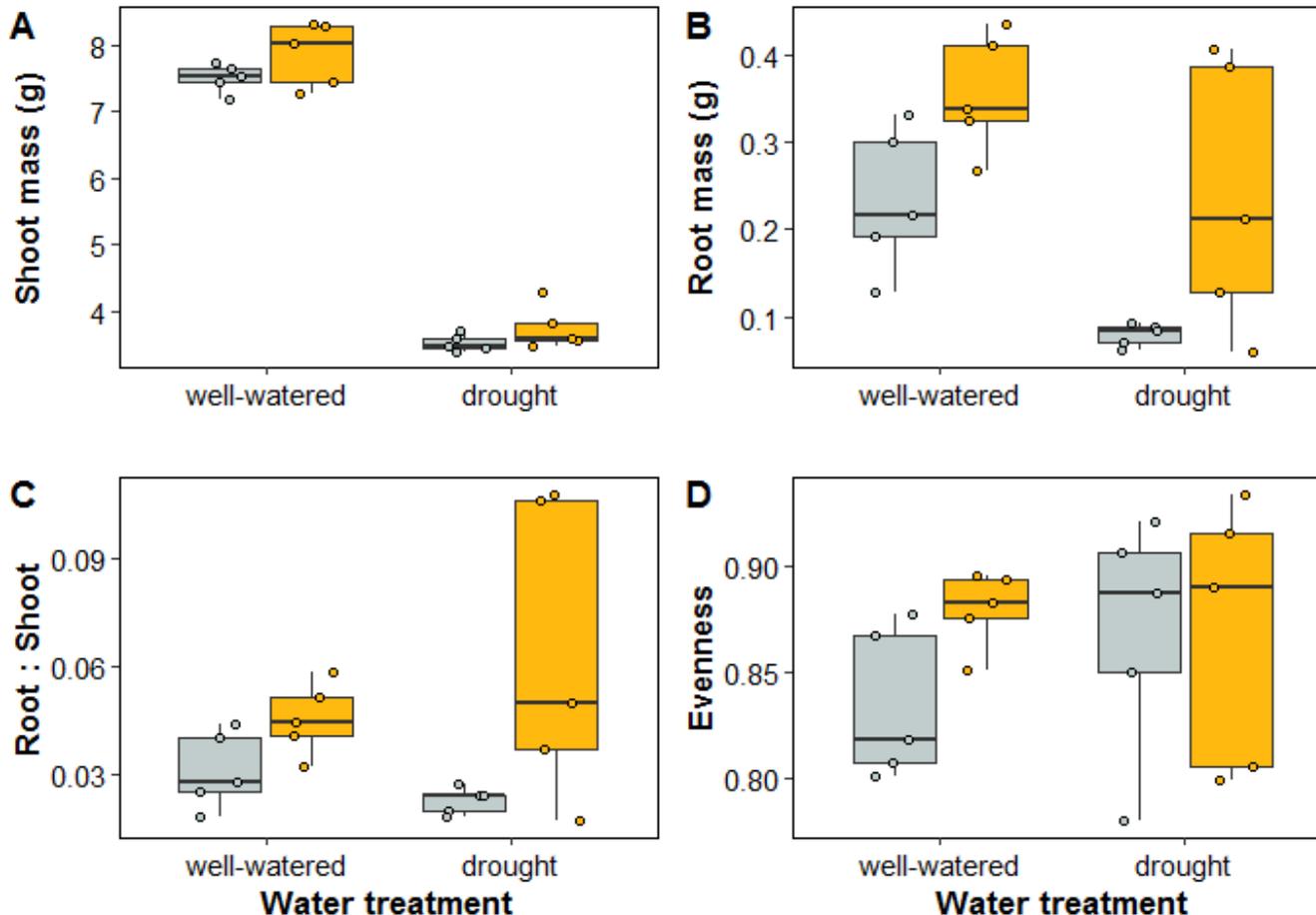
Machado et al. 2019 *Env Sci Tech*
Lehmann et al. 2020 *Soil Ecol Lett*
Leifheit et al. 2021 *Front Plant Sci*
Lozano et al. 2021 *Front Plant Sci*

What about the plant community (and ecosystem) level?

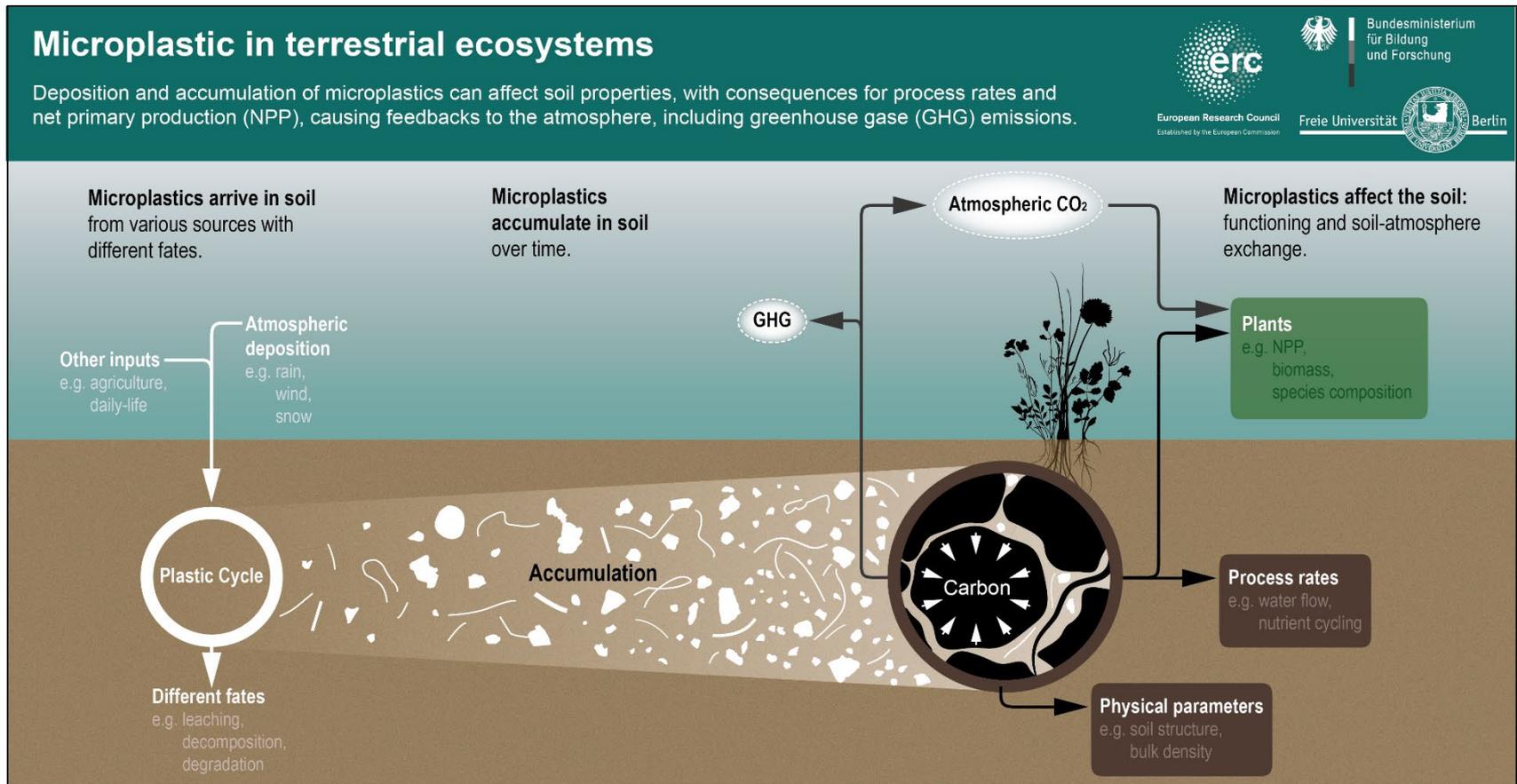


Plant community level responses: more biomass, but shifted community

Microplastic  absent  present

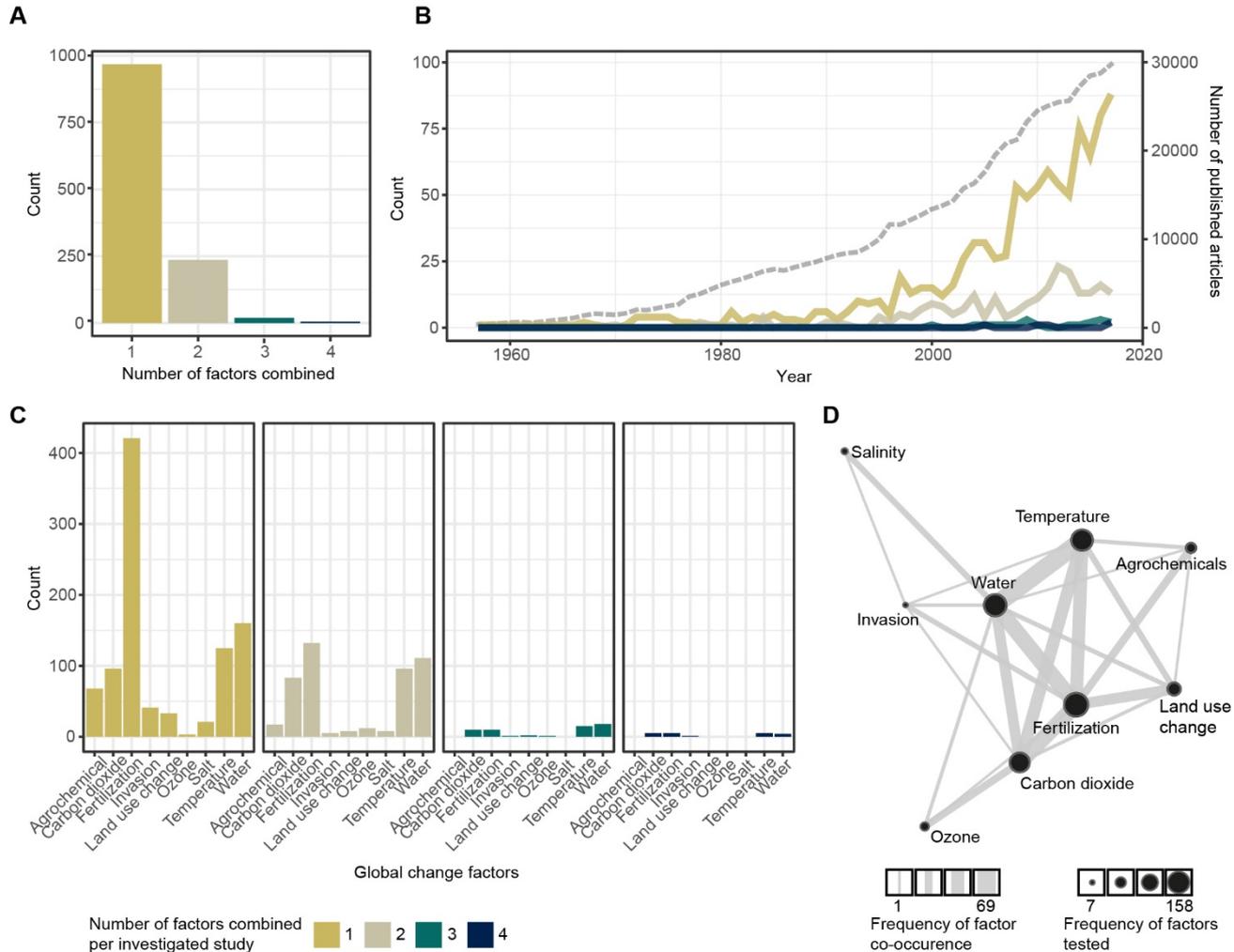


Consequences for Earth system feedbacks?



Rillig & Lehmann 2020, *Science*

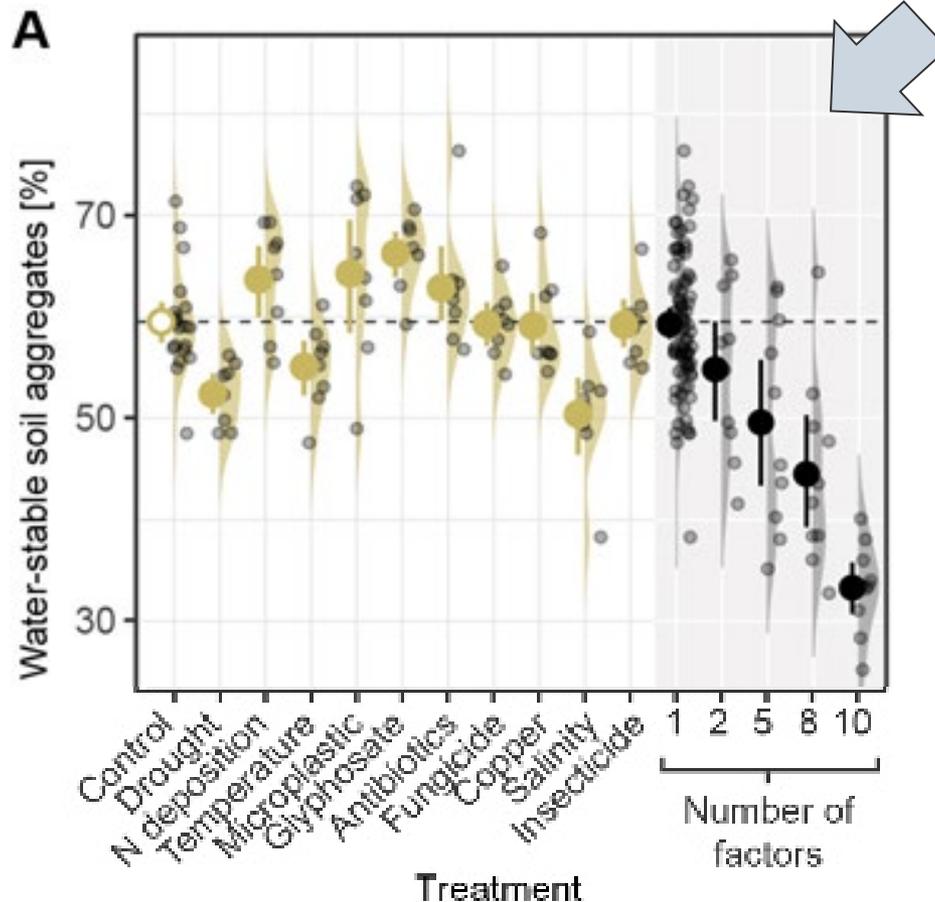
How well are we doing with multiple factors?



Multiple factors of global change



Multi-factor effects on soil aggregation

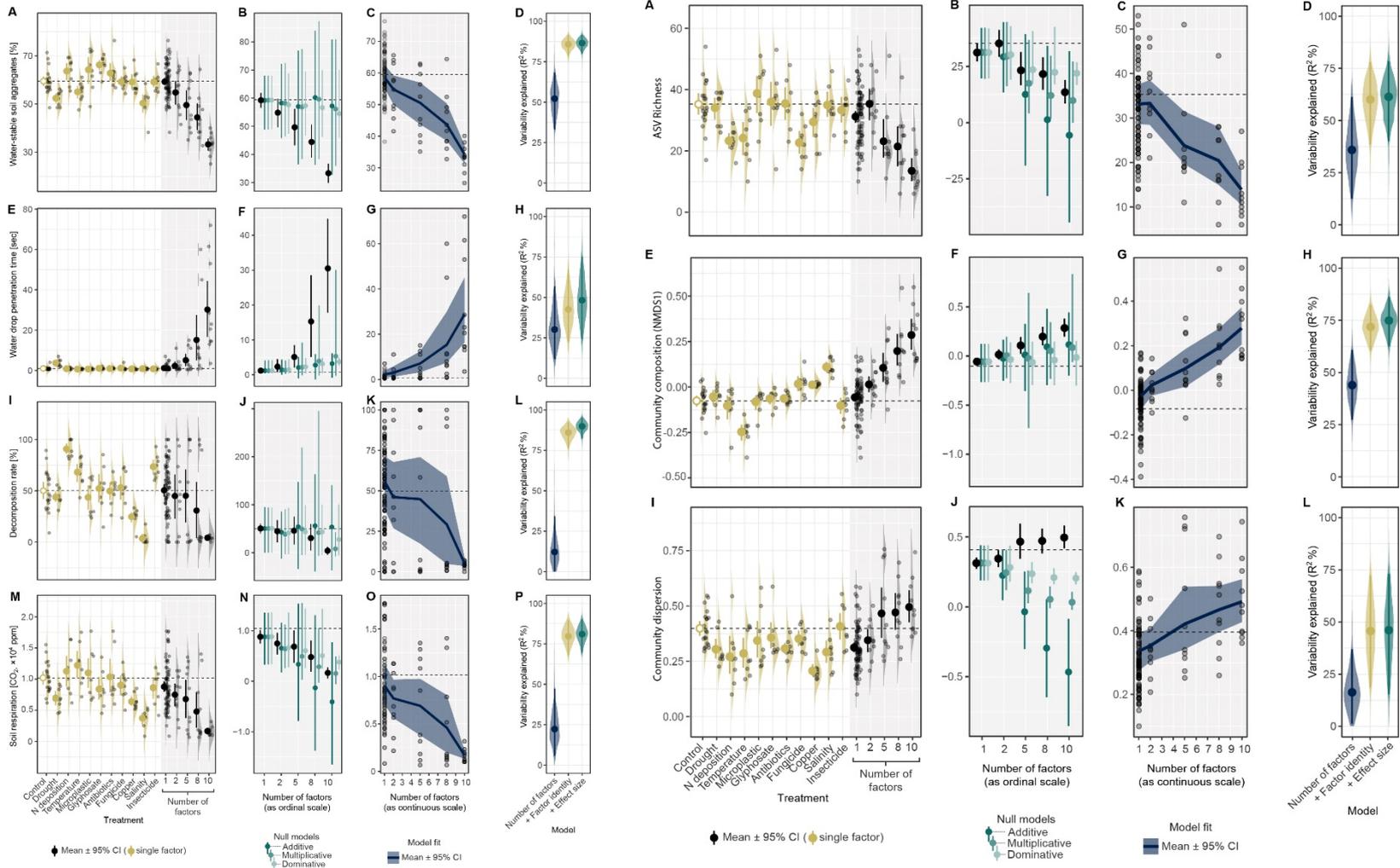


The *more factors*, the more soil functions and biodiversity decreased!

It didn't matter as much much *what factors (including microplastic)*!

● Mean ± 95% CI (● single factor)

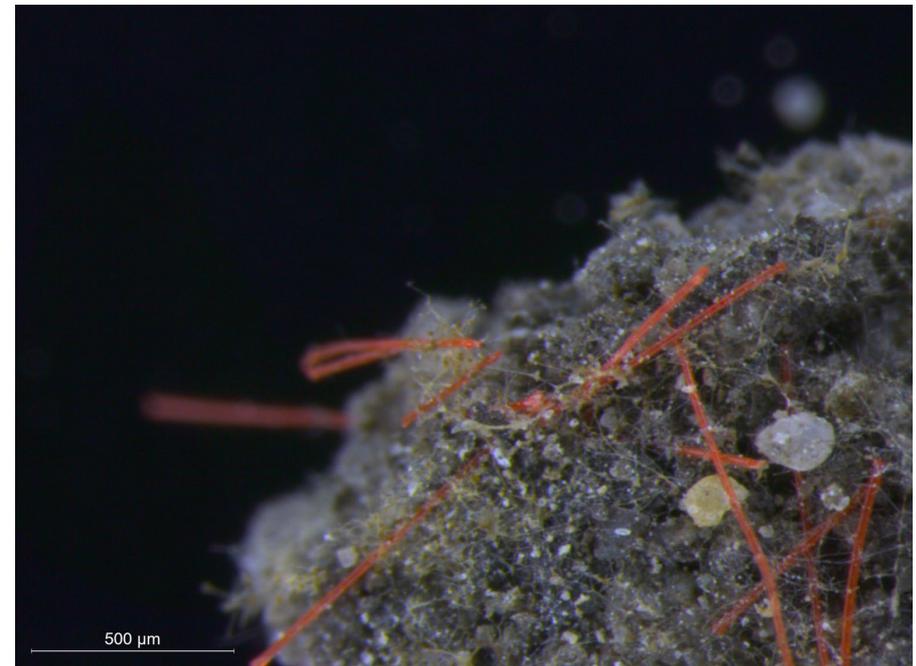
Similar effects on other soil parameters and biodiversity...



Take-home message I

Microplastic is also a new **global change factor**, not just an ecotoxicology problem, with effects on

- Soil properties
- Plant performance
- Community composition of plants and microbes
- Ecosystem processes



Take-home message II

We are only beginning to understand the effects of microplastic in soils

Major unknowns are:

- Long-term effects
- Diversity of microplastic types
- Interaction with other factors



Acknowledgements

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Bundesministerium
für Bildung
und Forschung





2 mm

Machado et al. 2018, 2019
Lehmann et al. 2019

Picture by: Dr. Anika Lehmann