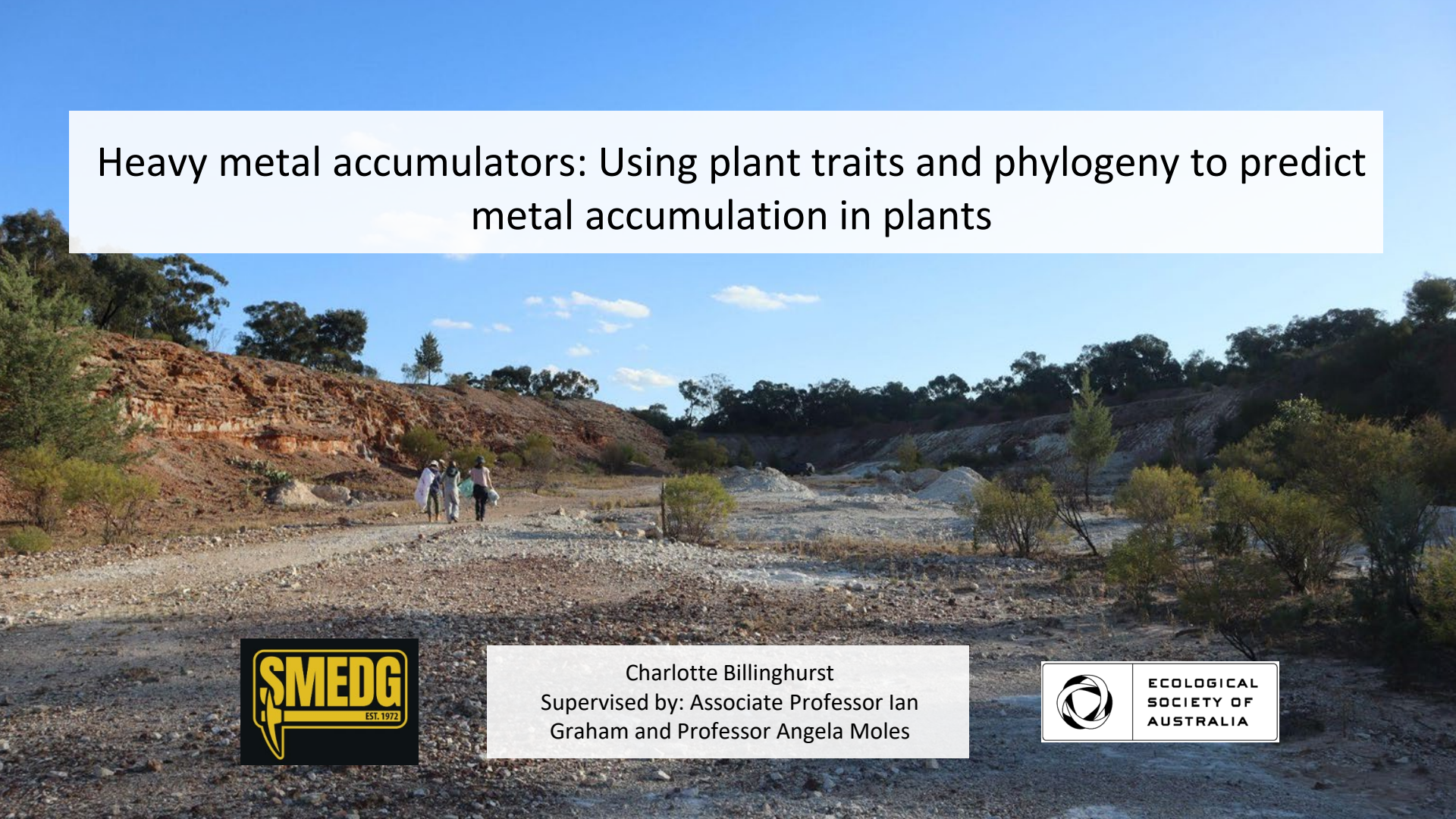
Heavy metal accumulators: Using plant traits and phylogeny to predict metal accumulation in plants



Charlotte Billinghurst
Supervised by: Associate Professor Ian Graham and Professor Angela Moles

We need metals


Hunter Galvanising (2019)


Scooter Doll (2023)


Maria Wachala (2014)


Jeremy Piper (2016)


PVcase(2025)


EuroKids (2025)

Managing heavy metal pollution is challenging

Geoengineer (2013)

Kenny Walter (2019)

Mintek Resources (2020)

Roberto González (2024)

Plants can help

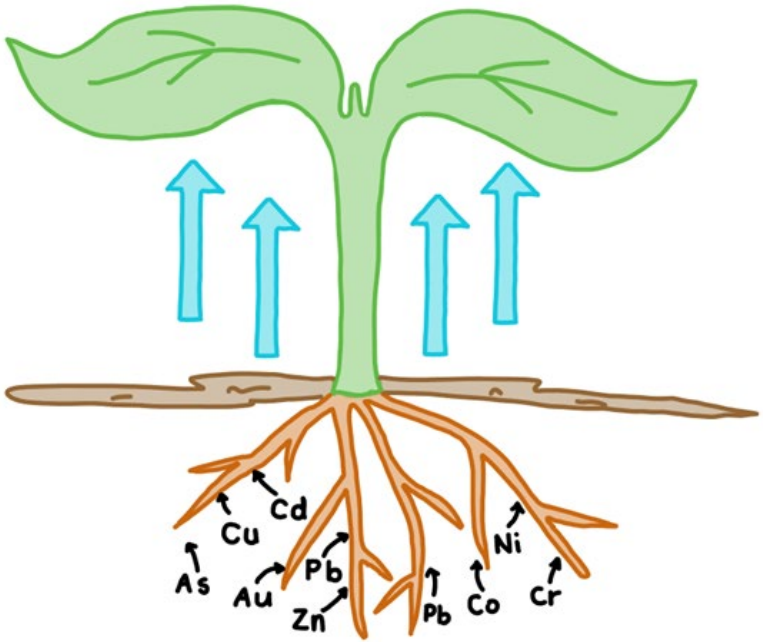
© Tilla Günther, iNaturalist (2020)

© Vojtěch Vyskočil, iNaturalist (2025)

© Guanning Liu, iNaturalist (2025)

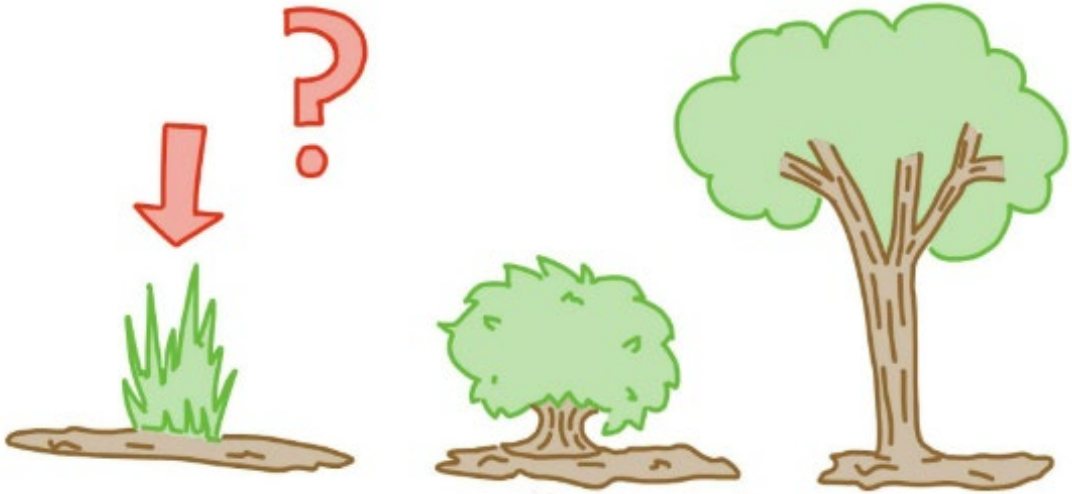
© Jan Doležal, iNaturalist (2025)

What type of plants take up the most metal?



Modified from Rascio & Navari-Izzo (2011)

- Plant traits (e.g. plant height)
- Phylogeny (how genetically related plants are)
- Multi-metal uptake



Historic Mine Sites

① Tallebung

High in tin, tungsten, arsenic, zinc and lead

② Budgery

High in copper and iron

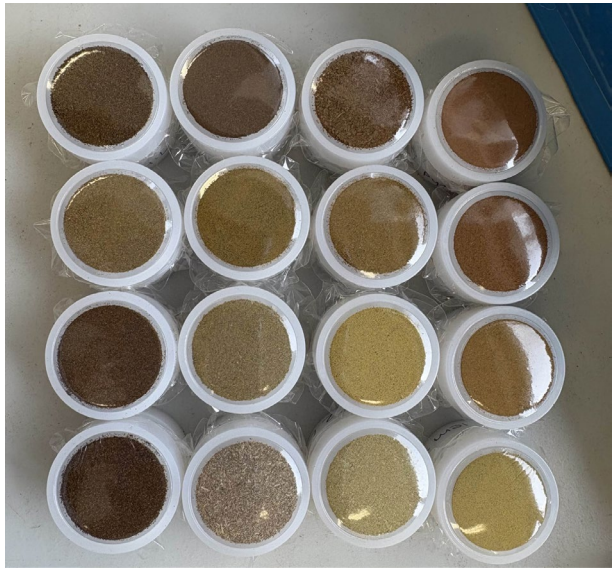
③ Budgerygar

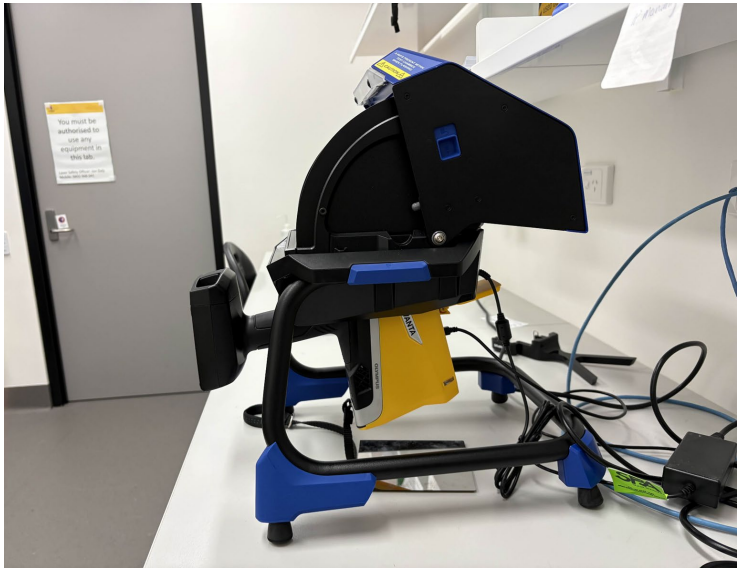
High in copper and iron

1. Crushed over 700 leaf and soil samples

2. Placed into cups

3. Analysed using portable X-ray fluorescence





4. Reference standards were used to calibrate raw pXRF values

5. Metals of interest were screened based on the quality of calibration curves

- Arsenic (As)
- Cadmium (Cd)
- Copper (Cu)
- Iron (Fe)
- Lead (Pb)
- Antimony (Sb)
- Tin (Sn)
- Titanium (Ti)
- Tungsten (W)
- Zinc (Zn)

- Arsenic (As)
- Copper (Cu)
- Iron (Fe)
- Titanium (Ti)
- Zinc (Zn)

Quantified metal accumulation for 31 plant species

2x higher copper in leaves

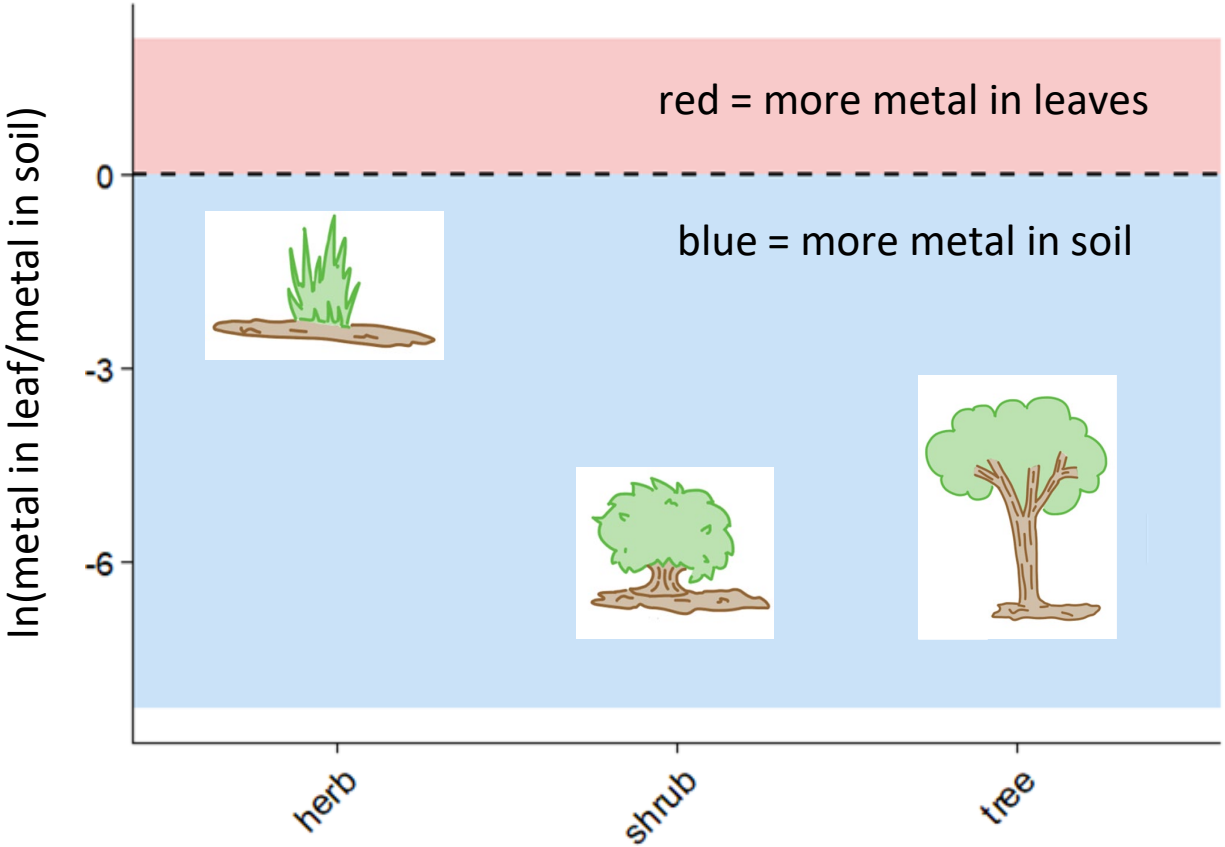
Hibiscus sturtii

Cassinia laevis

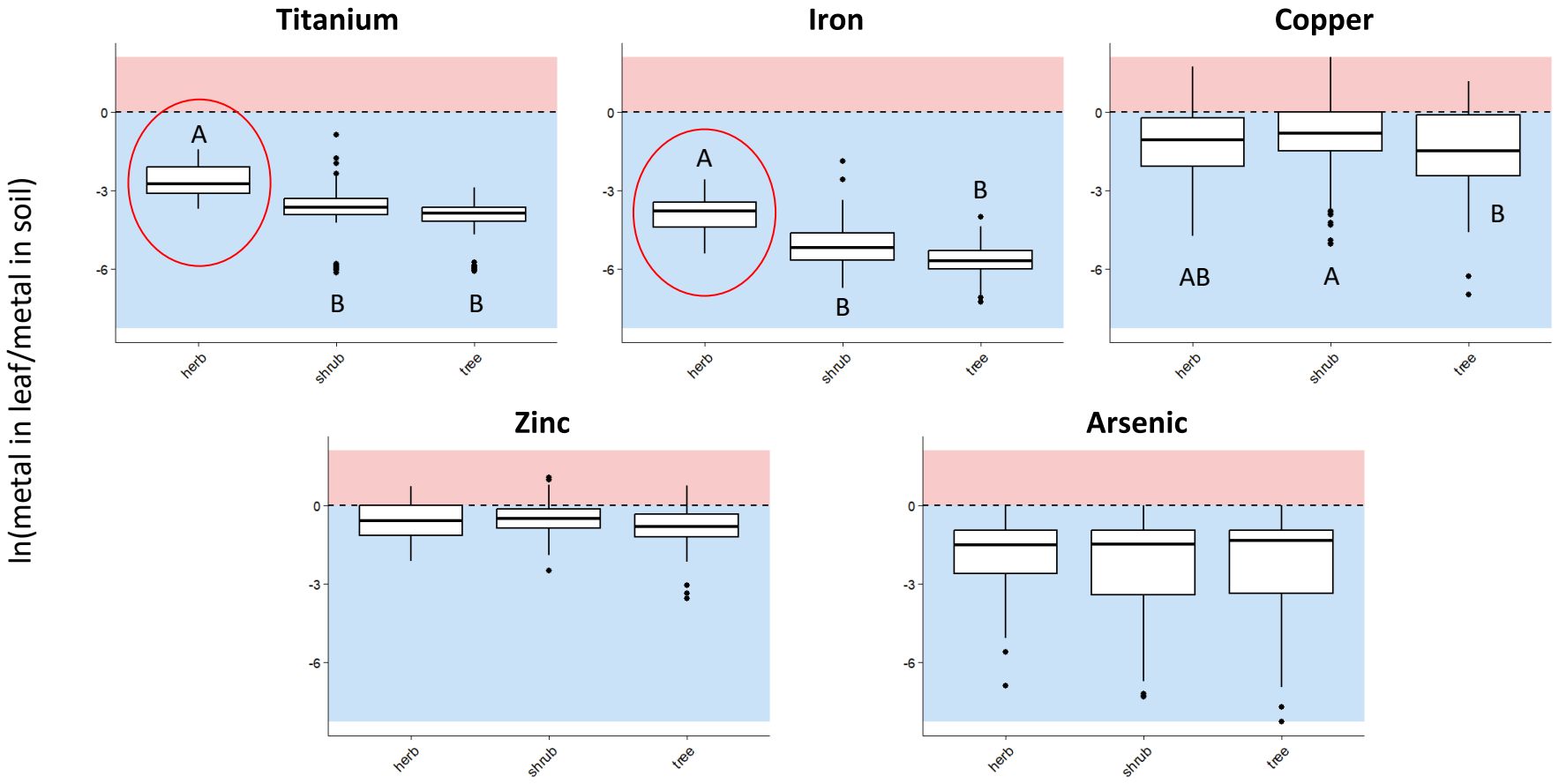
1.5x higher zinc in leaves

Growth form

H1: Herbs will accumulate the most metal

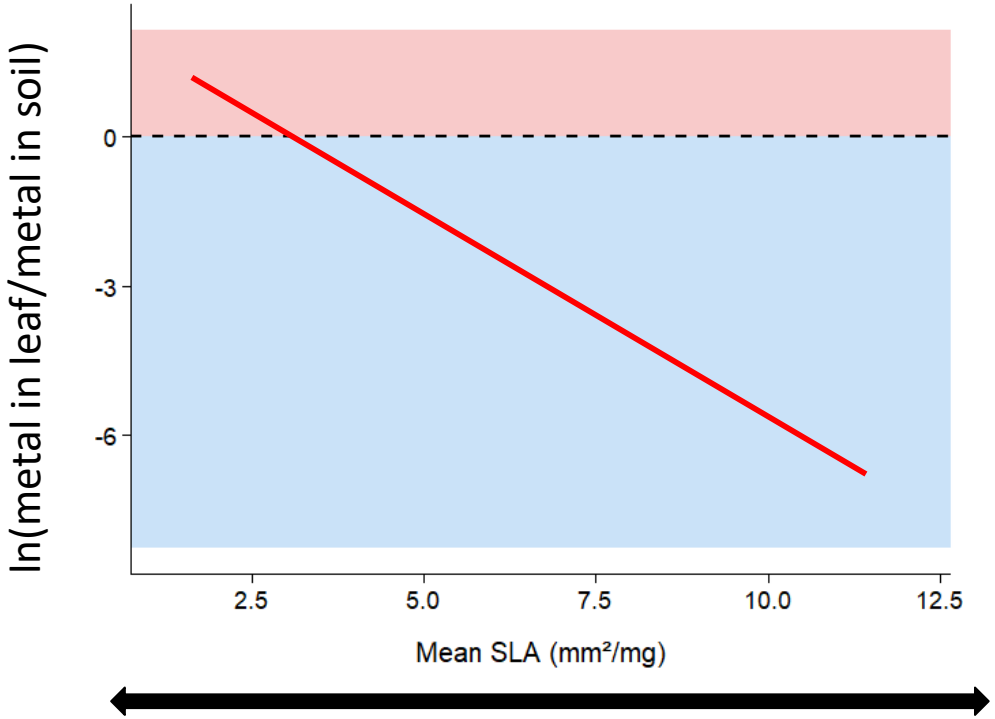


Herbs accumulate higher levels of titanium and iron



Specific leaf area

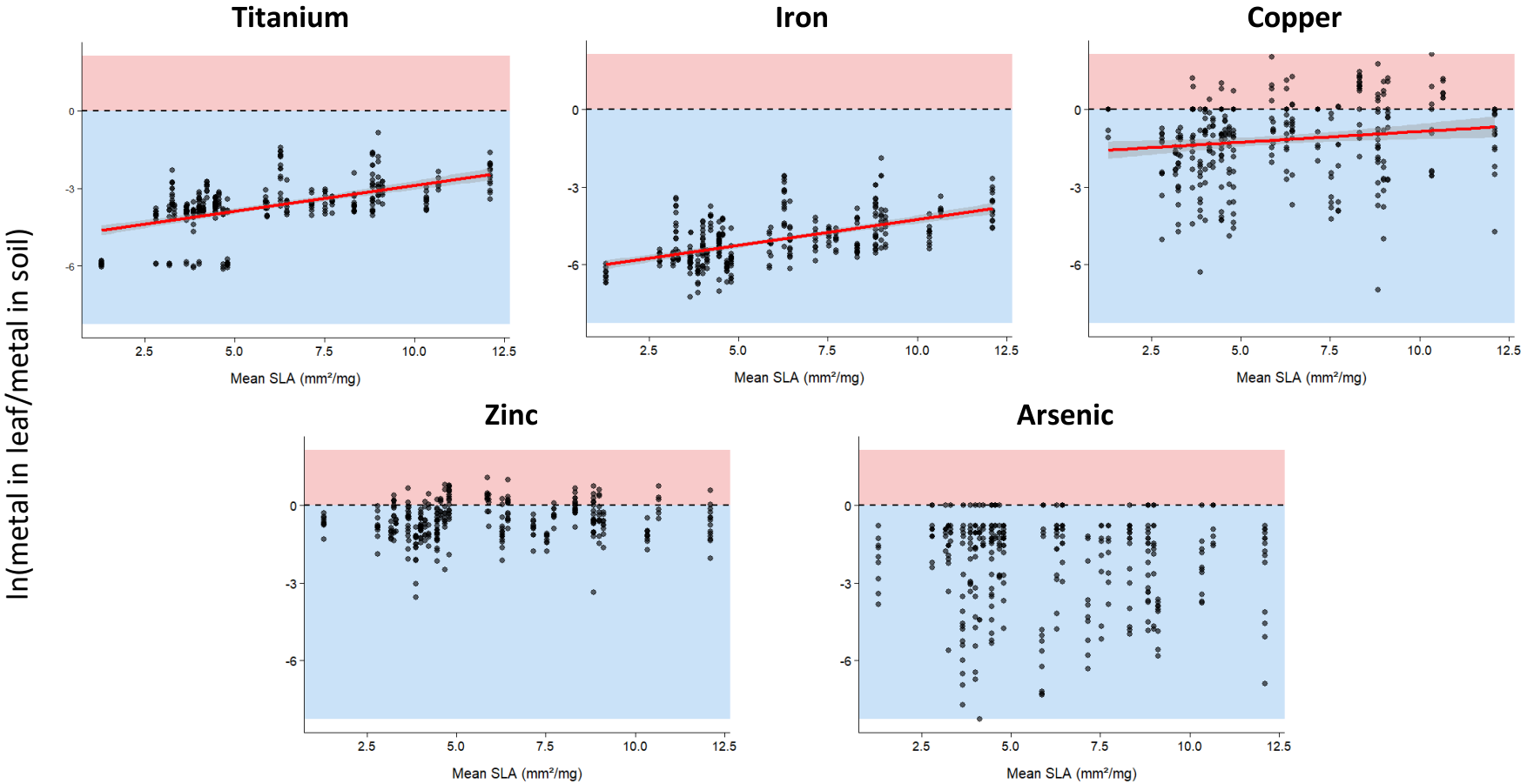
H2: Plant species with thick, tough leaves will accumulate more metals



Thick, dense leaves

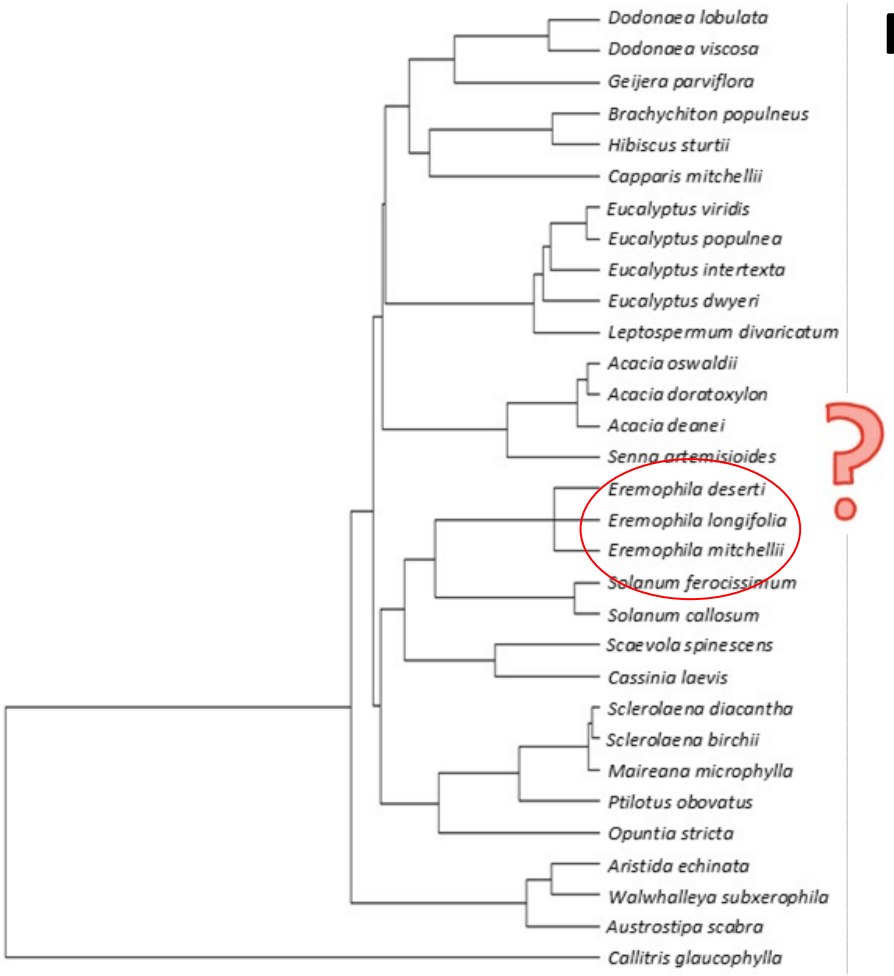
Thin, lightweight leaves

Plants with thin broad leaves accumulate higher levels of titanium, iron and copper



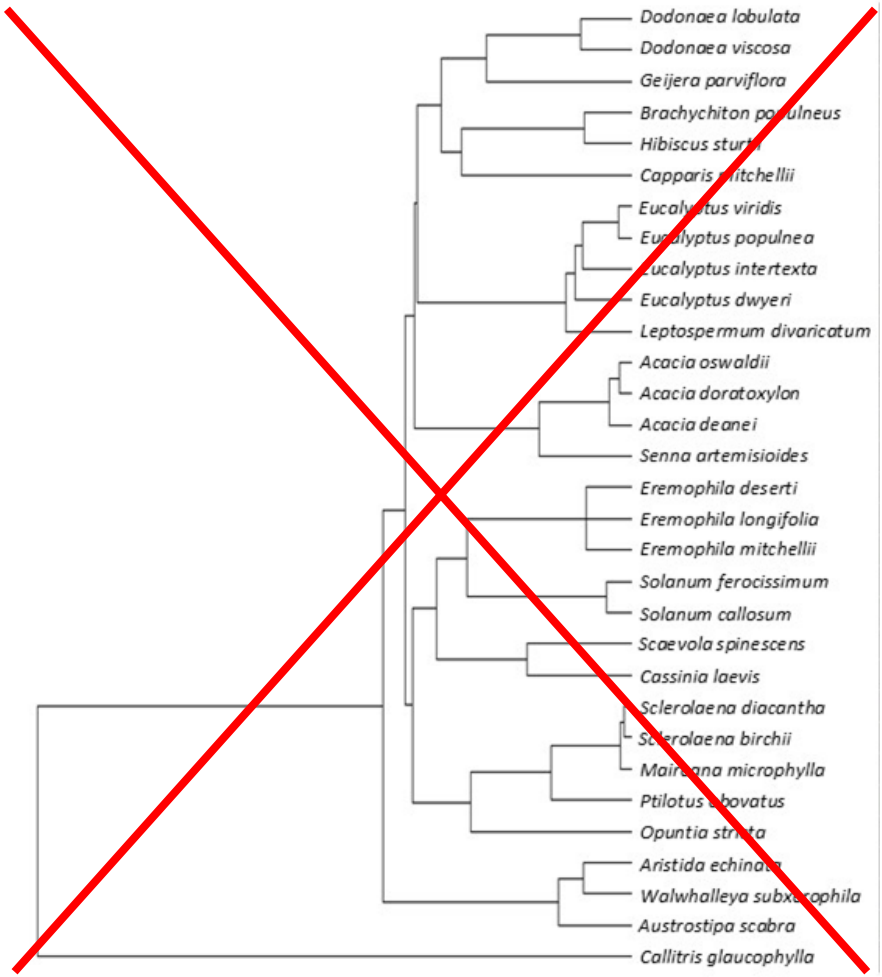
What does this mean?

- Other traits: plant height and differences in fungal associations had no effect on metal accumulation
- No universal plant trait associated with metal accumulation
- The relationship between plant traits and metal accumulation is more nuanced than expected



Phylogeny

H3: Closely related plant species will have similar metal accumulation levels.



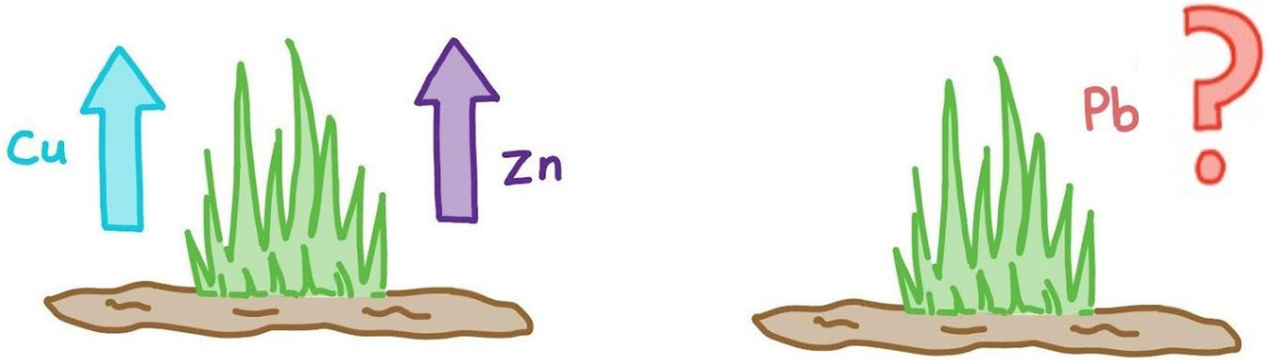
Phylogeny

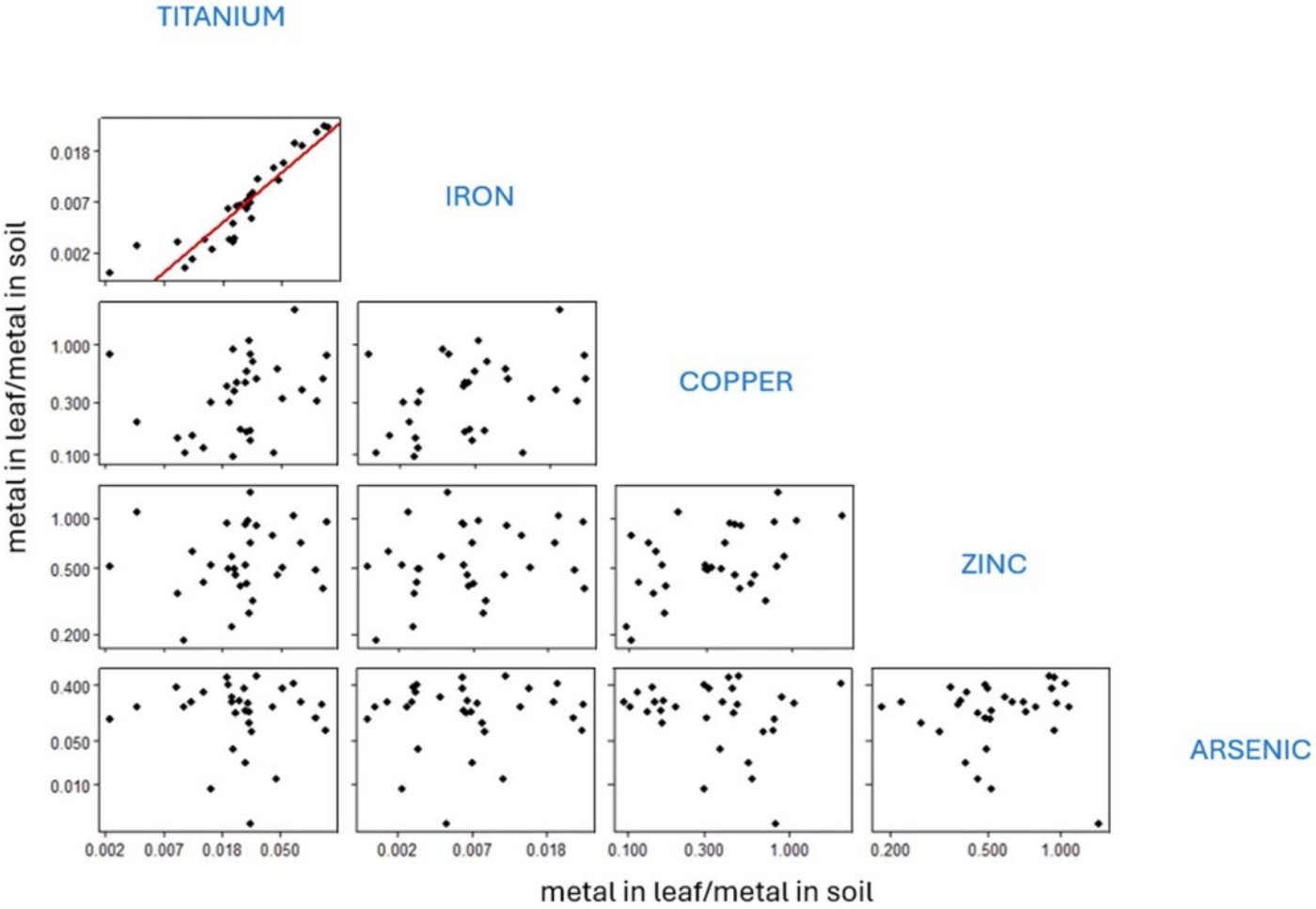
H3: Closely related plant species will have similar metal accumulation levels.

We cannot look to plants related to a known metal accumulator to easily identify other metal accumulating plants

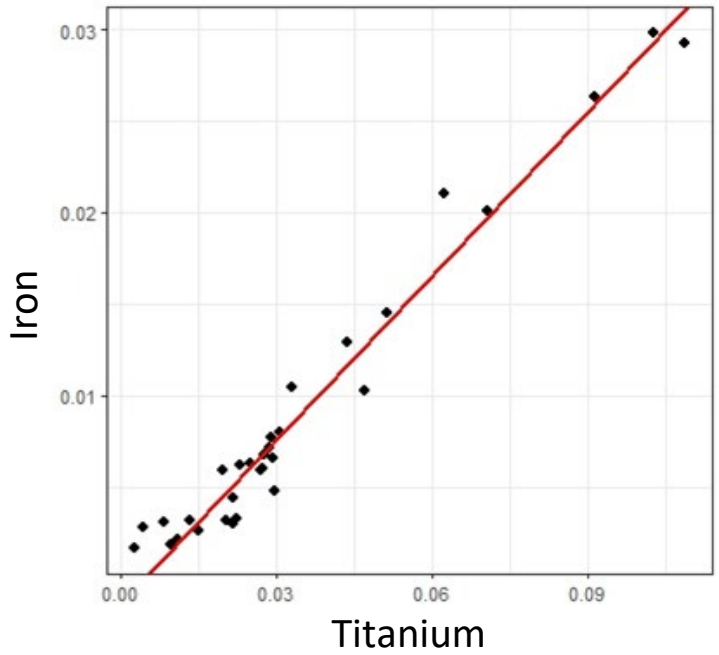
Multi-Metal Uptake

If a plant species can accumulate one metal, will it accumulate multiple metals?




TITANIUM
IRON
COPPER
ZINC
ARSENIC
metal in leaf/metal in soil
metal in leaf/metal in soil
0.018
0.007
0.002
1.000
0.300
0.100
1.000
0.500
0.200
0.400
0.050
0.010
0.002 0.007 0.018 0.050
0.002 0.007 0.018
0.100 0.300 1.000
0.200 0.500 1.000

Titanium and iron accumulation are significantly correlated…



R-squared = 0.83
$p < 0.001$

…but uptake levels were low

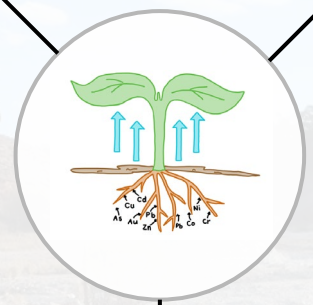
Implications

- First species level study into the effect of plant traits on metal accumulation
- New information on metal uptake in 30 Australian plant species
- *Hibiscus sturtii and Cassinia laevis* are potential candidates for use in mine restoration efforts

Contributes to a growing field which uses plants for…

Restoration
Cost effective approach

Extraction
“Phytomining” typically uneconomic resources



Exploration
Biogeochemical indicators

Thank you!