Linking long-term material demand scenarios to regional land use change for mining

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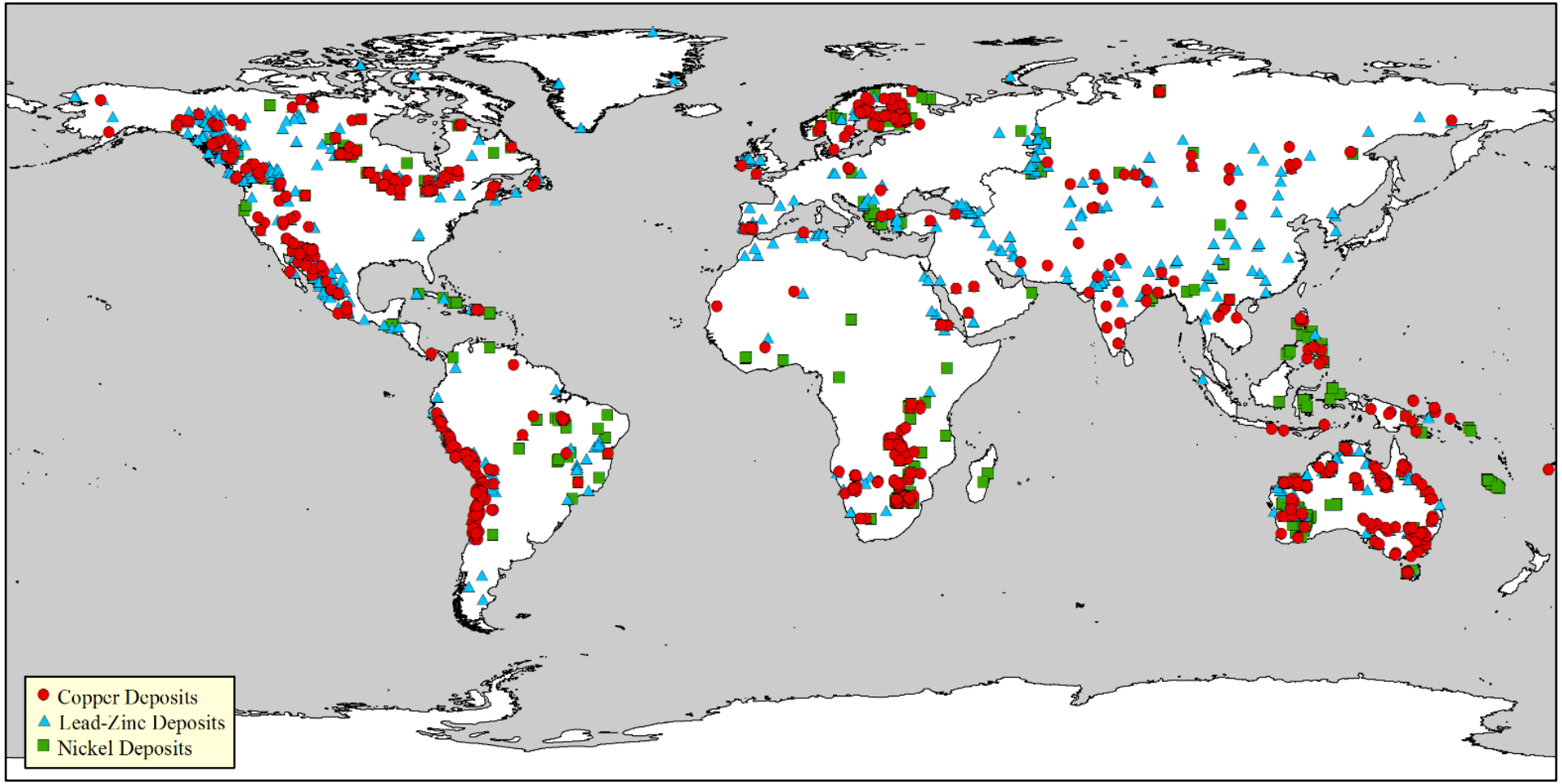
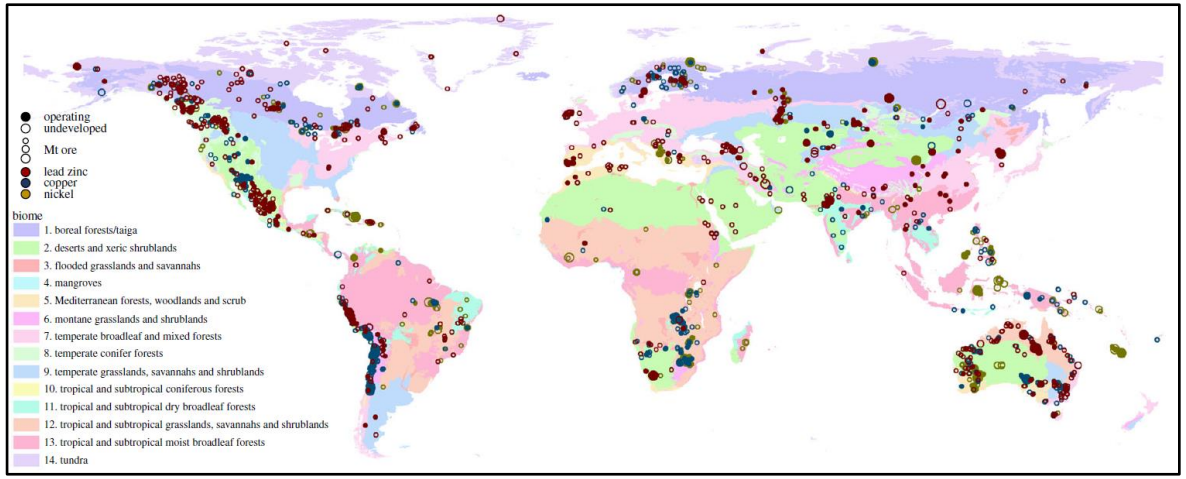
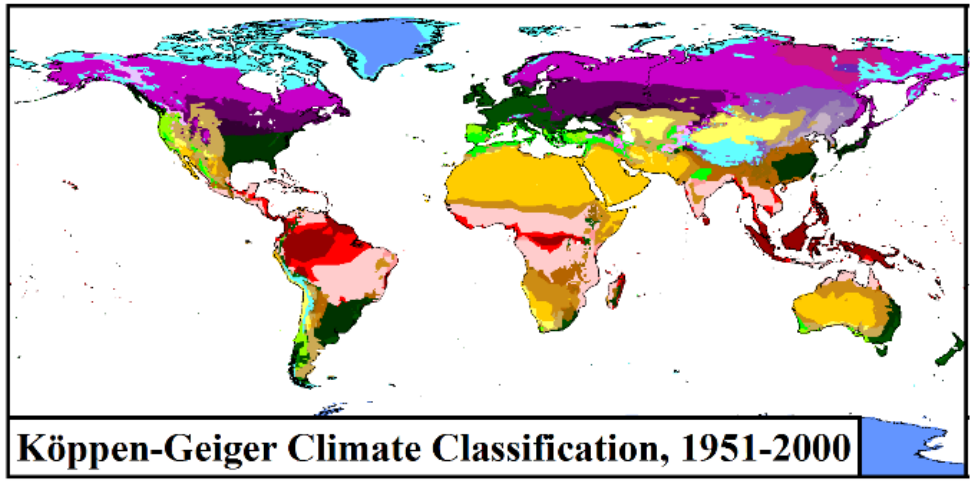
Mineral resources have differing spatial distributions

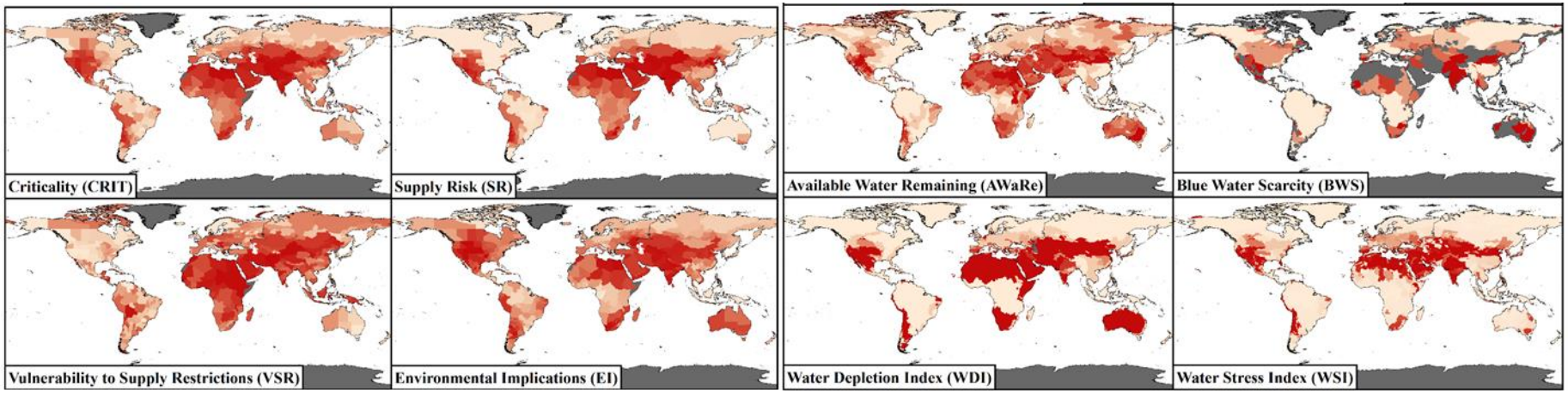


Northey *et al.*, 2017. Global Environmental Change 44: 109-124.

And face differing regional environmental contexts

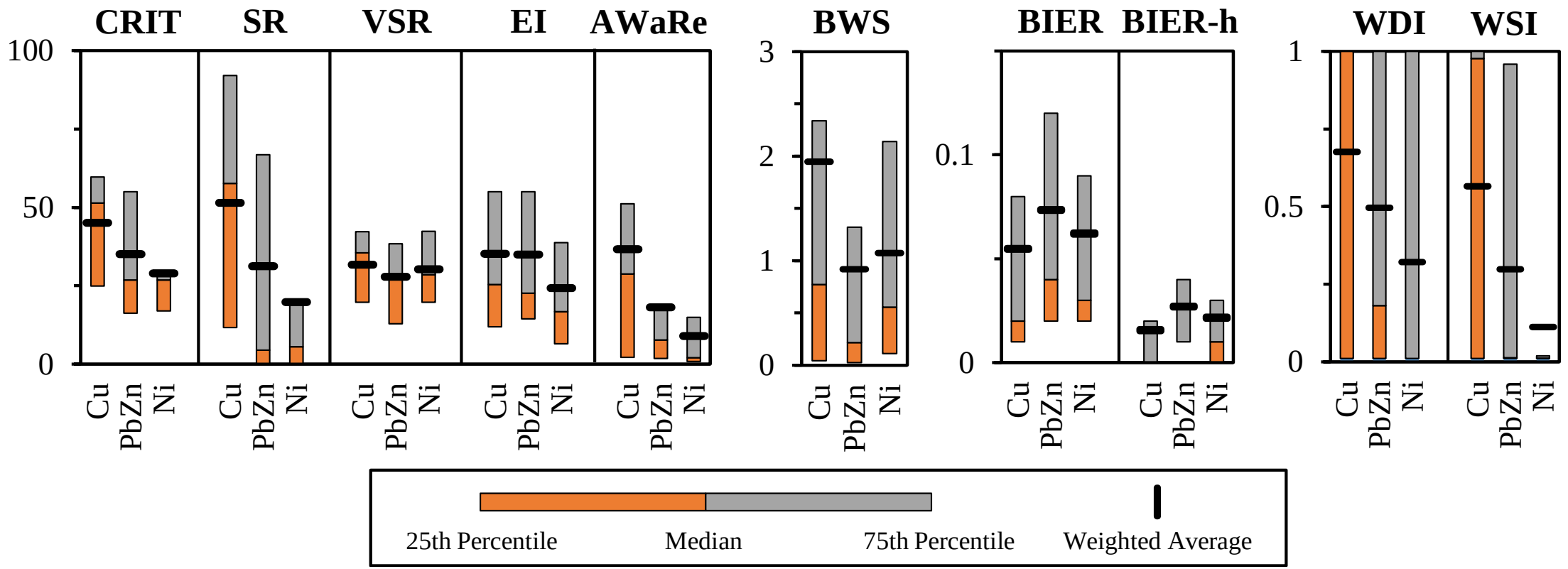






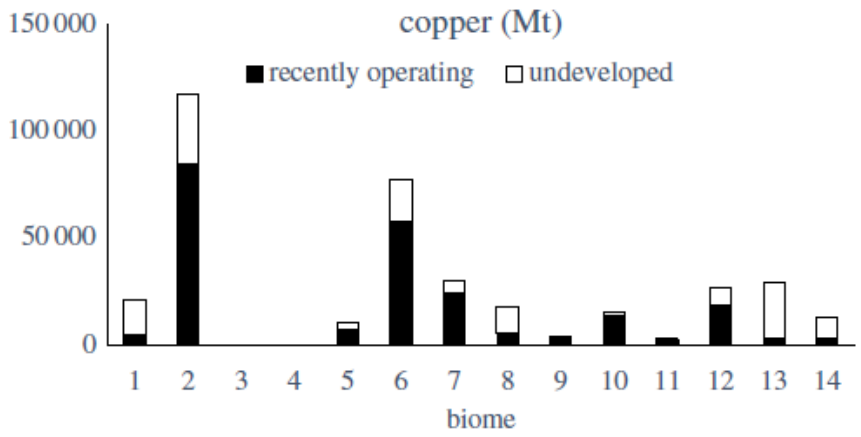
Northey *et al.*, 2017. Global Environmental Change 44: 109-124.
Sonter *et al.*, 2018. Proc. R. Soc. B. 285: 20181926.

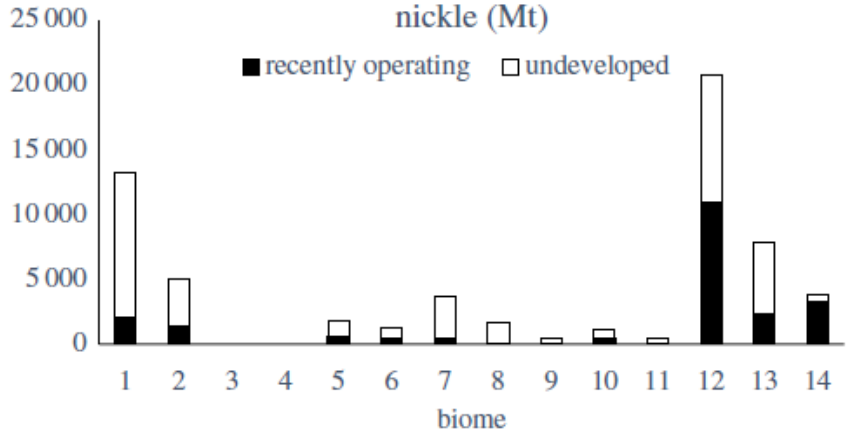
Mineral resources are situated in regions with differing water risks,

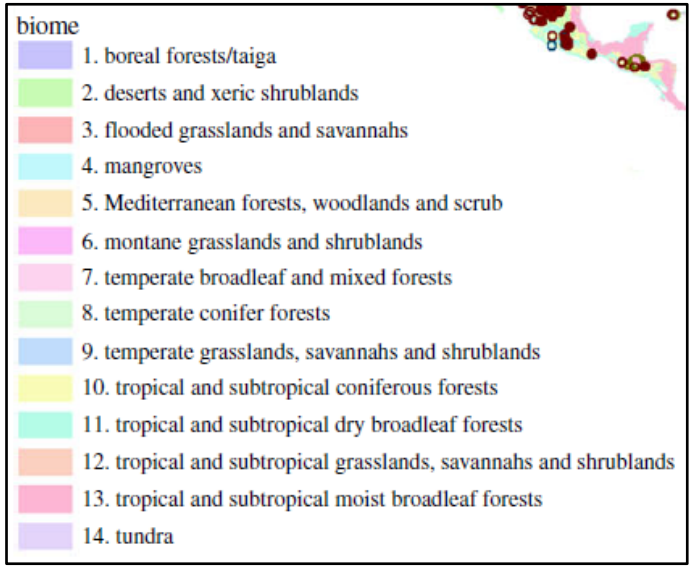


Northey *et al.*, 2017. Global Environmental Change 44: 109-124.

Across varied ecological biomes

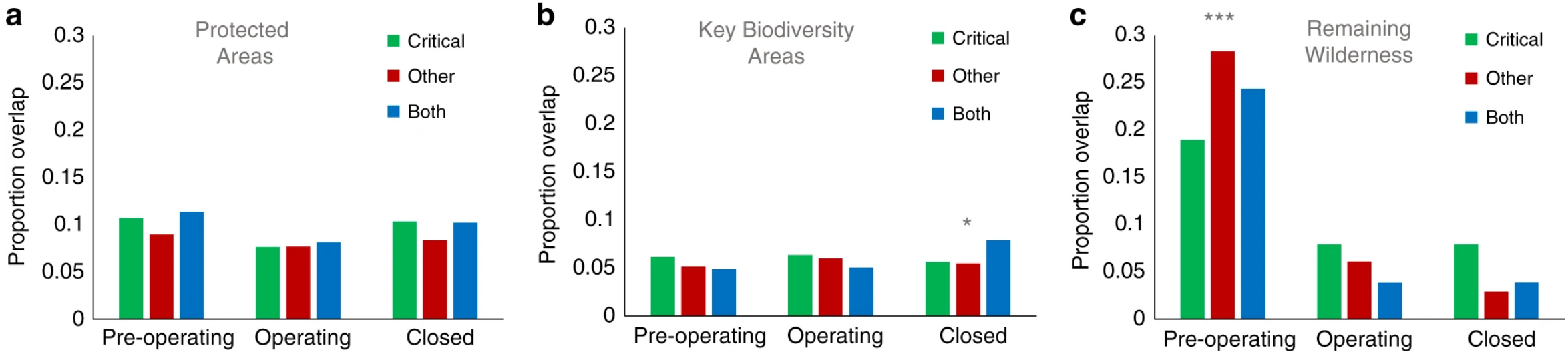






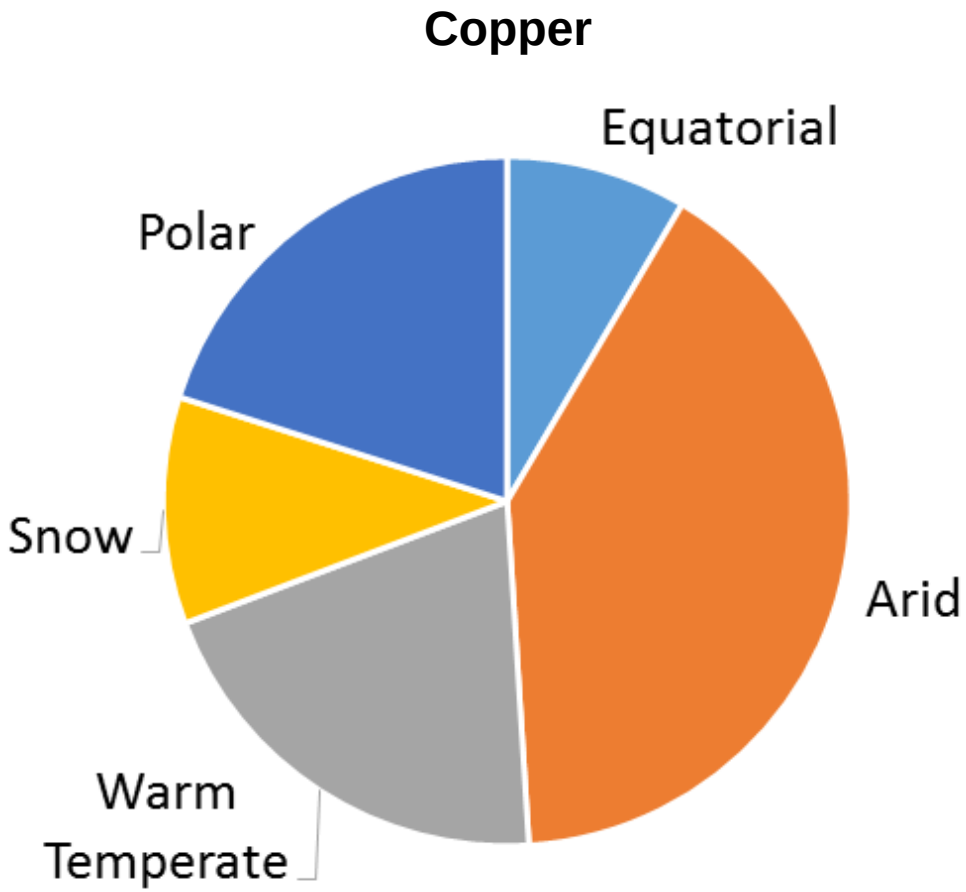
Sonter *et al.*, 2018. Proc. R. Soc. B. 285: 20181926.

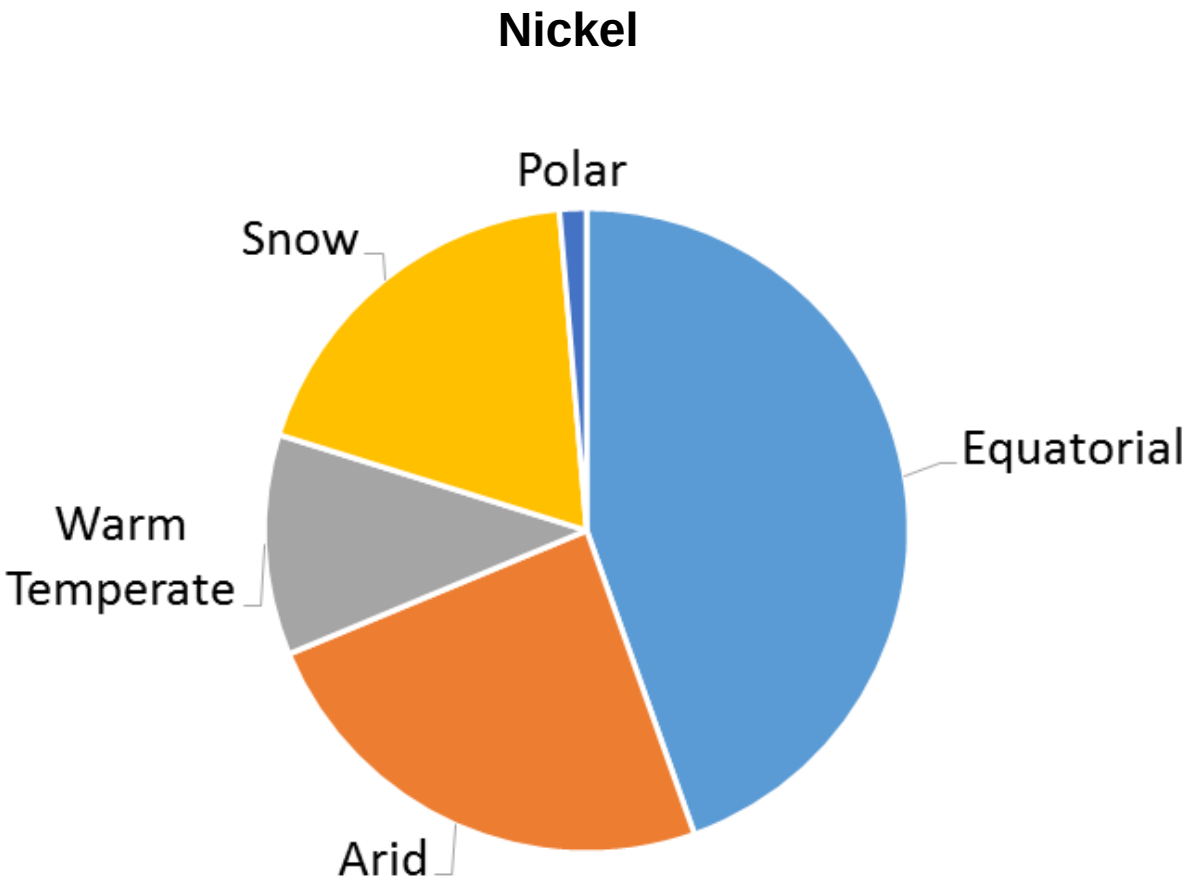
Within conservation areas



Sonter *et al.*, 2020. Nature Communications 11: 4174.

And across differing climates.

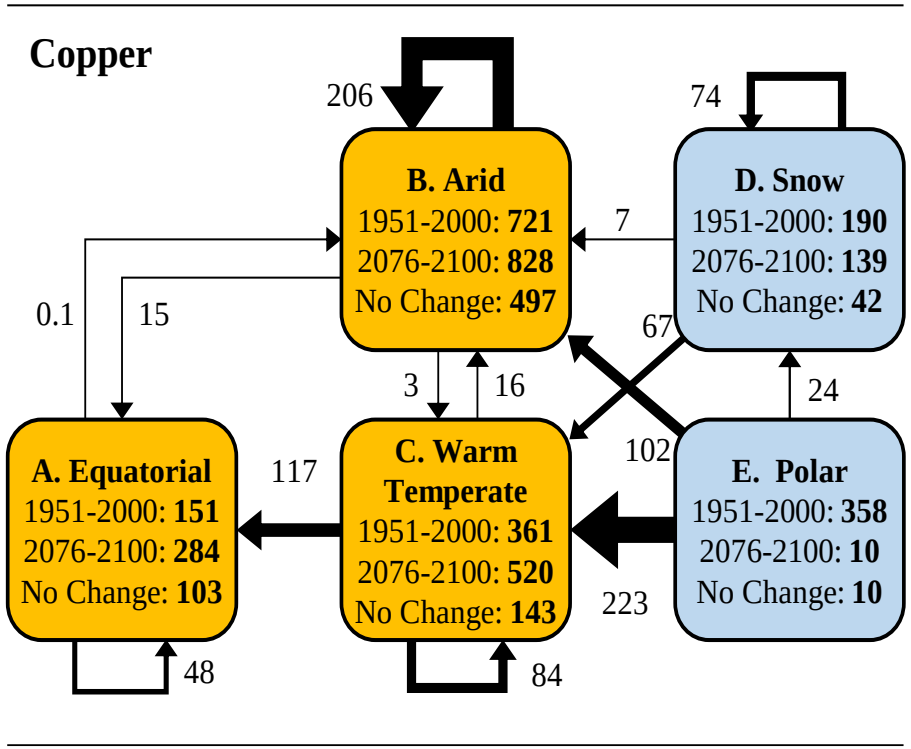




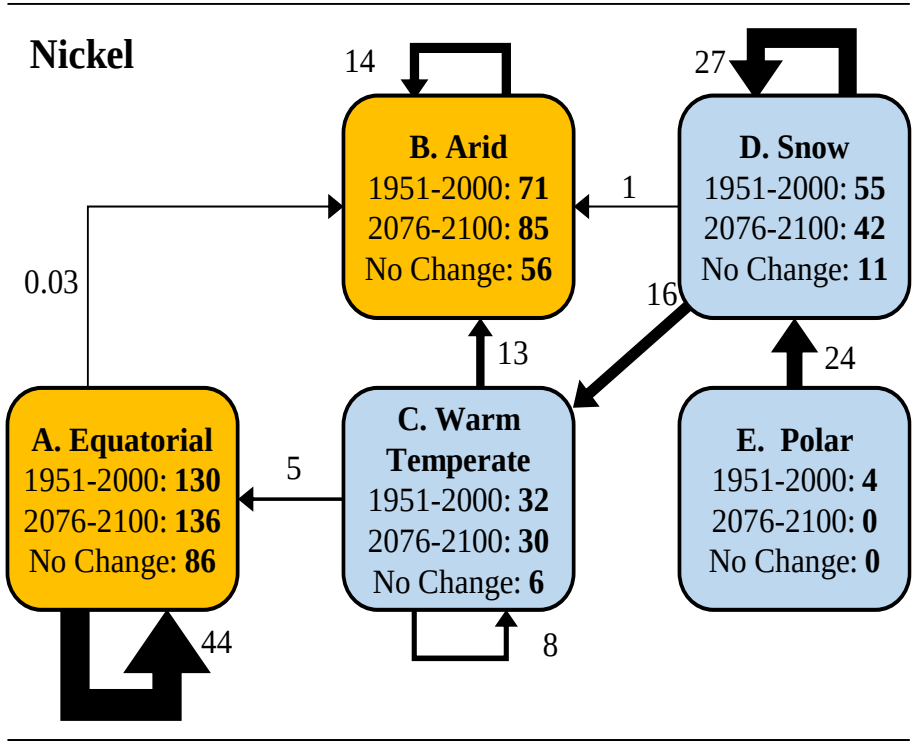
Northey *et al.*, 2017. Global Environmental Change 44: 109-124.

We know that the climate will change in regions hosting mineral resources

Copper

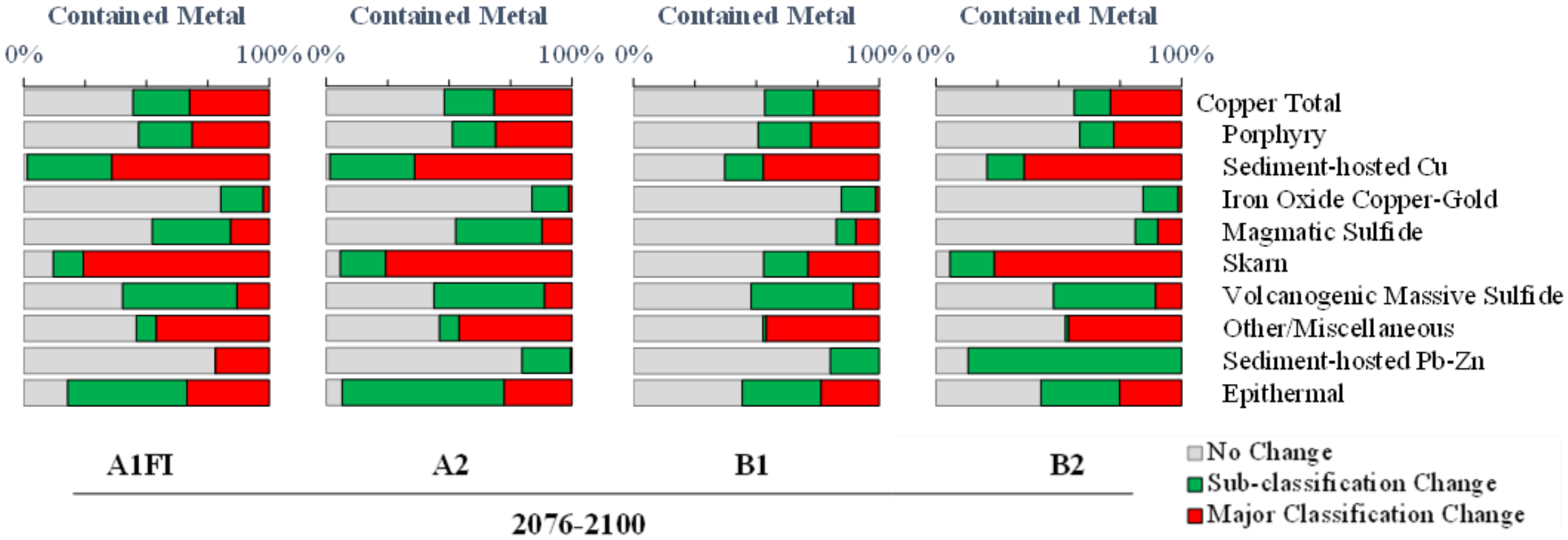


Nickel



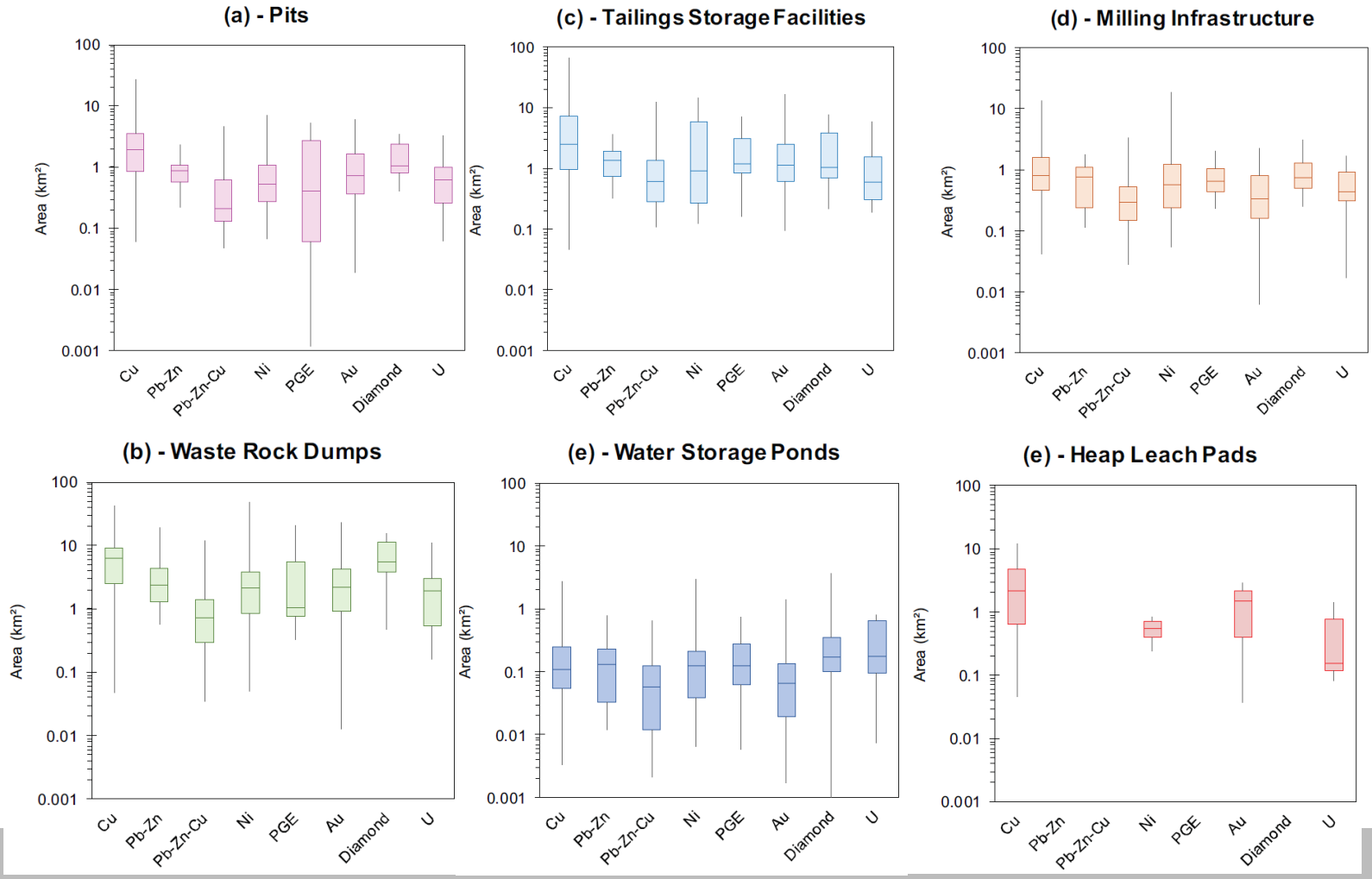
Northey *et al.*, 2017. Global Environmental Change 44: 109-124.

And that exposure differs for specific deposit types.



Northey *et al.*, 2017. Global Environmental Change 44: 109-124.

Our understanding of land transformations associated with mining is better than ever



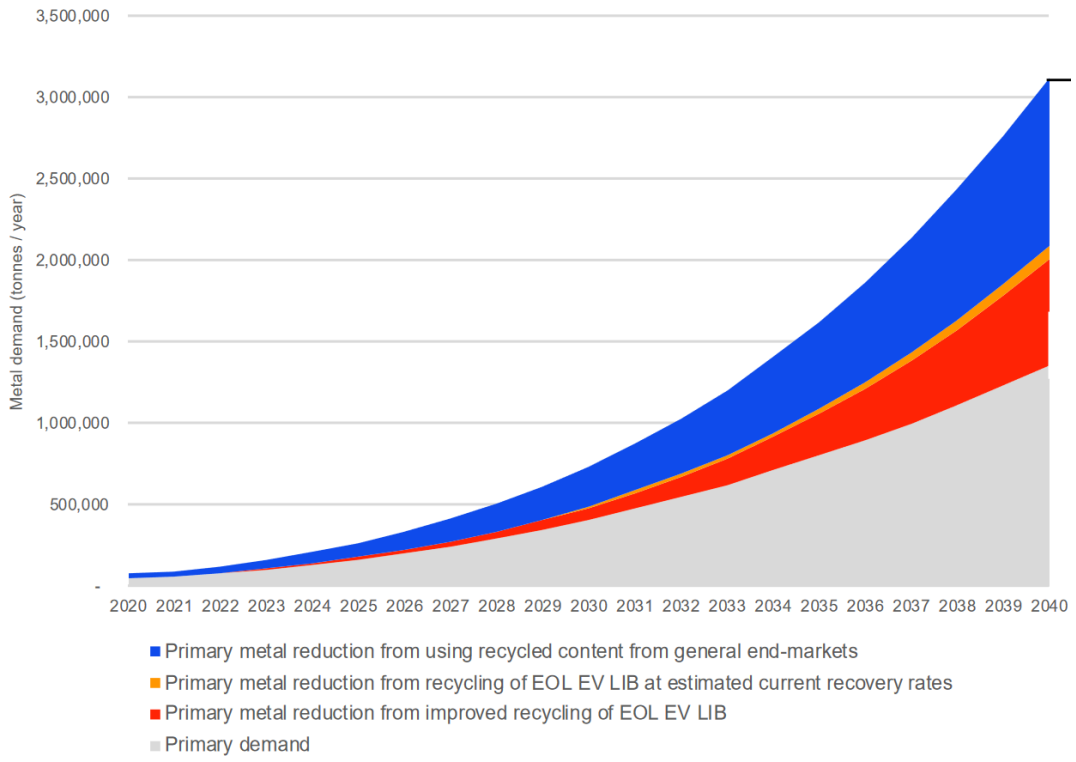
Werner *et al.*, 2020. Global Environmental Change 60: 102007.

However, there’s still a lot we don’t know

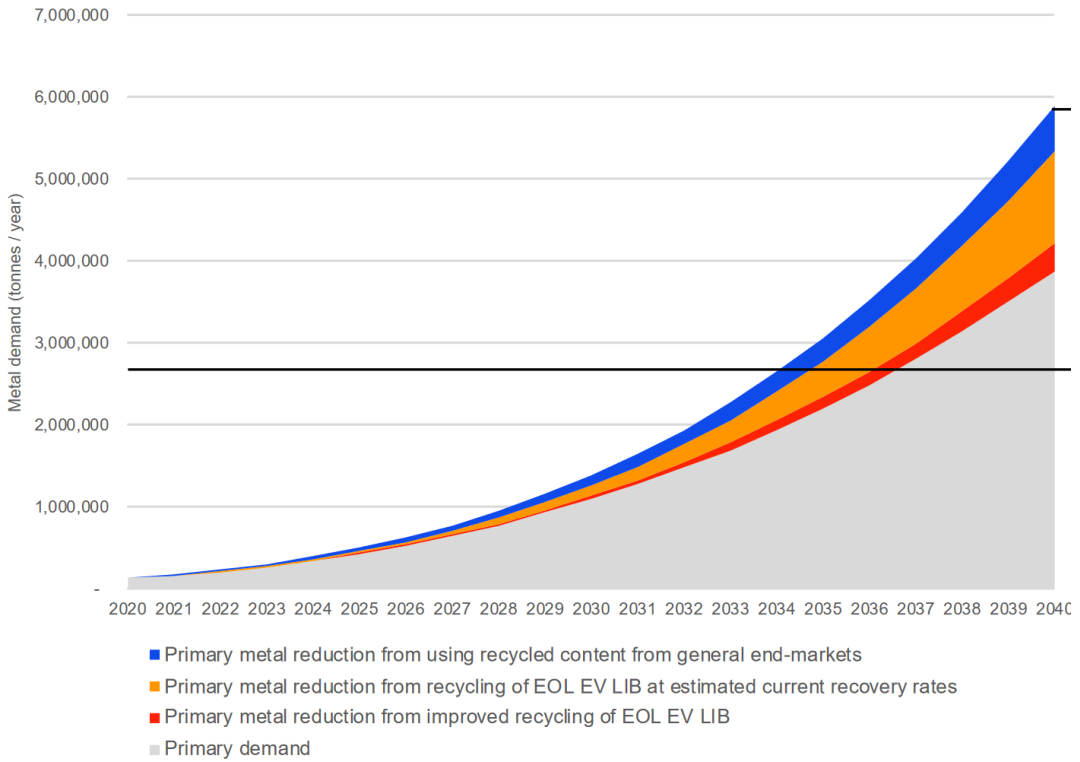
Especially about the future…

Our understanding of future mineral demand is improving

Copper in Batteries



Nickel in Batteries



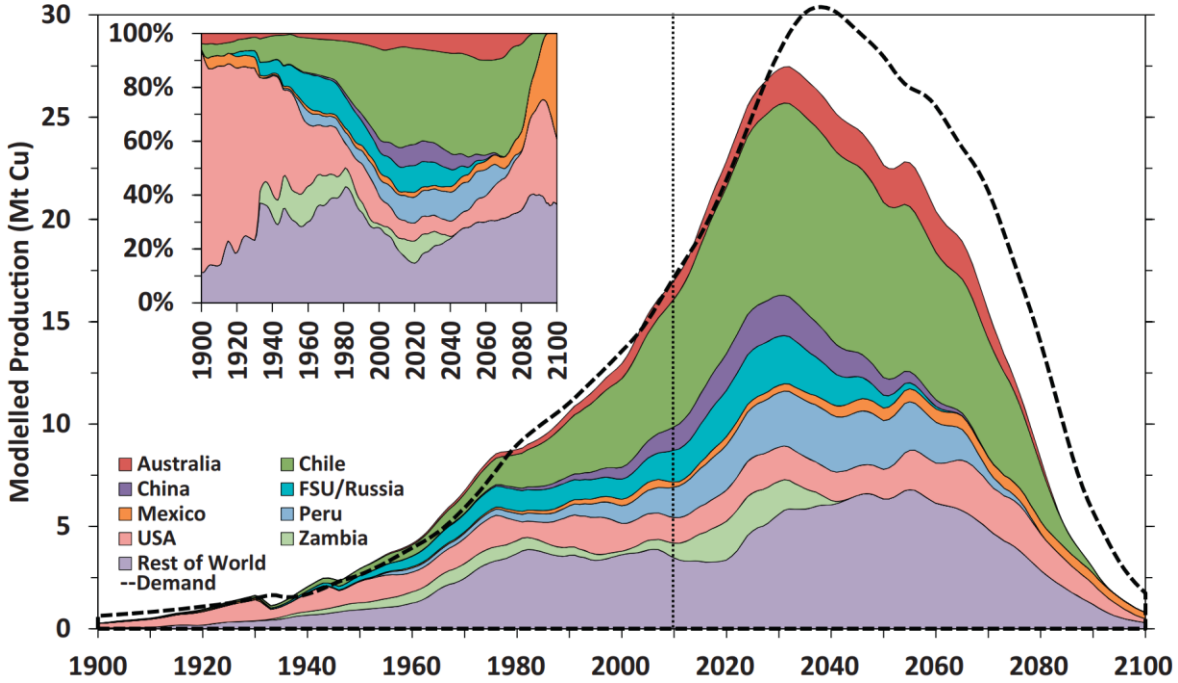
Dominish *et al.*, 2021. Reducing mining for electric vehicle battery metals: responsible sourcing through demand reduction strategies and recycling.

But our understanding of future regional mineral supply is limited

Existing models poorly capture:

- Brownfield Expansion
- Greenfield exploration and regional likelihood of discovery
- Mineral co-production
- Production scheduling & resource valuation
- Regional likelihoods of discovery
- Changing regional enablers and constraints for resource development

Example model with the illusion of good regional predictive capability



Northey *et al.*, 2014. Resources, Conservation and Recycling 83: 190-201.

We still don’t know much about future land transformations of mining

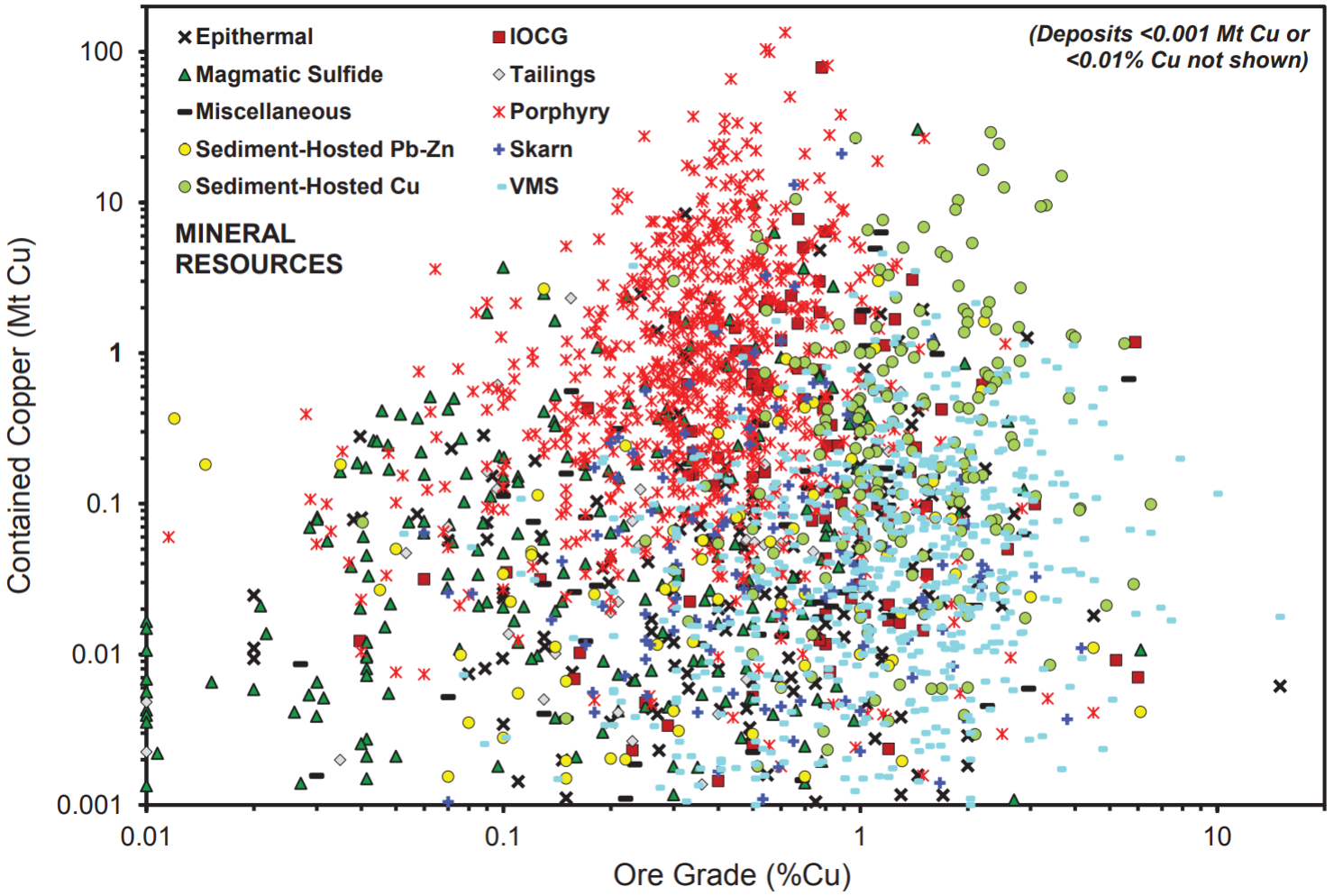
Where will they occur?

When will they occur?

What impacts will they have?

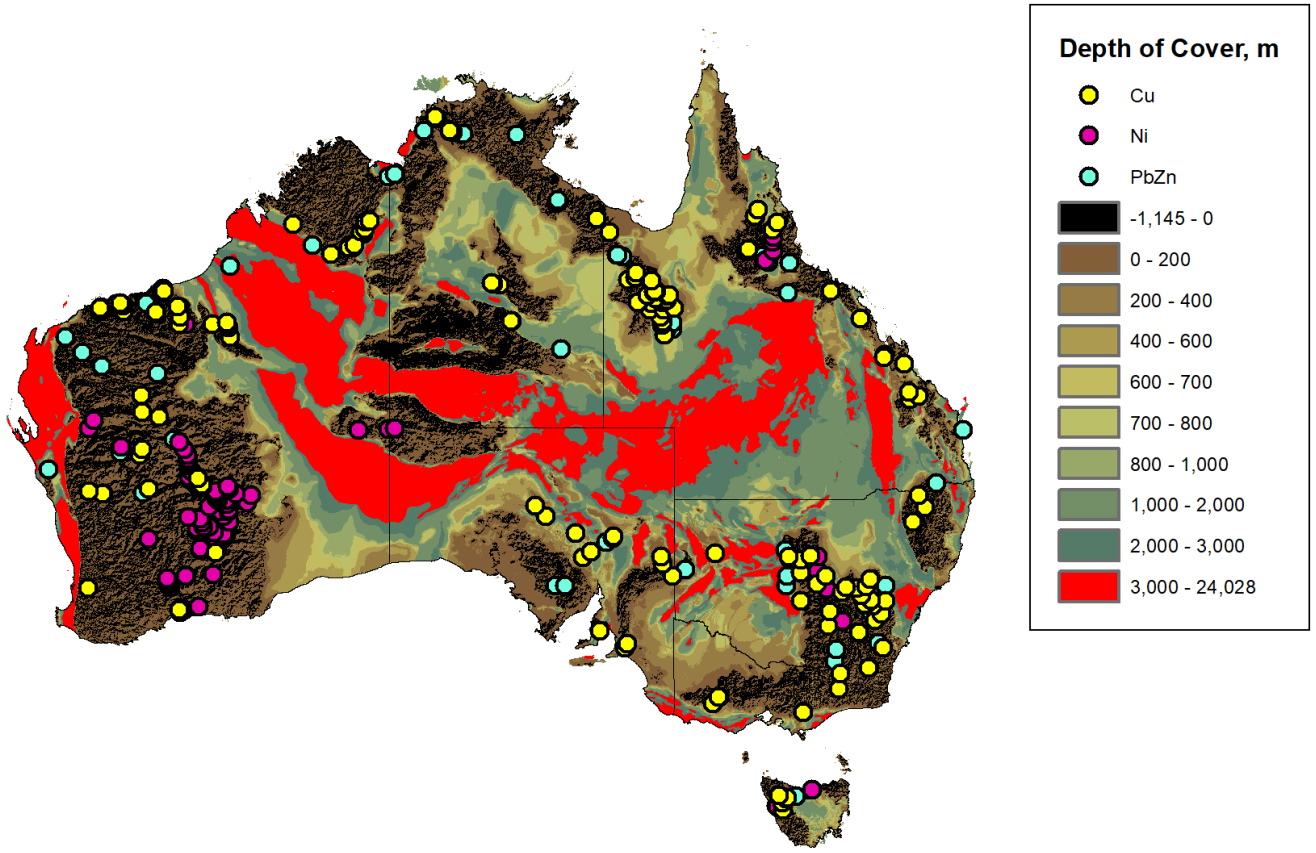
There must be a better way…

We have rich data regarding known resources

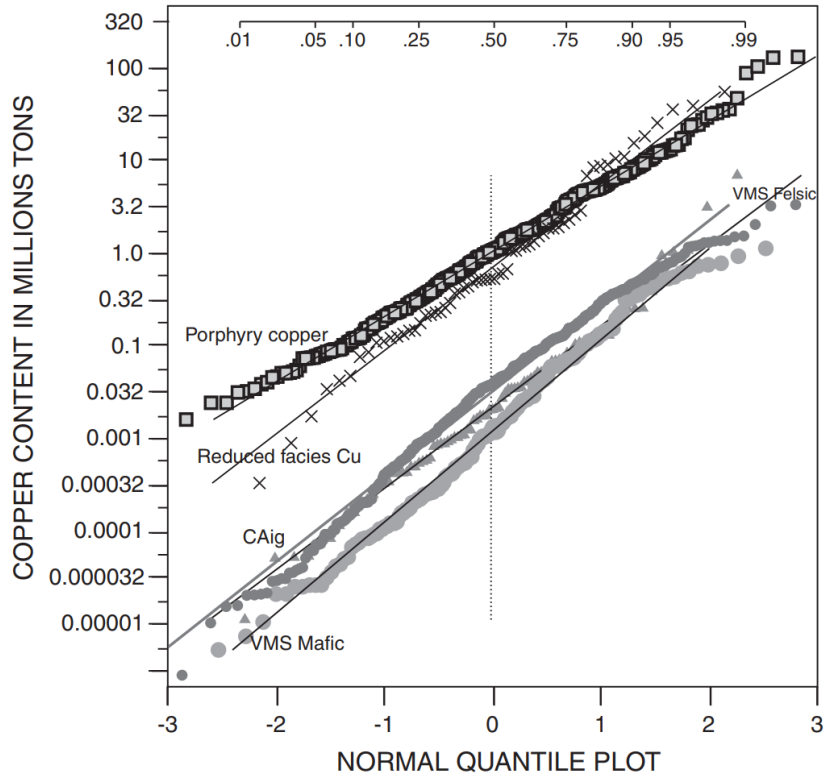


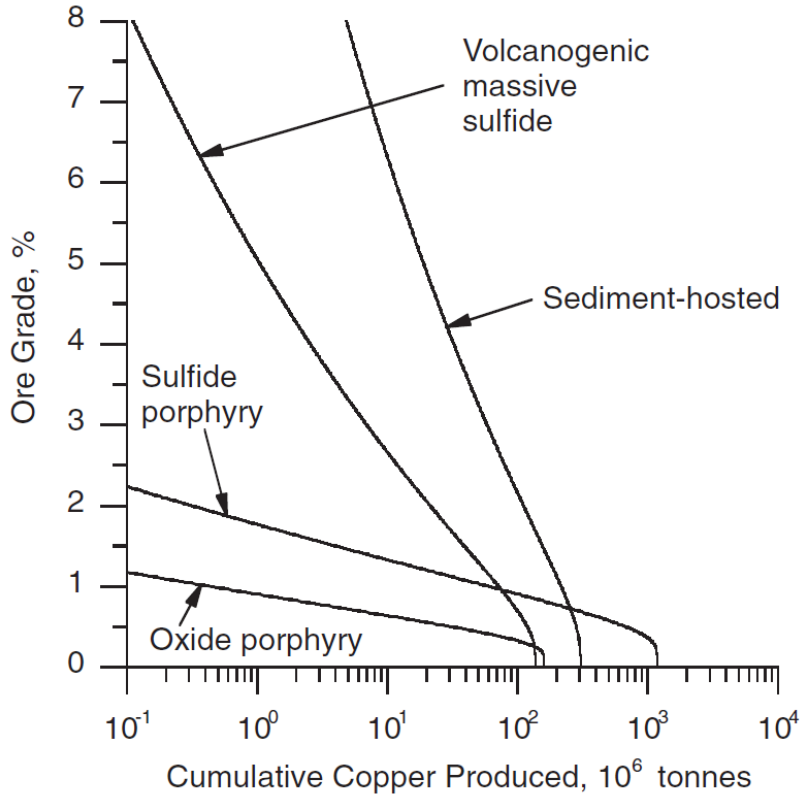
Mudd and Jowitt, 2018. Economic Geology 113(6): 1235-1267.

But we are still only scratching the surface in terms of mineral exploration



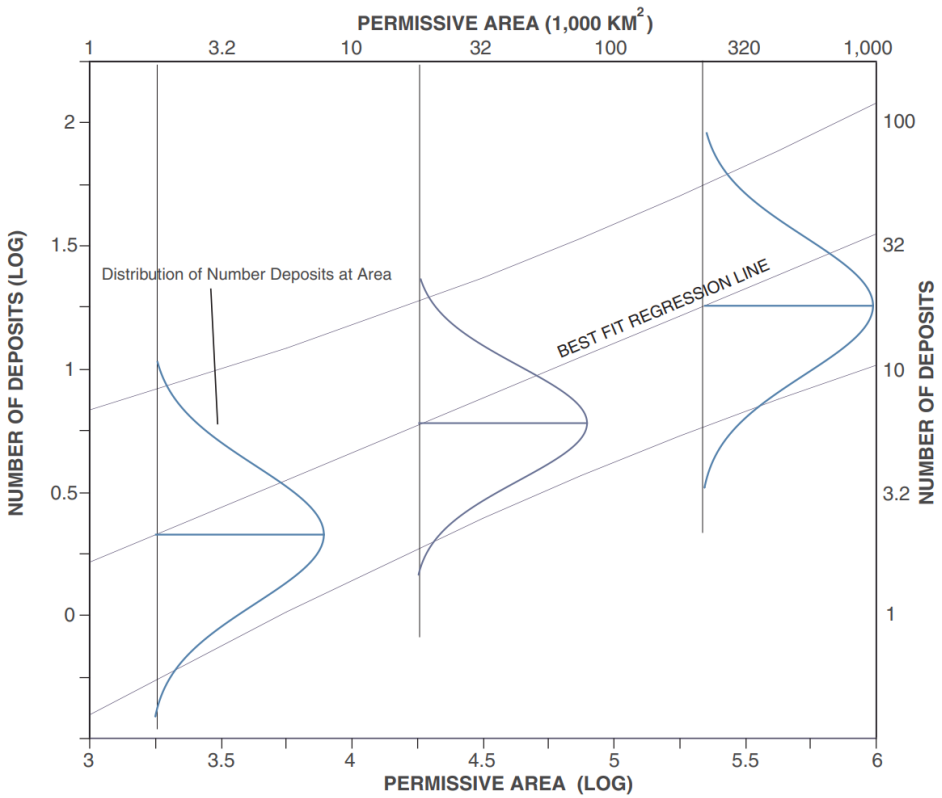
We can determine the likely characteristics of undiscovered resources

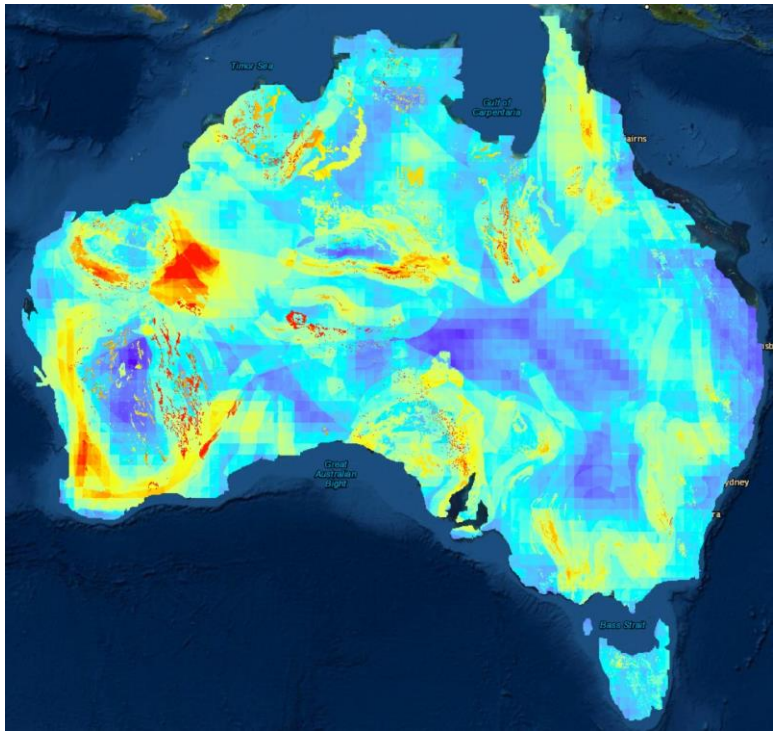




Gerst, 2008. Economic Geology, 103: 615-628.
Singer, 2013. Ore Geology Reviews 55: 80-86.

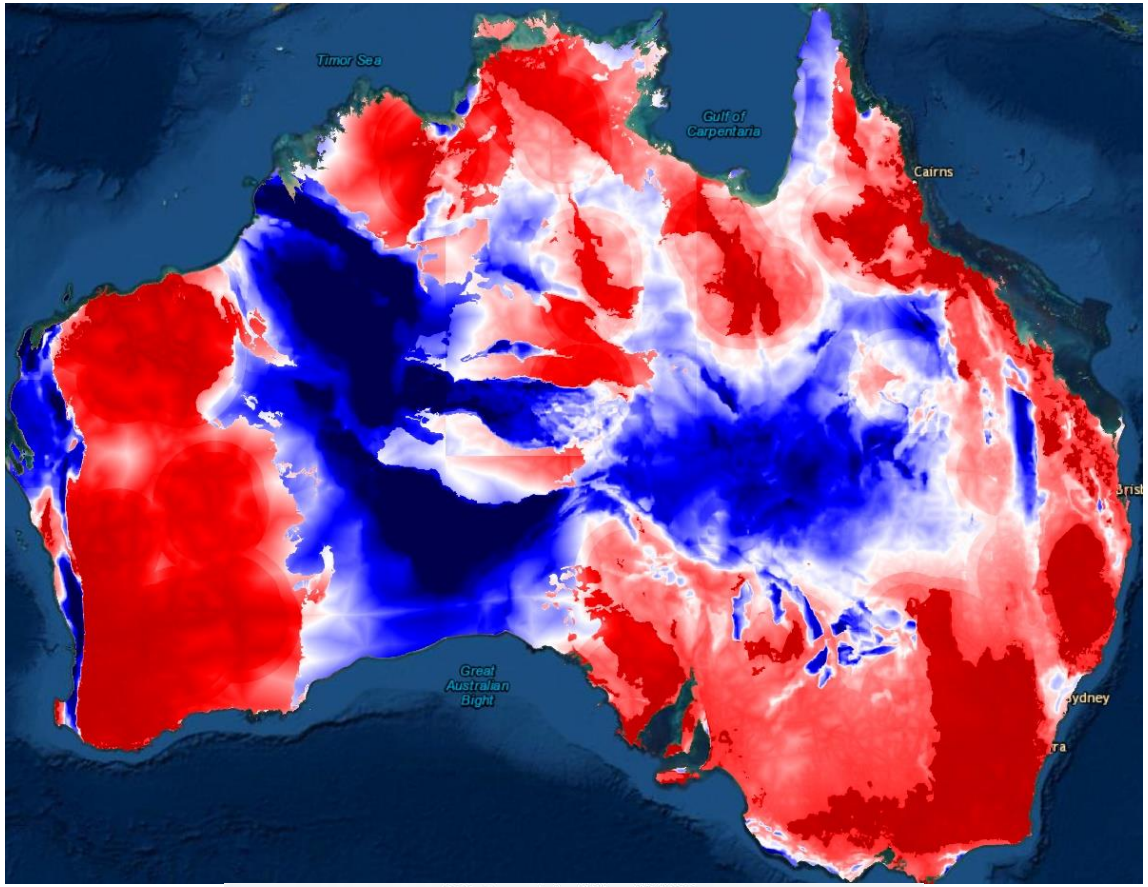
We can evaluate where undiscovered deposits might be hiding





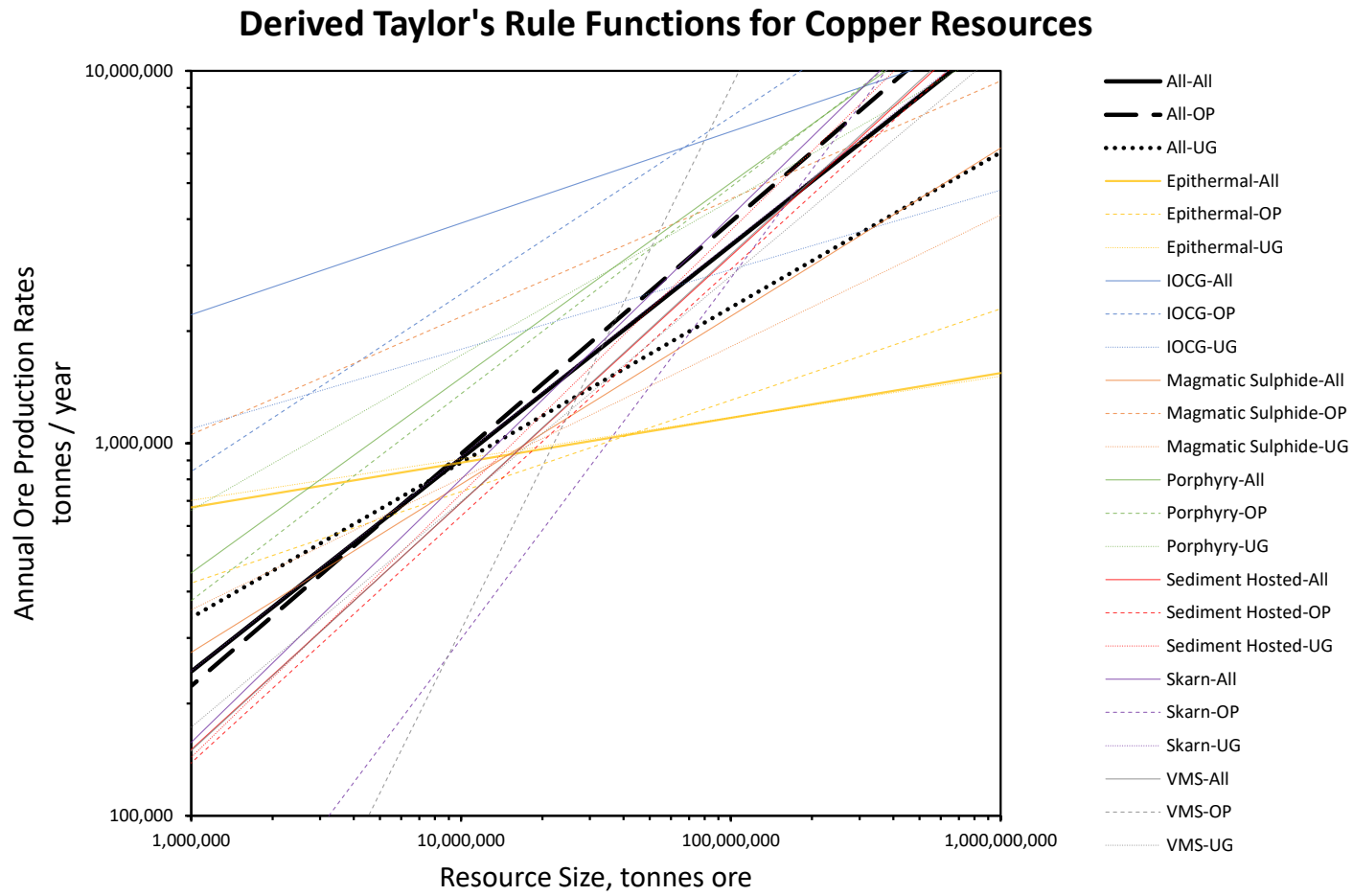
Singer, 2018. Ore Geology Reviews 99: 235-243.
Prospectivity Map of Tholeitic Intrusion-Hosted Ni-Cu-PGE deposits. portal.ga.gov.au

We can estimate the potential costs of extraction



Walsh et al., 2020. Resources Policy 66: 101598.

And the potential rate of extraction



Primary, Exploration Mining and Mineral Supply Scenario (PEMMSS) model

- Transparent, open source model being developed in python

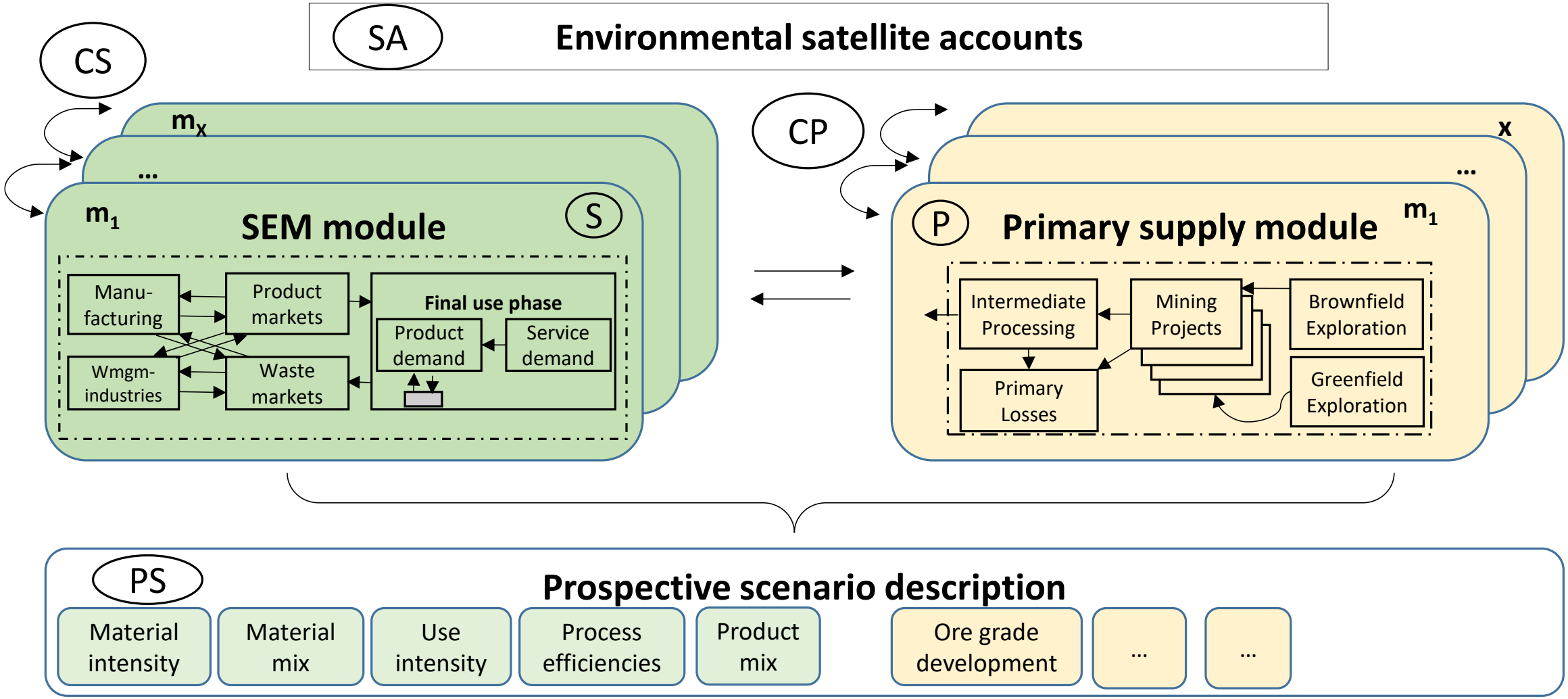
- Aim is to leverage big, dumb data and turn it into concise, smart data

  Recognising that all models are wrong, some are useful.

- Scenarios generated will improve regional understanding of future natural resource burdens of mining such as water consumption and land-use change impacts

Developed in collaboration with Stefan Pauliuk (Uni. of Freiburg), Stefanie Klose (Uni. of Freiburg) and Mohan Yellishetty (Monash University)

```
# Priority Ranking Algorithm
# P7
if parameters['priority_active'][i] == 1:
    # Sort then prioritise existing mines
    projects.sort(key=lambda x: x.value)
    projects.sort(key=lambda x: x.status, reverse=True)
else:
    projects.sort(key=lambda x: x.value)

# Commodity Supply-Demand Balance Algorithm
# P8
for c in demand:
    if demand[c]['balance_supply'] == 1:

        # Project Loop
        # P9
        for project in projects:
            # break loop if residual demand less than the commodities demand threshold
            if demand[c][year_current] <= demand[c]['demand_threshold']:
                break

            # Determine intermediate supply for all the project's commodities. Note project will not supply
            supplied = project.supply(demand[c][year_current]/demand[c]['intermediate_recovery'], year_curre
            # Subtract supply from demand for all commodities produced by the project.
            if supplied == 1:
                for p_commodity in project.commodity:
                    if p_commodity not in demand:
                        log_message.append('Project '+str(project.name)+' attempted to supply commodity '+st
                    else:
                        demand[p_commodity][year_current] -= project.production_intermediate[p_commodity][yea

        # Greenfield Discovery (Demanded). If supply insufficient, generate new deposits
        # P10
        if parameters['greenfield_exploration_on'][i] == 1:
            while demand[c][year_current] > demand[c]['demand_threshold']:
                projects.append(deposit.resource_discovery(factors, year_current, False, len(projects)+1))
                # Subtract supply from demand for all commodities produced by the project. Note that this me
                supplied = projects[-1].supply(demand[c][year_current]/demand[c]['intermediate_recovery'], y
                if supplied == 1:
                    for p_commodity in projects[-1].commodity.keys():
                        demand[p_commodity][year_current] -= projects[-1].production_intermediate[p_commodit

# Adjust next years commodity demand by a ratio of any under or over commodity supply.
# P10
```


SA
Environmental satellite accounts
CS
CP
m_x
...
m_1
SEM module
S
Manu-facturing
Product markets
Final use phase
Product demand
Service demand
Wmgm-industries
Waste markets
x
...
P
Primary supply module
m_1
Intermediate Processing
Mining Projects
Brownfield Exploration
Primary Losses
Greenfield Exploration
PS
Prospective scenario description
Material intensity
Material mix
Use intensity
Process efficiencies
Product mix
Ore grade development
...
...

For further information:

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Topics touched on:

Spatial distribution of mineral resources
Regional Water and Climate Risks
Mining Land Use Change
Mineral resource datasets
Advanced Scenario Modelling