RestREco

Restoring Resilient Ecosystems

Drivers of complexity in ecosystem restoration

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Calcareous grasslands & broadleaf woodlands

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Natural experiment set-up

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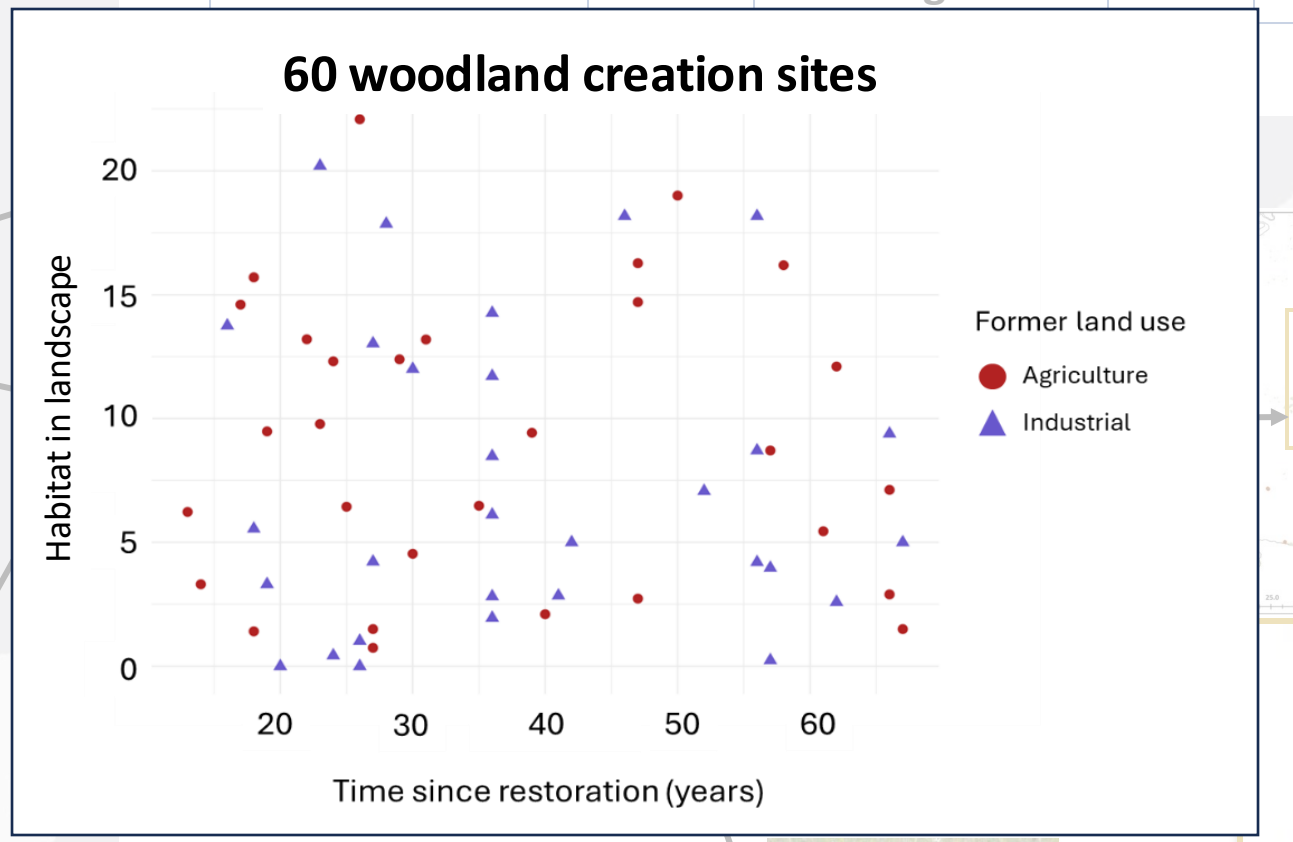
Former land-use

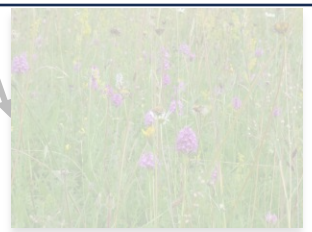
Age

Habitat in landscape

Woodlands
(60 sites)

Grasslands
(60 sites)



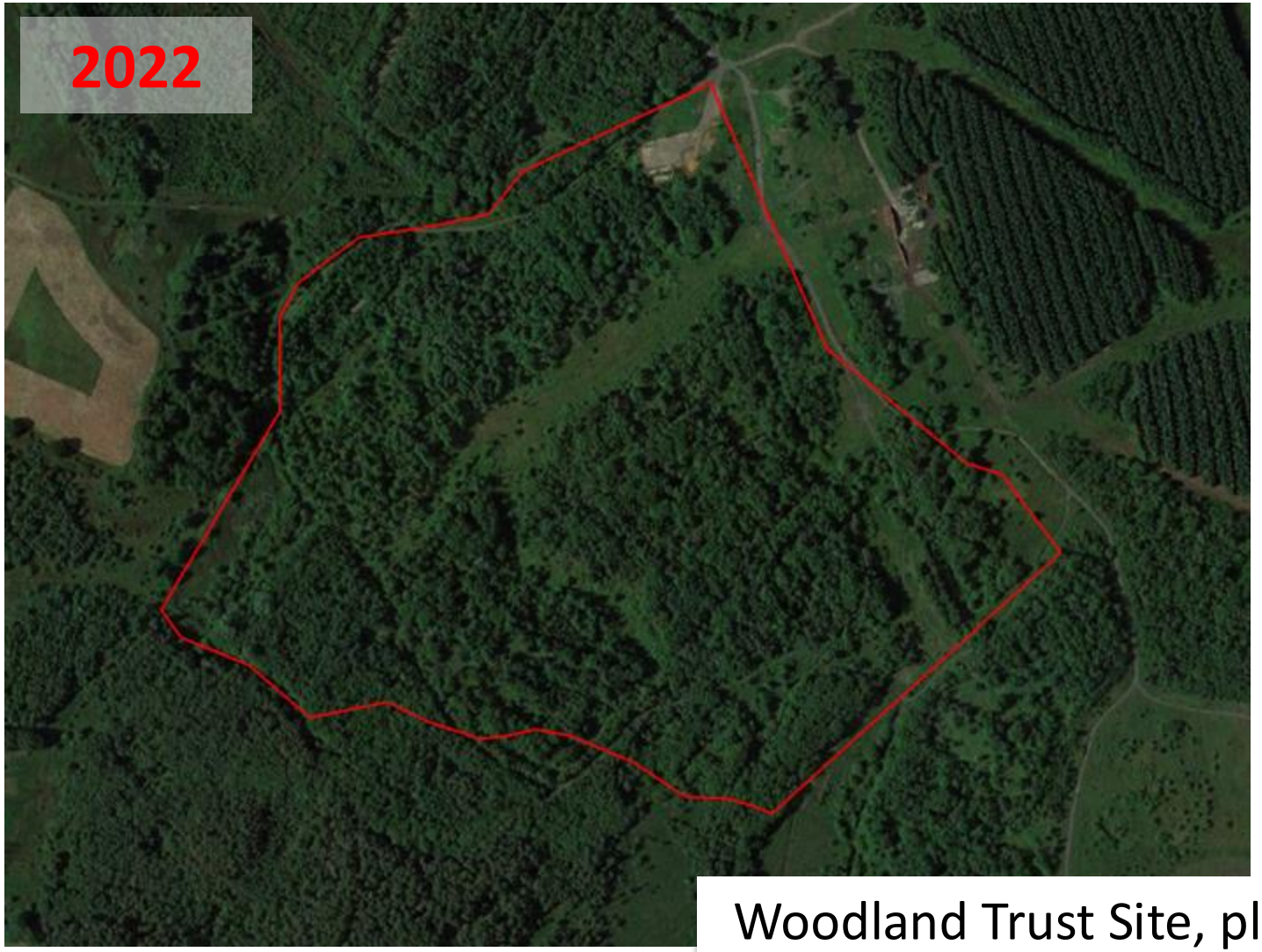






Selecting sites

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Woodland Trust Site, planted in the 1990s

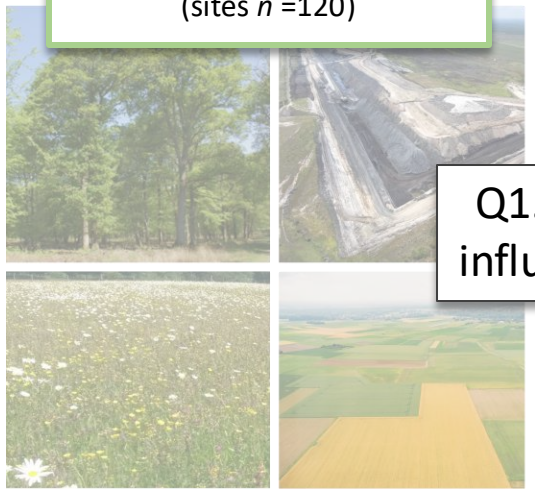
Overarching research questions

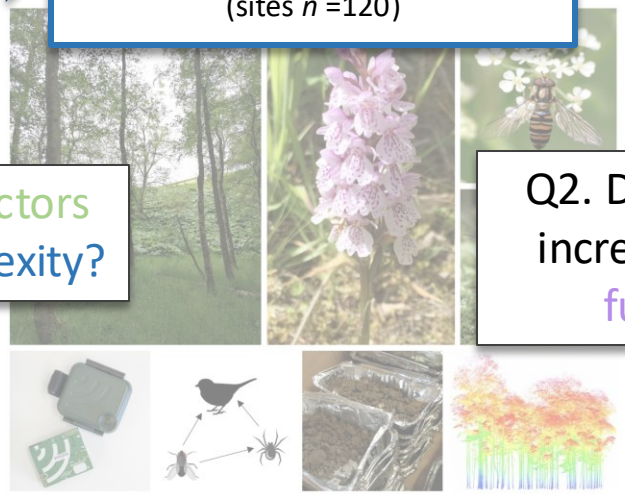
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Site factors
(sites *n* =120)

Metrics of complexity
(sites *n* =120)

Measurements of ecosystem function (sites *n* = 36)





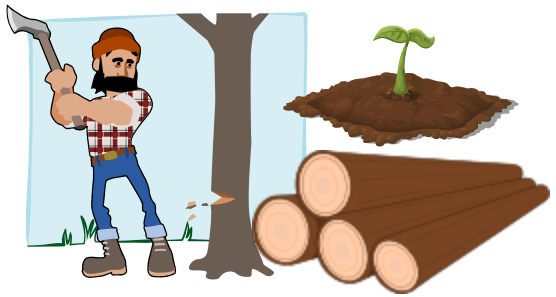


Q1. How site factors influence complexity?

Q2. Does complexity increase ecosystem functioning?

Q3. Does complexity increase resilience?

Q4. Can interventions speed up complexity?



Management interventions (sites *n* = 20)

Drought experiment – resilience (sites *n* = 5)

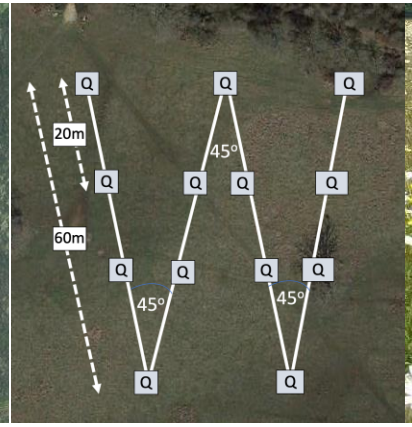


Measuring complexity – ecological surveys

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ground flora

habitat structure

trophic webs

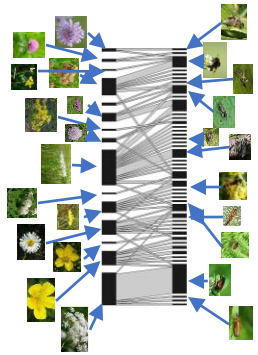
acoustics

inverts

soil properties & microbes









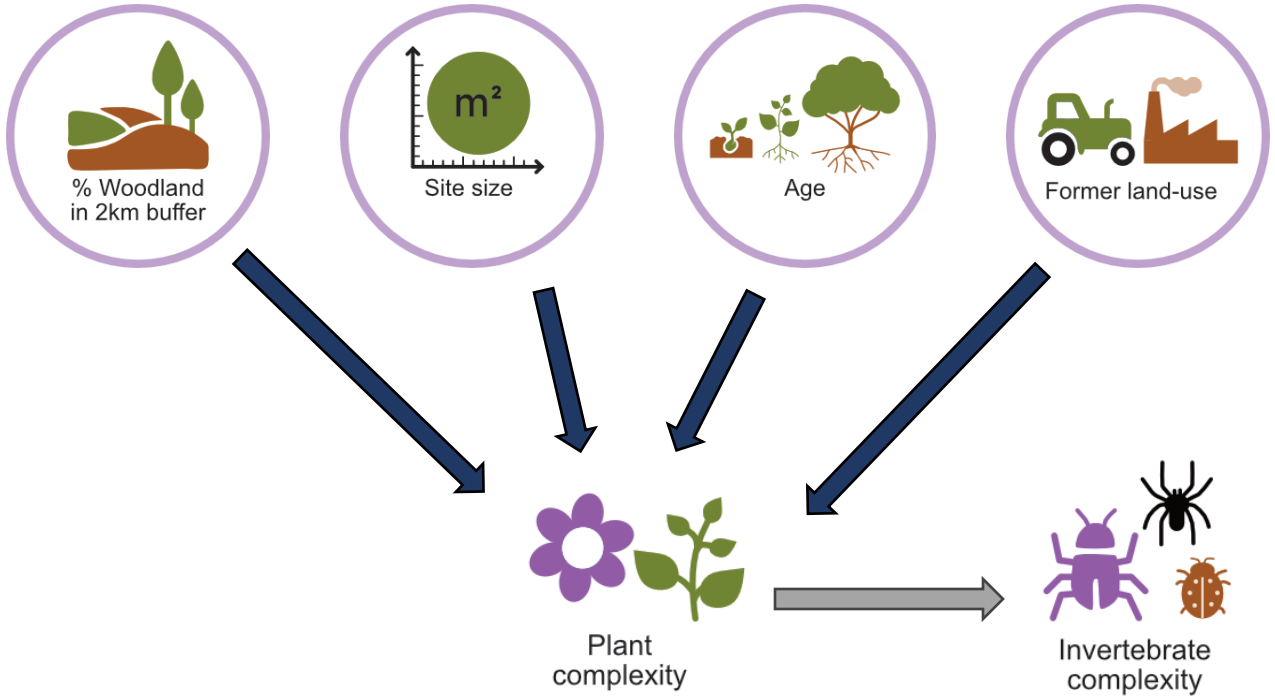




Research questions

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1. What are the *key drivers* of *ecological complexity* in restored ecosystems?
2. How do *different aspects of ecological complexity* *interact* when ecosystems are restoring?

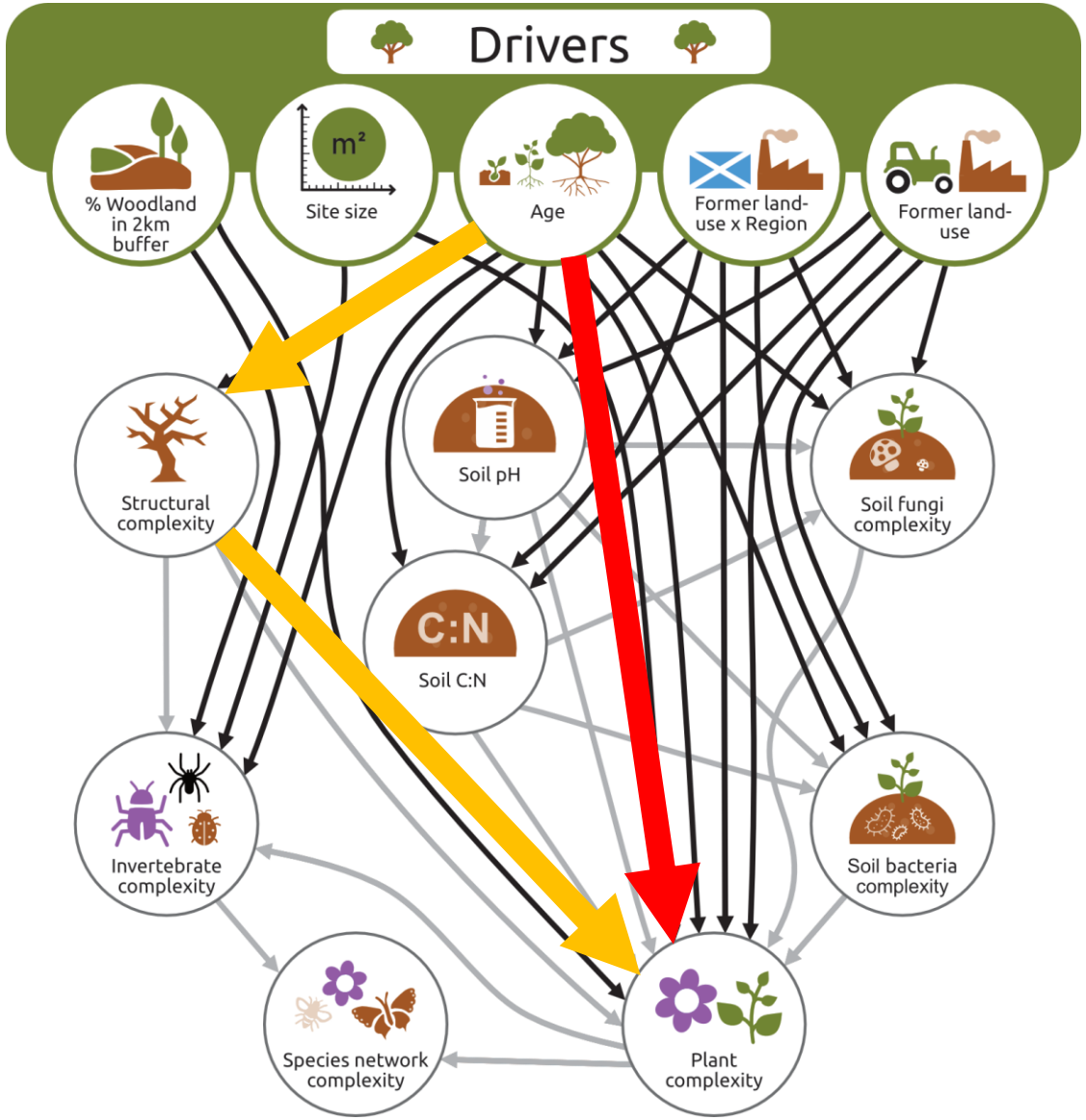


'the number of components in a system and the number of connections among them' (Bullock et al., 2022)

Bullock et al. (2022) Ecography

Structural Equation Modelling

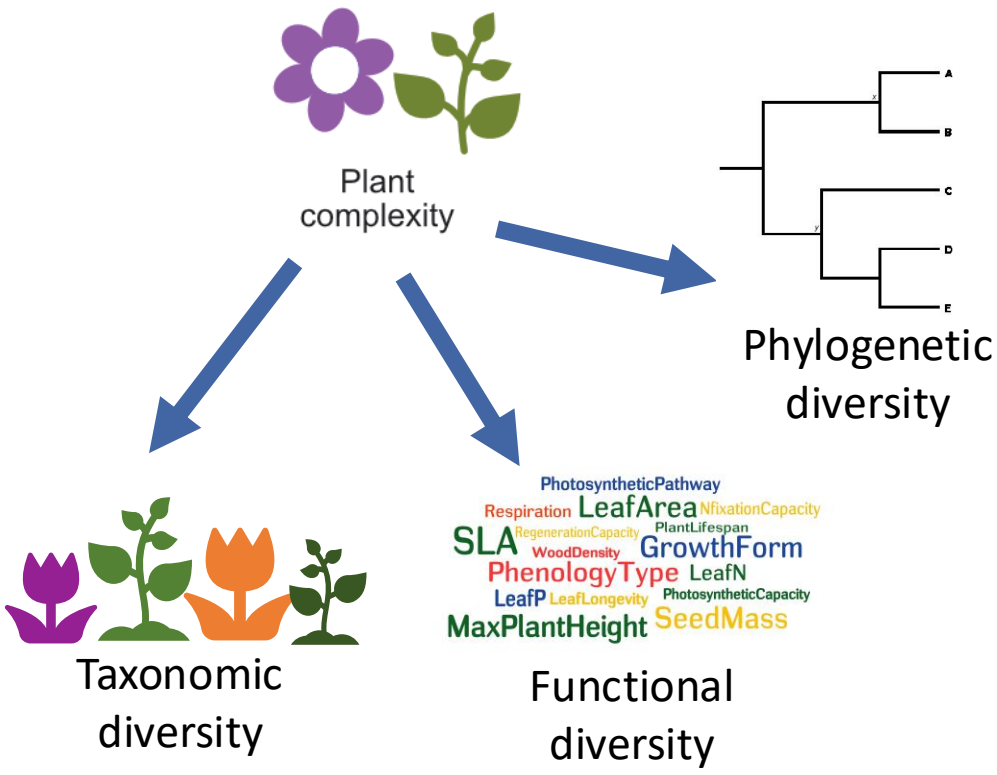
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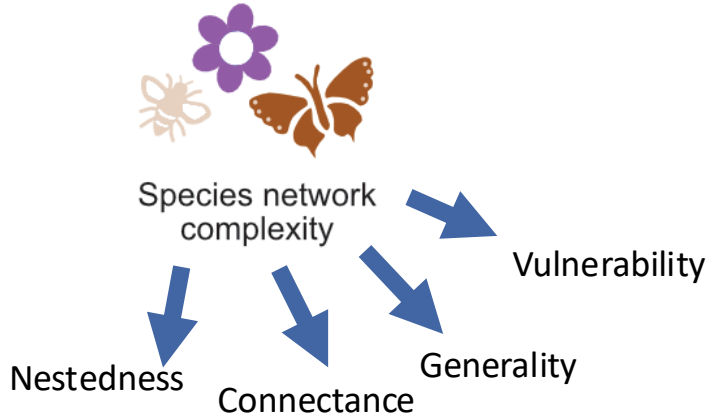
Complexity metrics

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Components



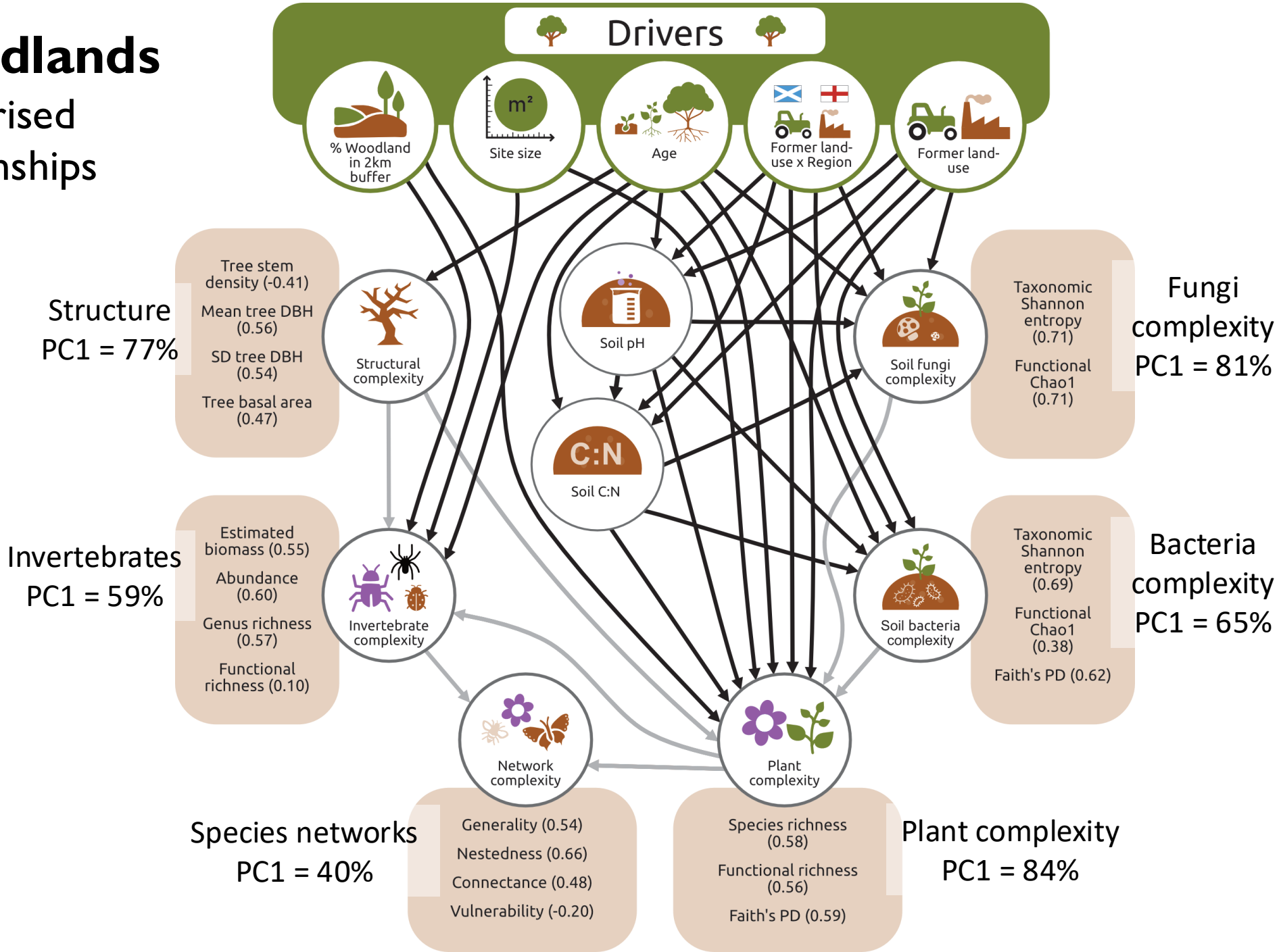
Connections



Principal component analysis (PCA) to combine multiple variables into one **'complexity metric'**

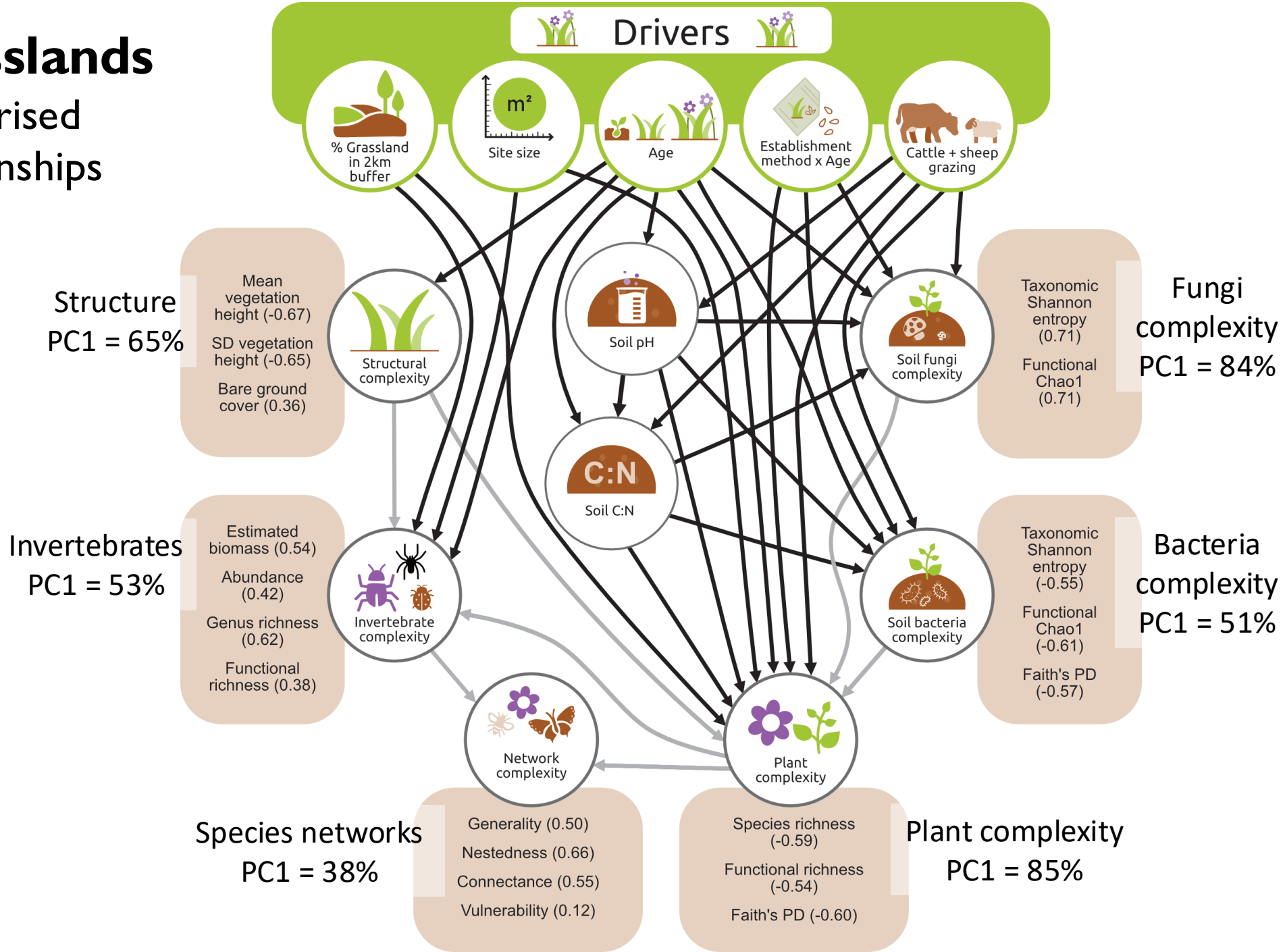
Woodlands

- Theorised relationships

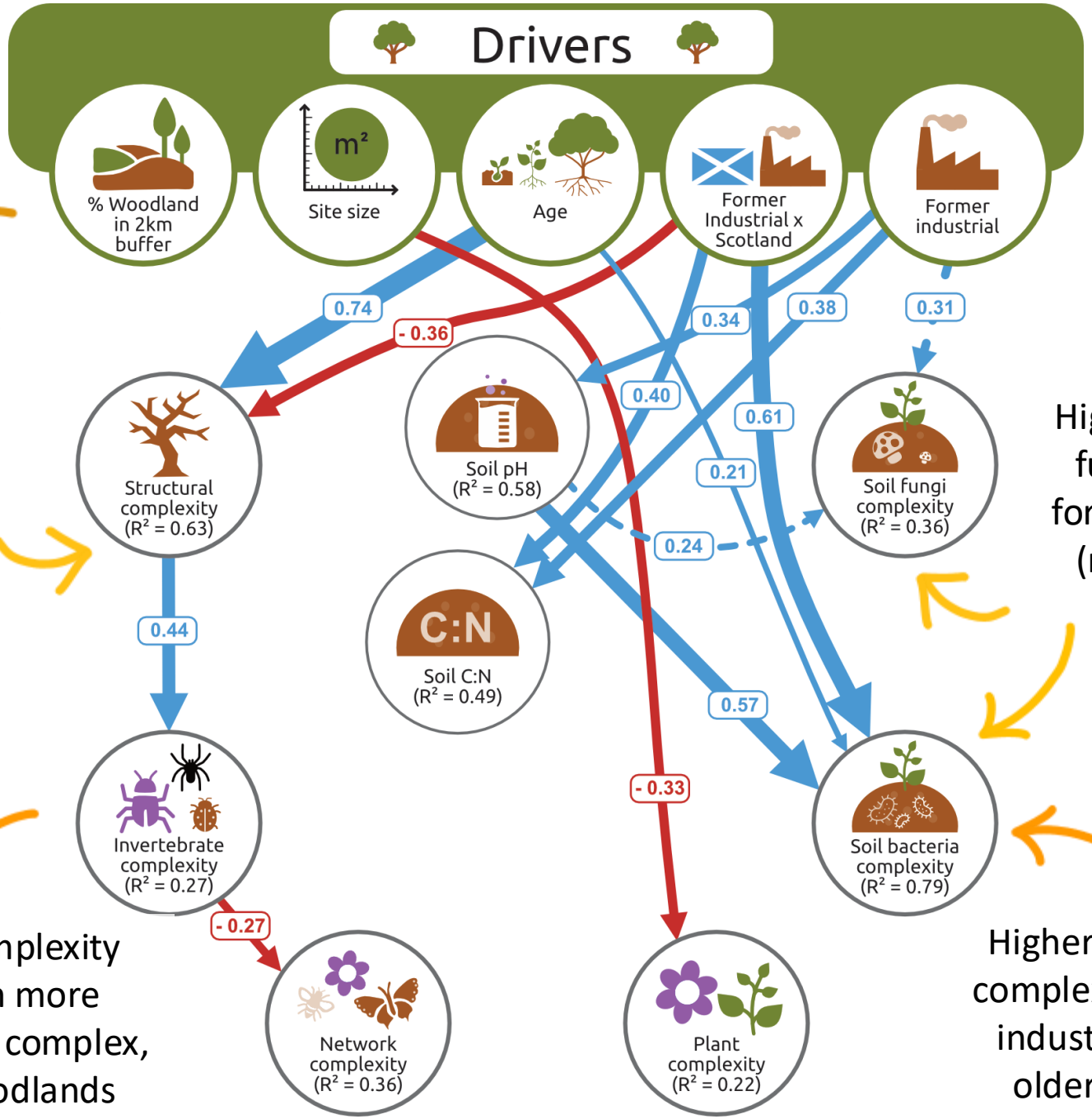


Grasslands

- Theorised relationships



Woodlands - results



Red = Significant negative effect

Blue = Significant positive effect

Dashed line = marginal effect

No effect of habitat in landscape

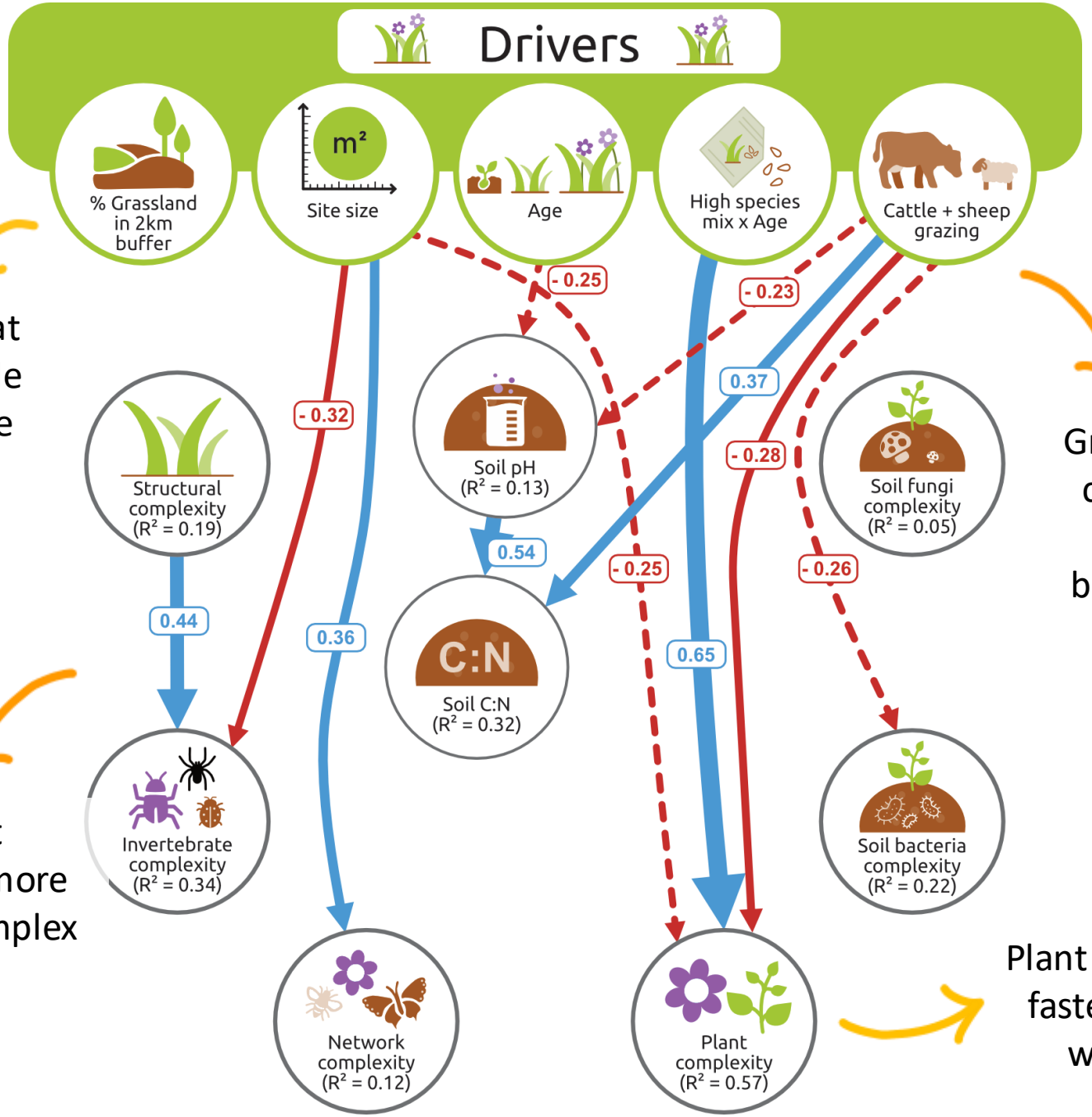
Structural complexity increases with age, & is lower in former Scottish industrial sites

Higher soil bacteria & fungi complexity in former industrial sites (mediated through soil pH)

Invert complexity higher in more structurally complex, older woodlands

Higher soil bacterial complexity in Scottish industrial sites and older woodlands

Grasslands
- results



Red = Significant negative effect

Blue = Significant positive effect

Dashed line = marginal effect

No effect of habitat in landscape & little *direct* effect of age

Grasslands with both cattle & sheep had lower plant & bacterial complexity

High invert complexity in more structurally complex grasslands

Plant complexity developed faster in grasslands sown with a rich seed mix

Conclusions - drivers

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Parallels across habitats

- Importance of starting context
  - Woodlands (Former land-use) – soil microbial complexity higher and structural complexity lower in (Scottish) former industrial sites
  - Grasslands (Establishment method) – speeds up plant complexity (interaction with site age)
- Age not as dominant as we expected
  - Structure & bacteria higher in older woodlands
- Management (sheep & cattle) reduced complexity (plants & bacteria) in grasslands
- No effect of habitat in surrounding landscape
- Negative effects of size
  - Driven by non-habitat specific species?



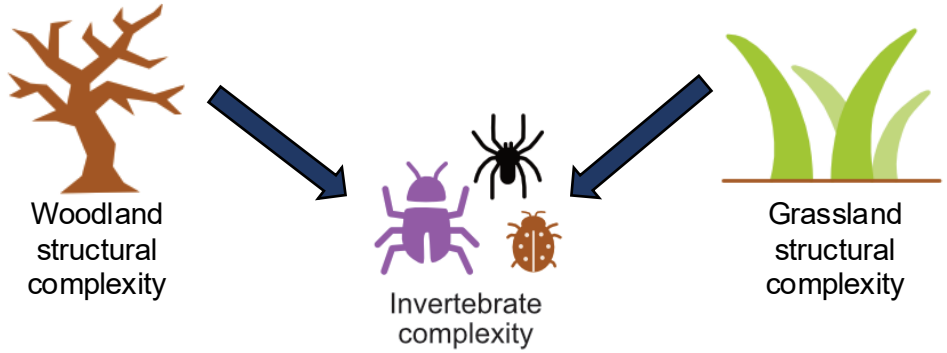


Conclusions - relationships

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Relationships between different aspects

- Across habitats – few relationships between different biotic components of complexity
  - Biotic components developing independently at ecosystem scale
  - Complexity cannot be reduced to a metric or two
- High structural complexity drives invertebrate complexity in both habitats – foundational aspect of complexity









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What do these findings mean for future restoration that seeks to target complexity?

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