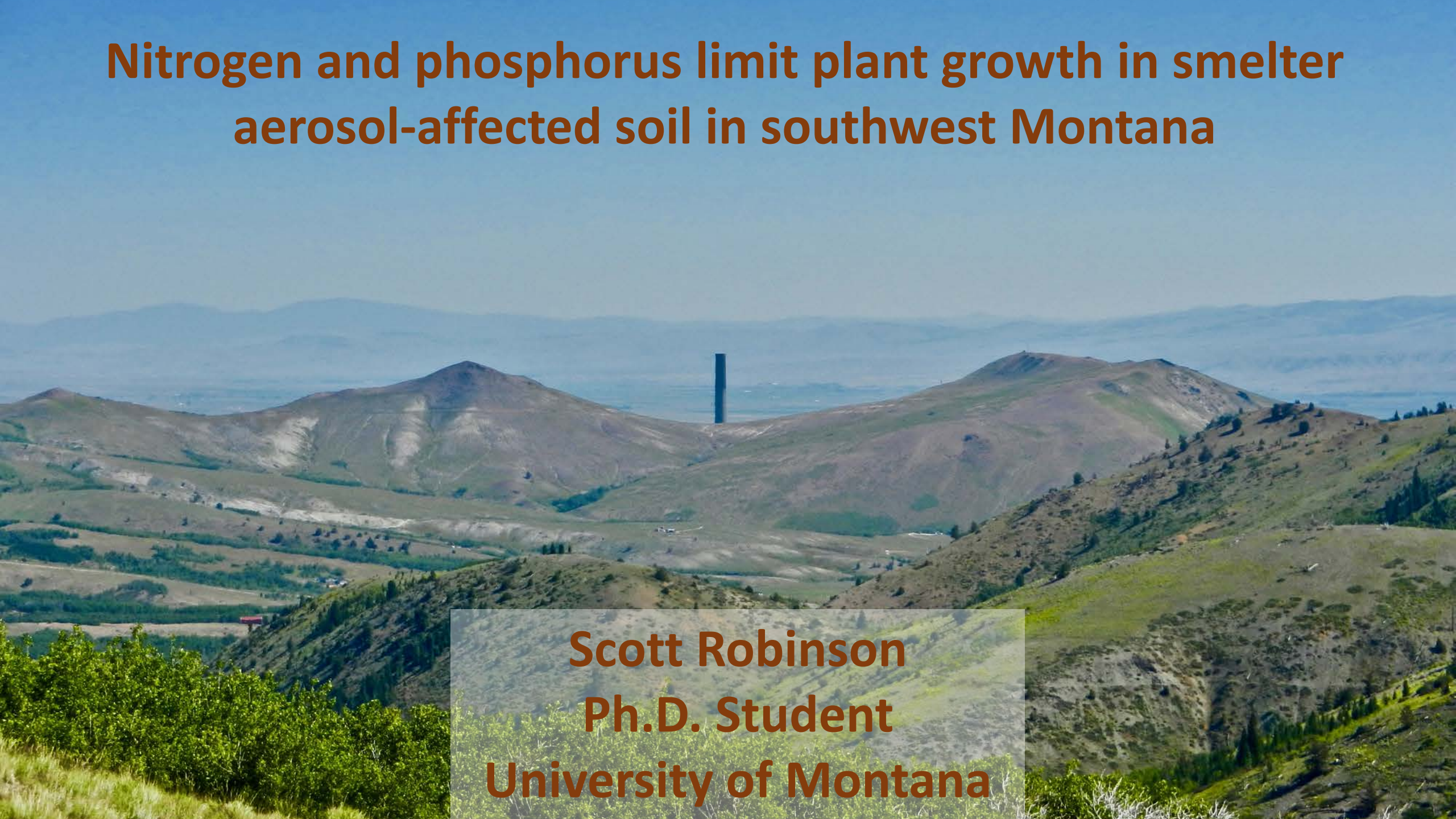


Nitrogen and phosphorus limit plant growth in smelter aerosol-affected soil in southwest Montana



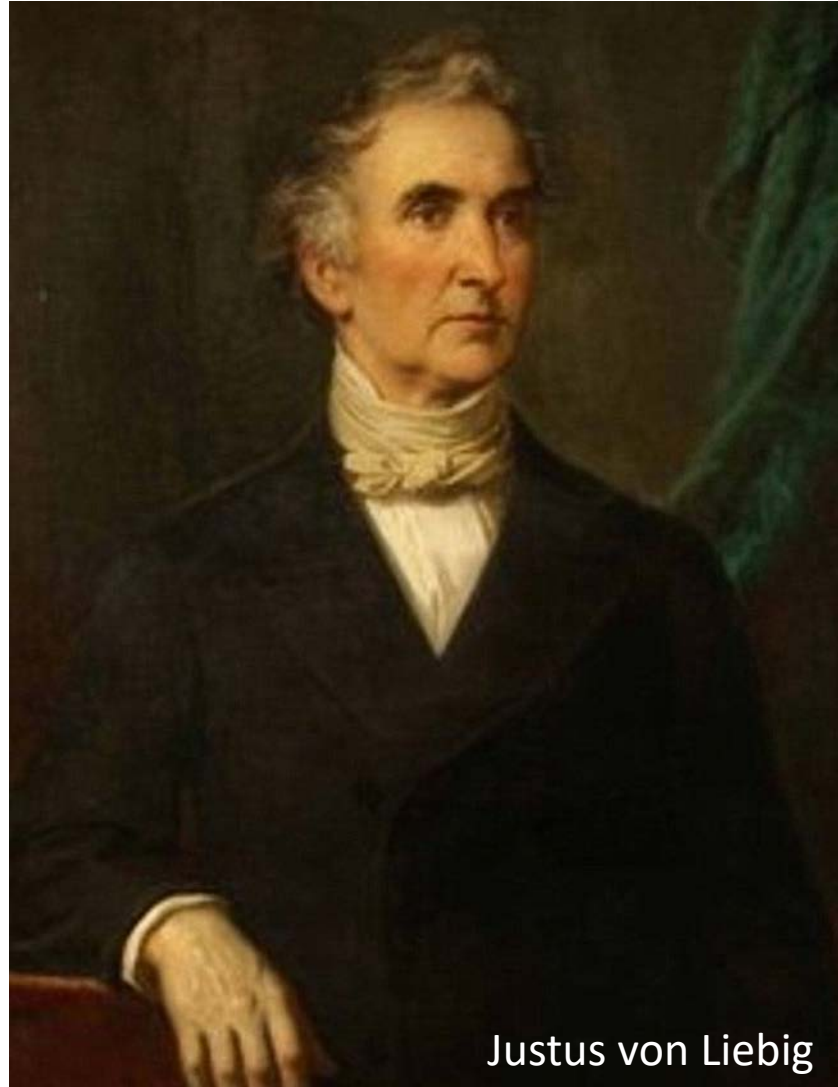
Scott Robinson
Ph.D. Student
University of Montana

Nutrient Limitation – Limiting Factor

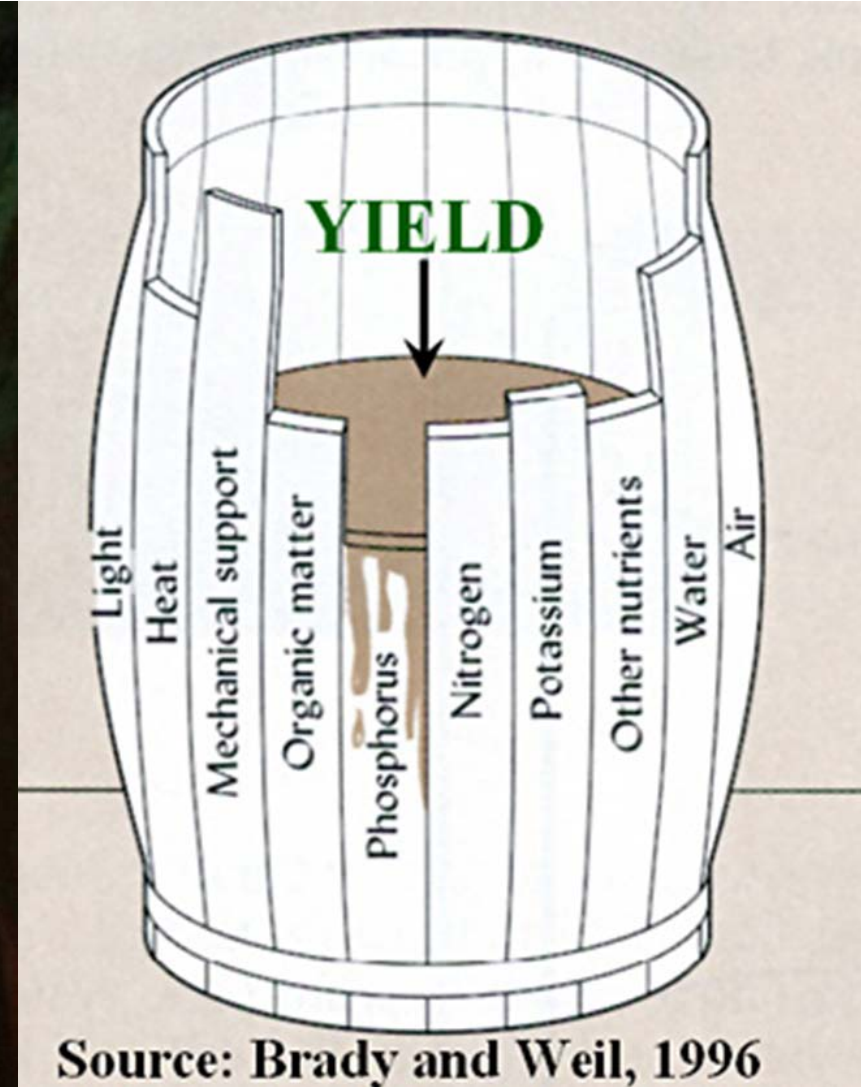
~1830's Liebig's Law

Plant growth \leq level
allowed by the growth
factor present in the
lowest amount

Gave rise to fertilizer
use in agriculture



Justus von Liebig



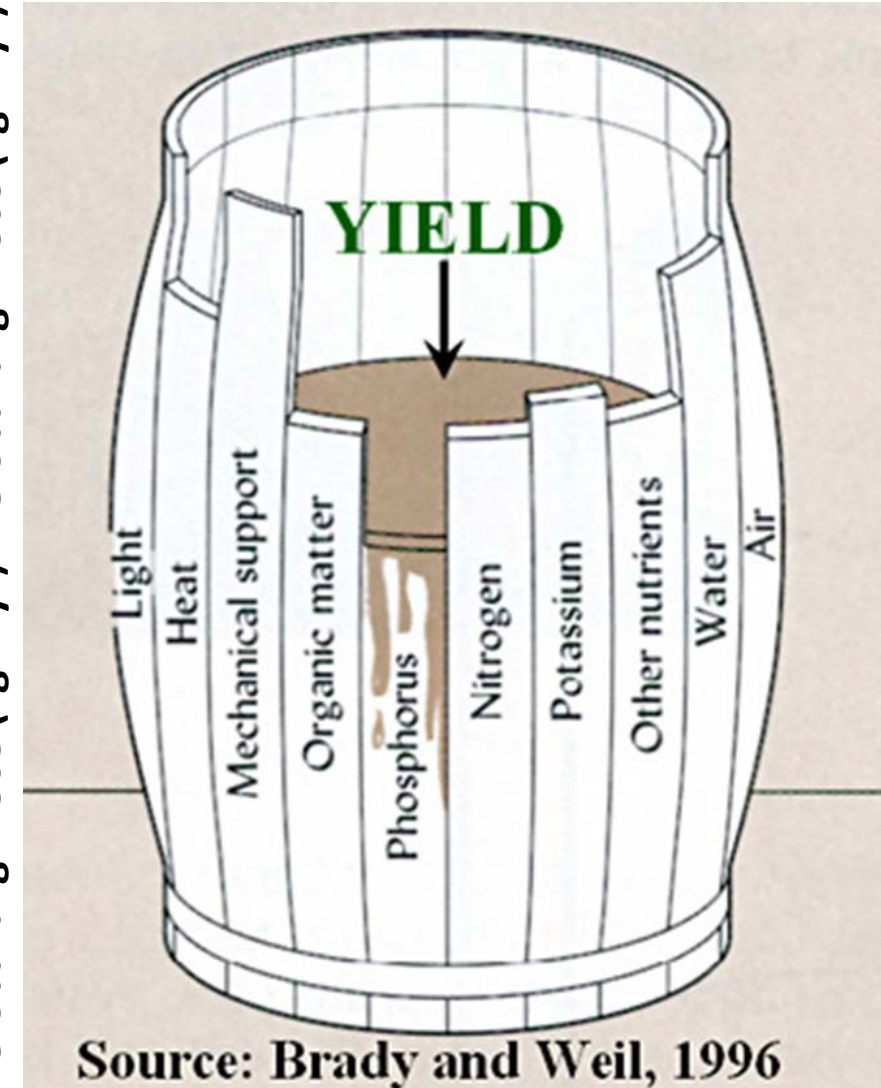
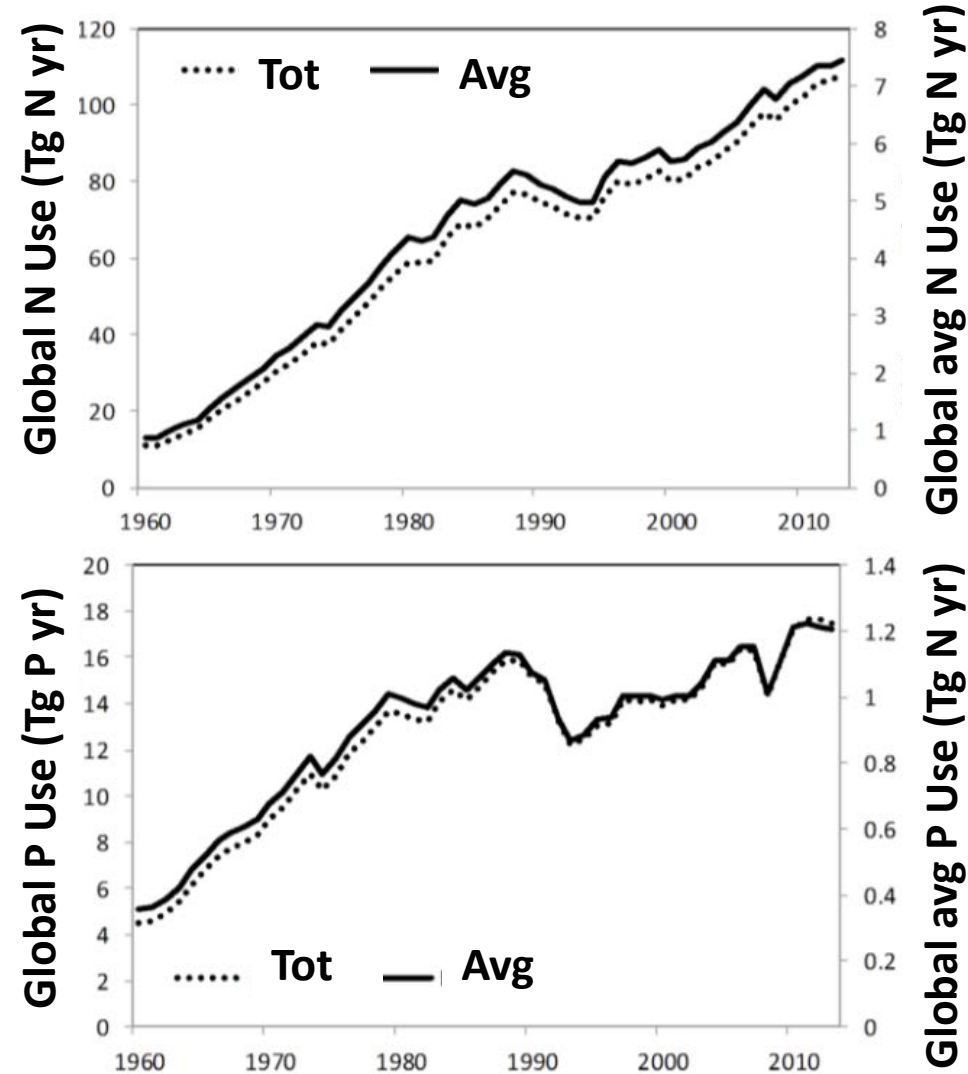
Source: Brady and Weil, 1996

Nutrient Limitation – Limiting Factor

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Plant growth \leq level allowed by the growth factor present in the lowest amount

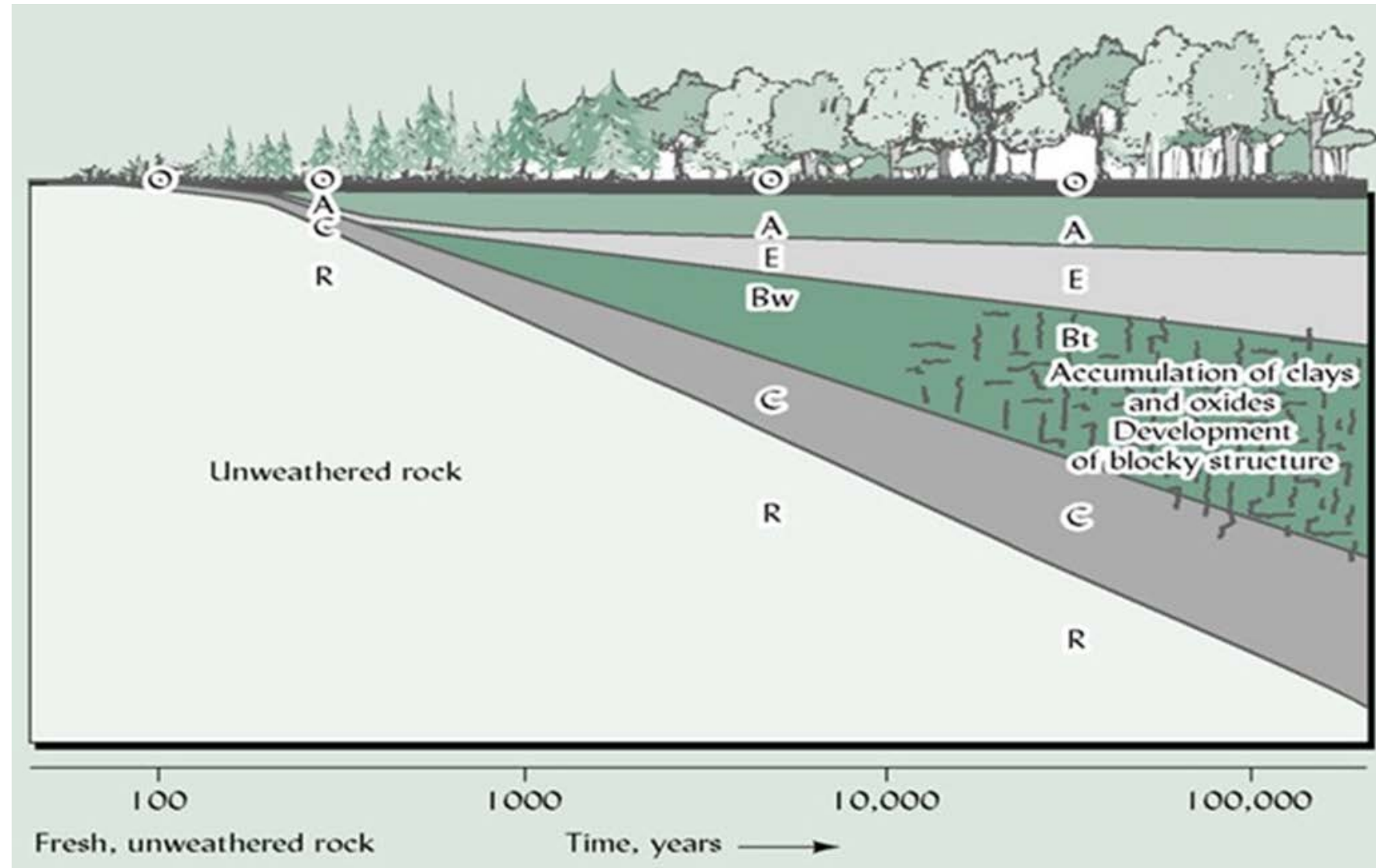
Gave rise to fertilizer use in agriculture



Nutrient Limitation – Ecosystem Ecology

Phosphorus is derived from parent material

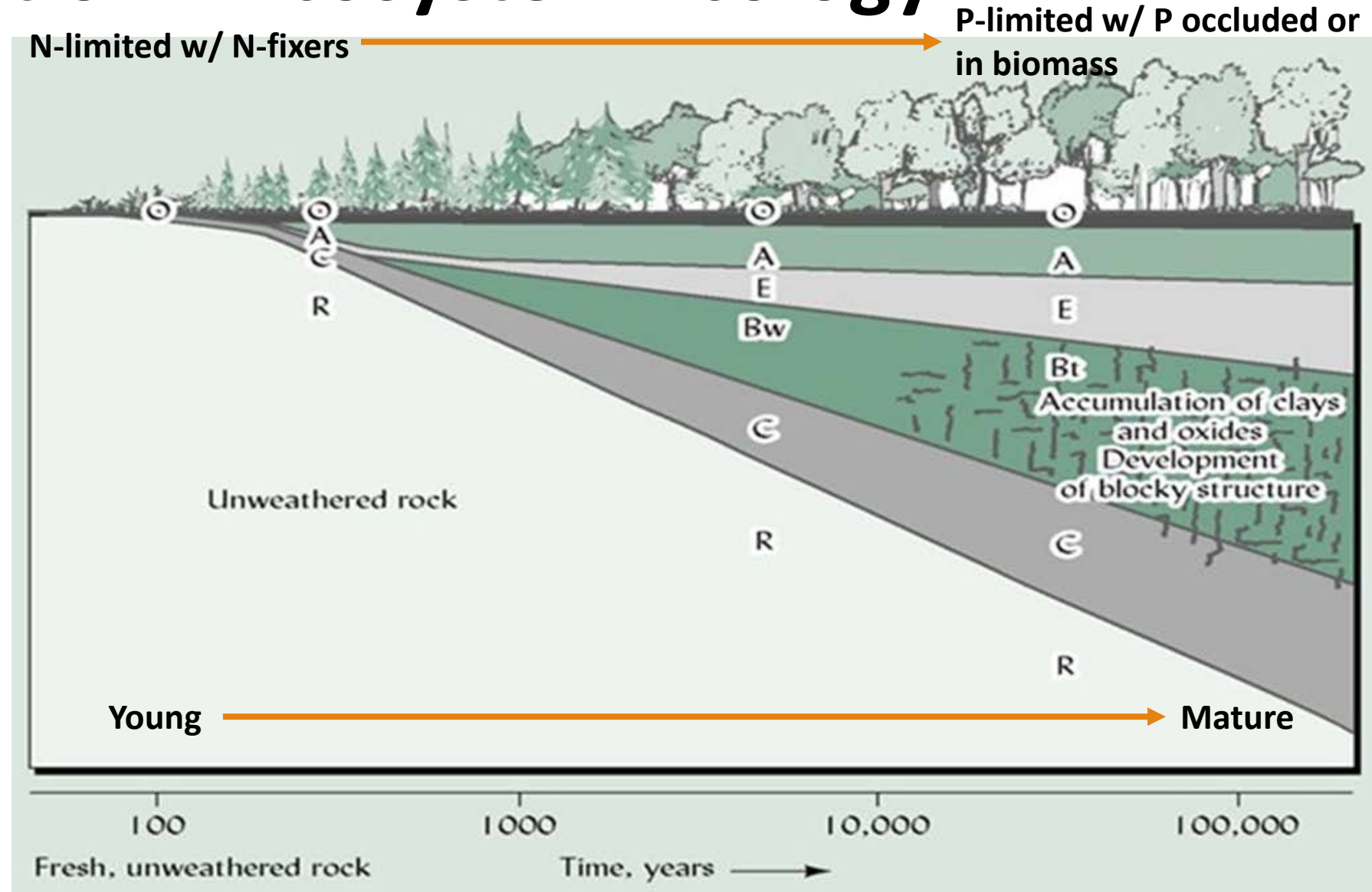
Nitrogen is primarily biological



Nutrient Limitation – Ecosystem Ecology

Young soil = N-limited

Mature soil = P-limited



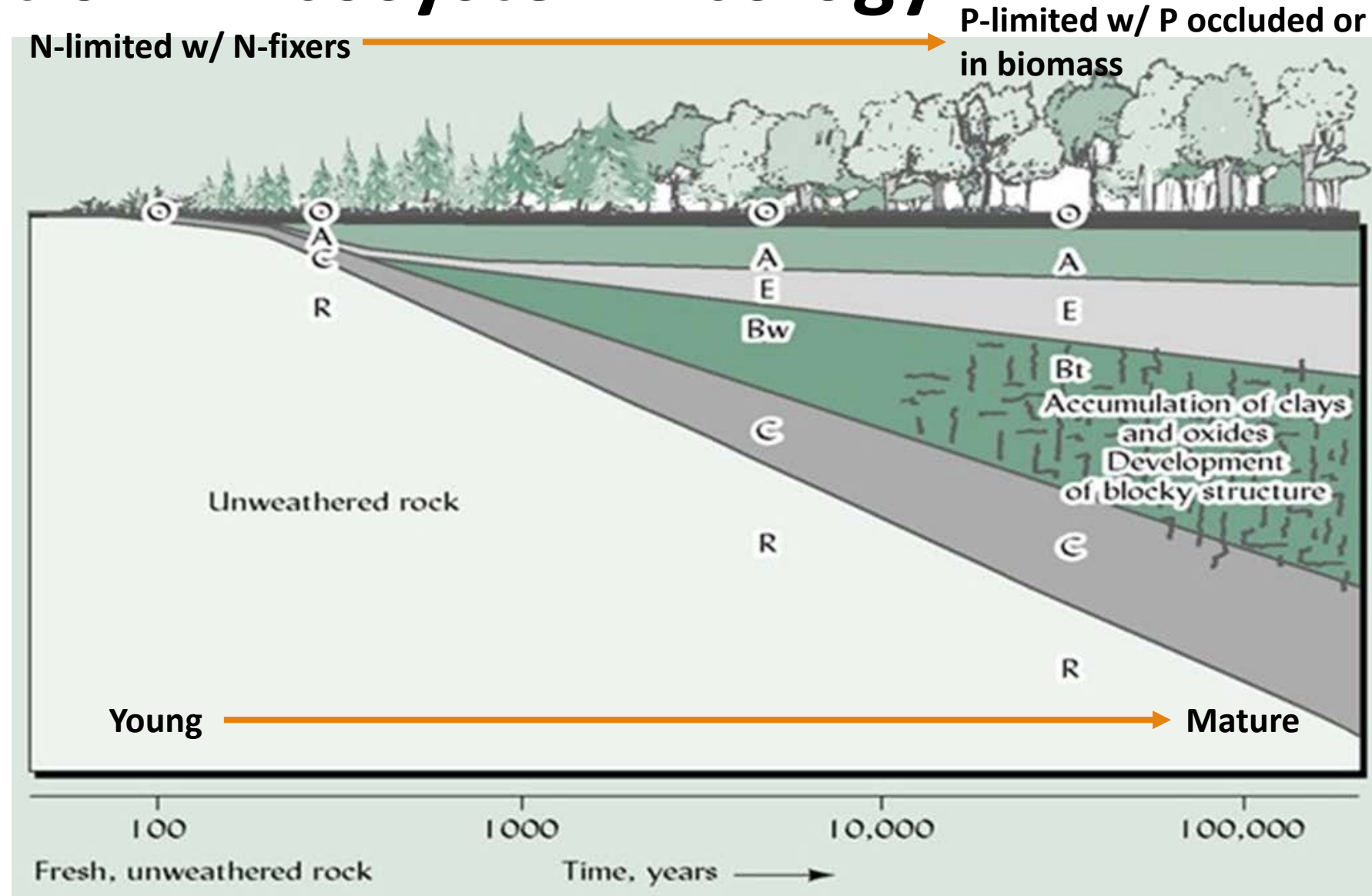
Nutrient Limitation – Ecosystem Ecology

Young soil = N-limited

Mature soil = P-limited

High-latitude = N-limited

Tropics = P-limited



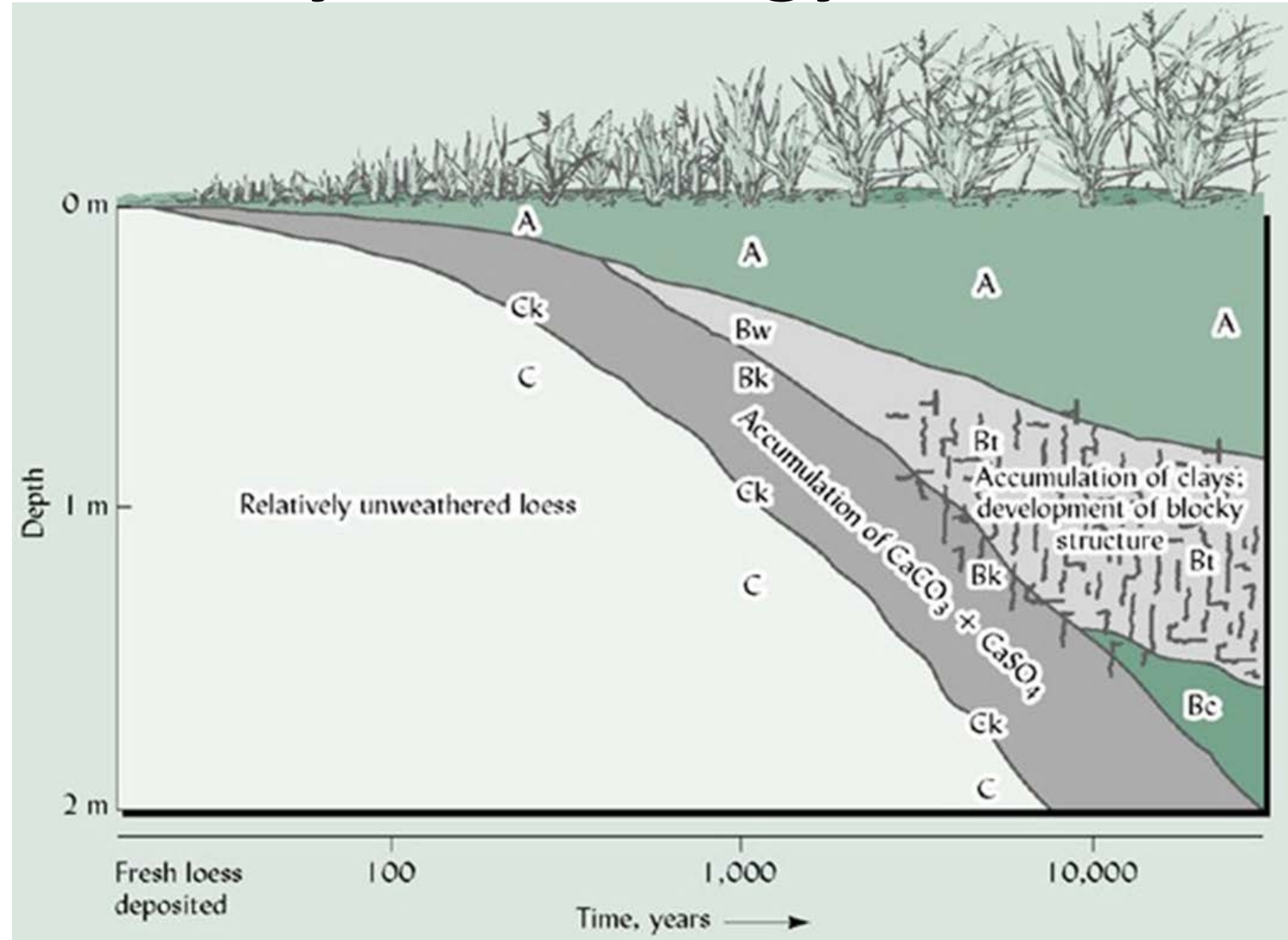
Nutrient Limitation – Ecosystem Ecology

Diverse set of factors that influence nutrient availability:

Parent material

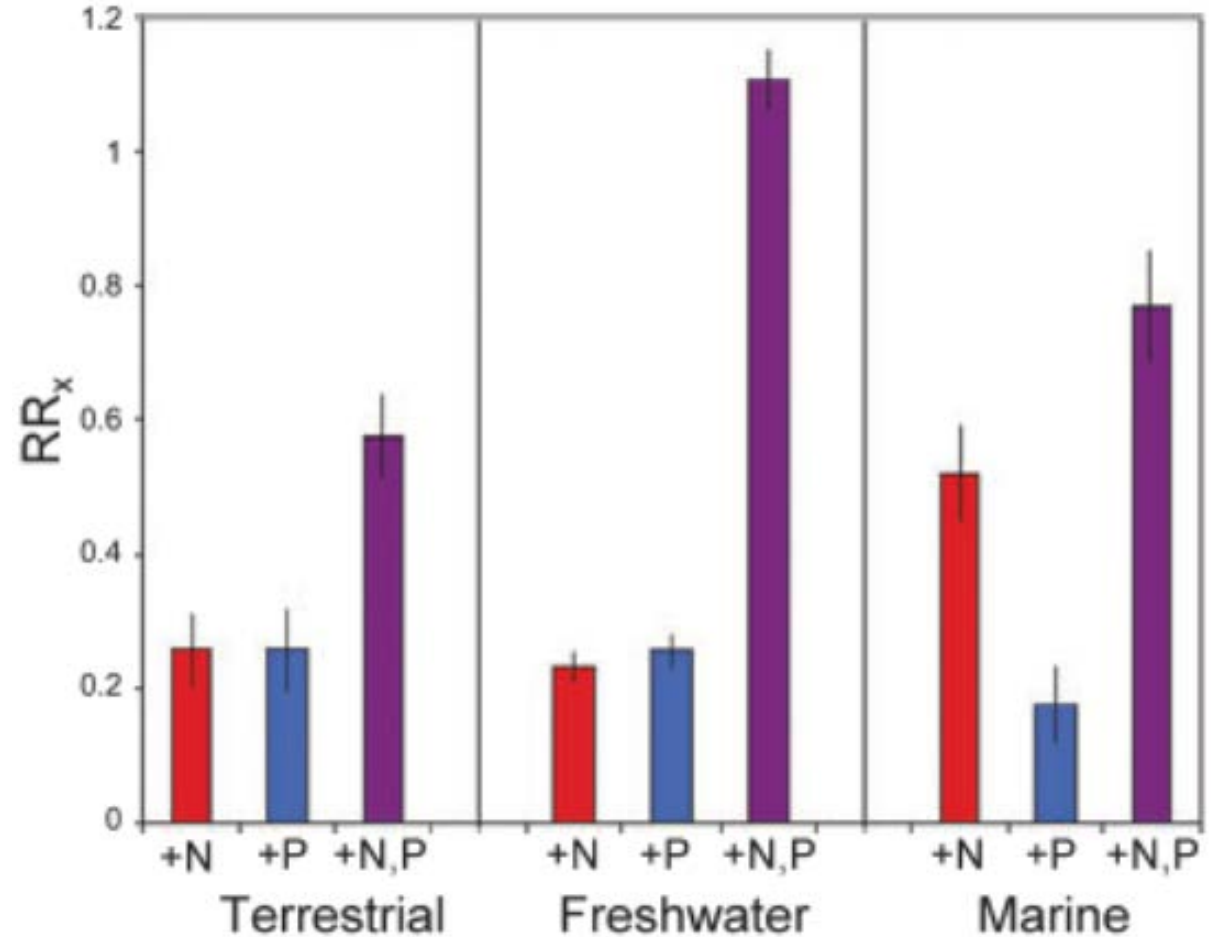
Climate

Vegetation



Nutrient Limitation

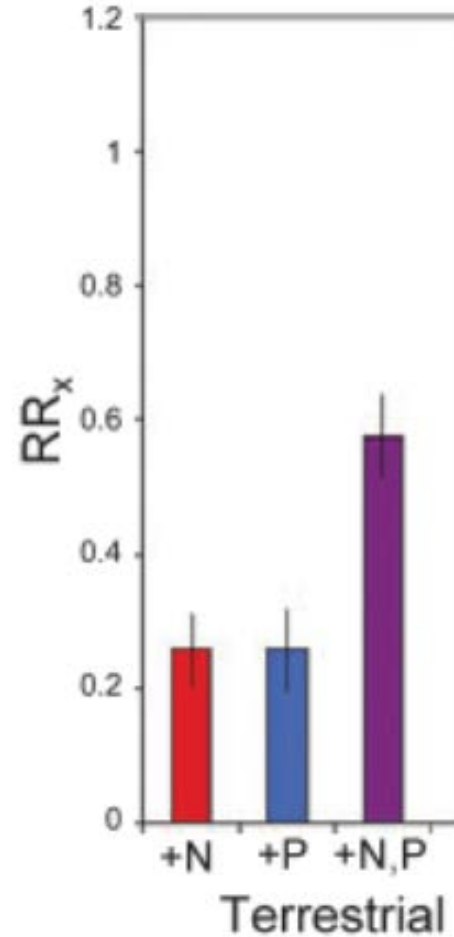
Elser et al. – Most studies report growth limitation by N + P



Nutrient Limitation

Elser et al. – Most studies report growth limitation by N + P

Fay et al. – Grassland productivity co-limited by multiple nutrients

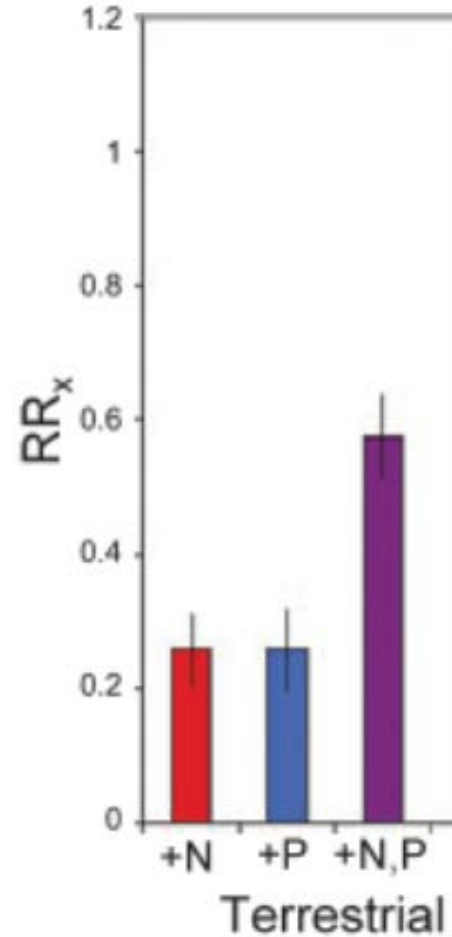


Nutrient Limitation

Elser et al. – Most studies report growth limitation by N + P

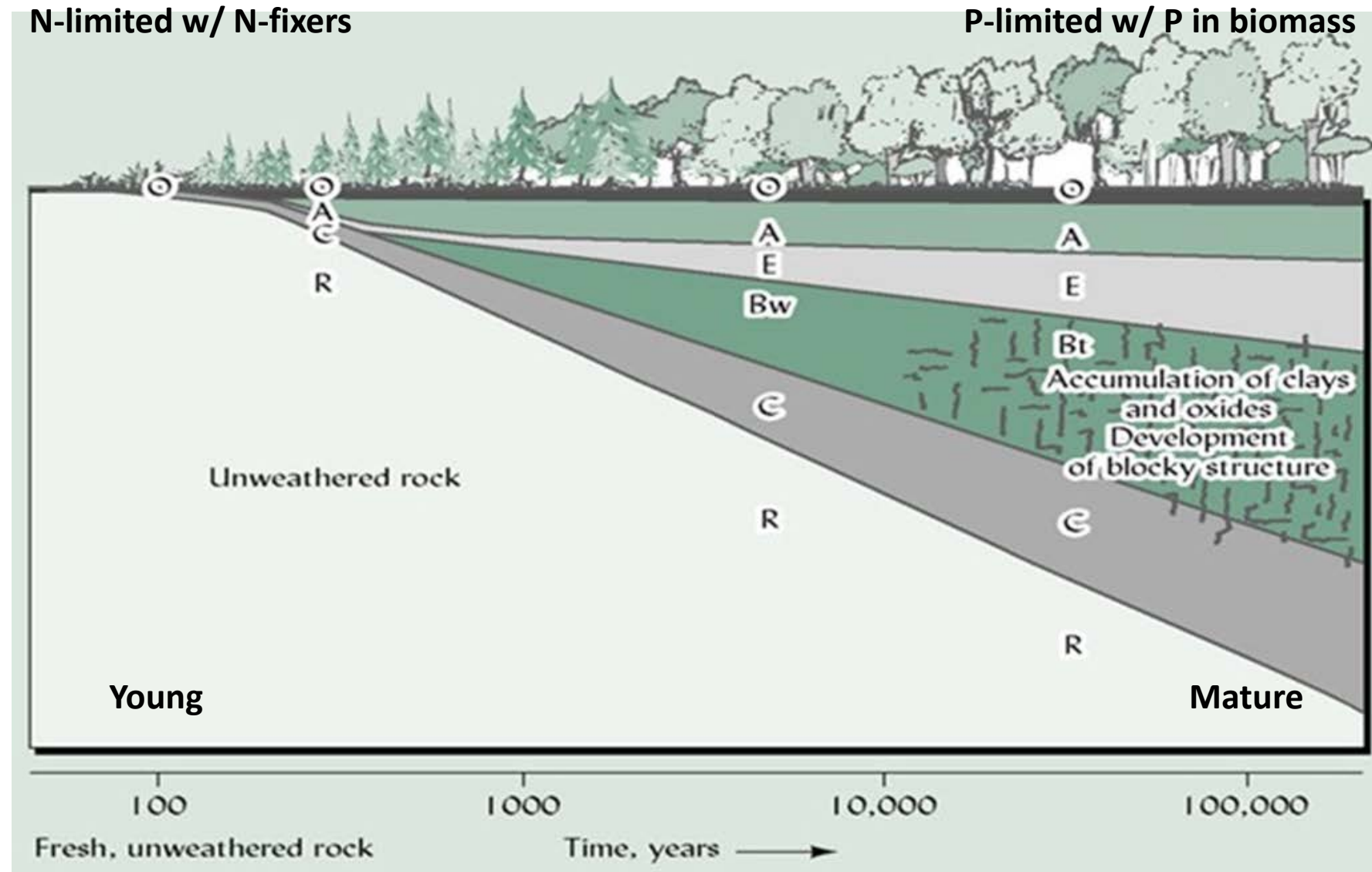
Fay et al. – Grassland productivity limited by multiple nutrients

Nitrogen-limitation peaked at high latitudes, but not widespread



Nutrient Limitation – Disturbance

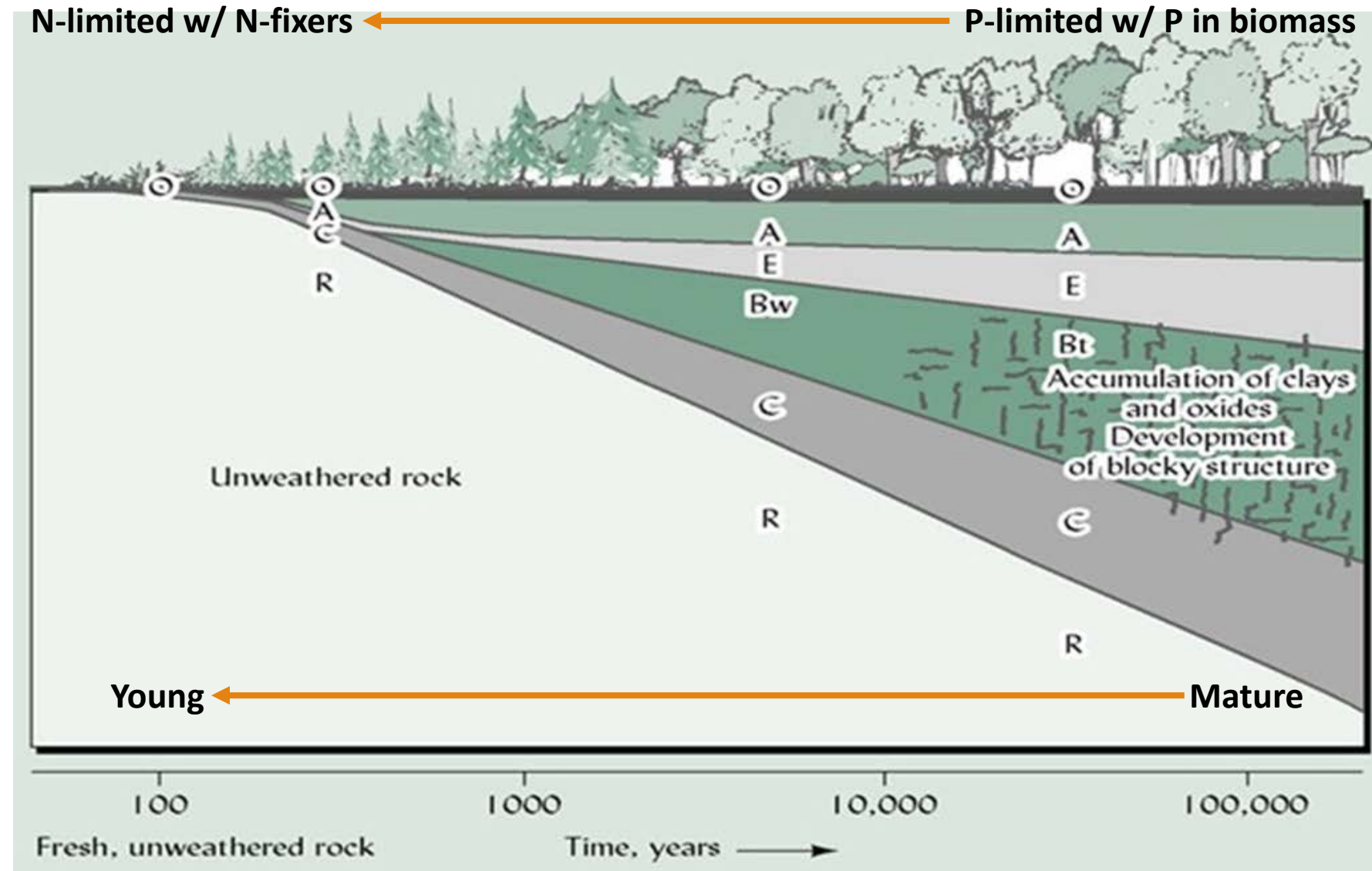
What happens after a major disturbance removes vegetation?



Nutrient Limitation – Disturbance

What happens after a major disturbance removes vegetation?

Succession and soil and ecosystem formation starts over

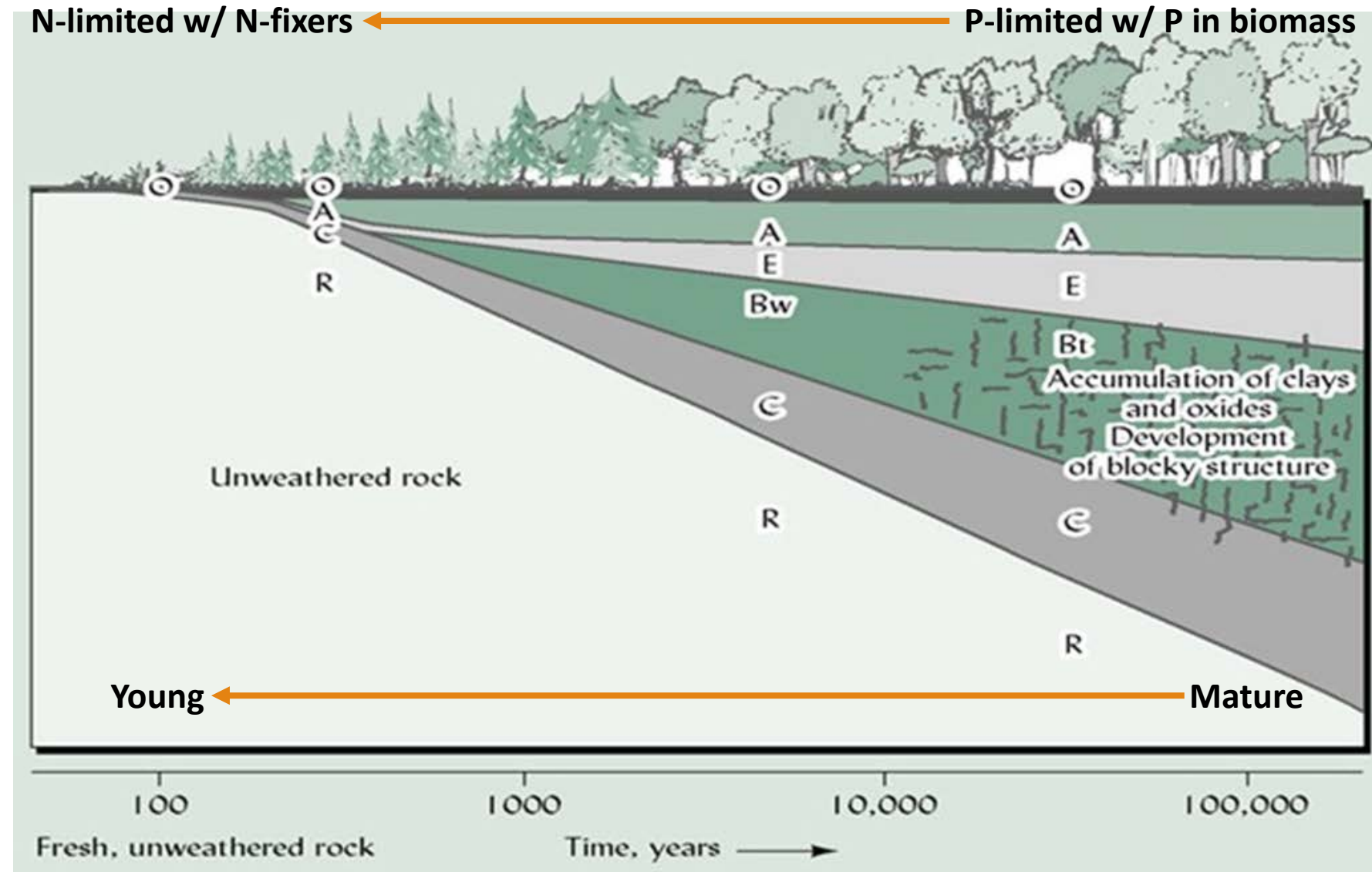


Nutrient Limitation – Disturbance

What happens after a major disturbance removes vegetation?

Succession and soil and ecosystem formation starts over

Contaminated sites?



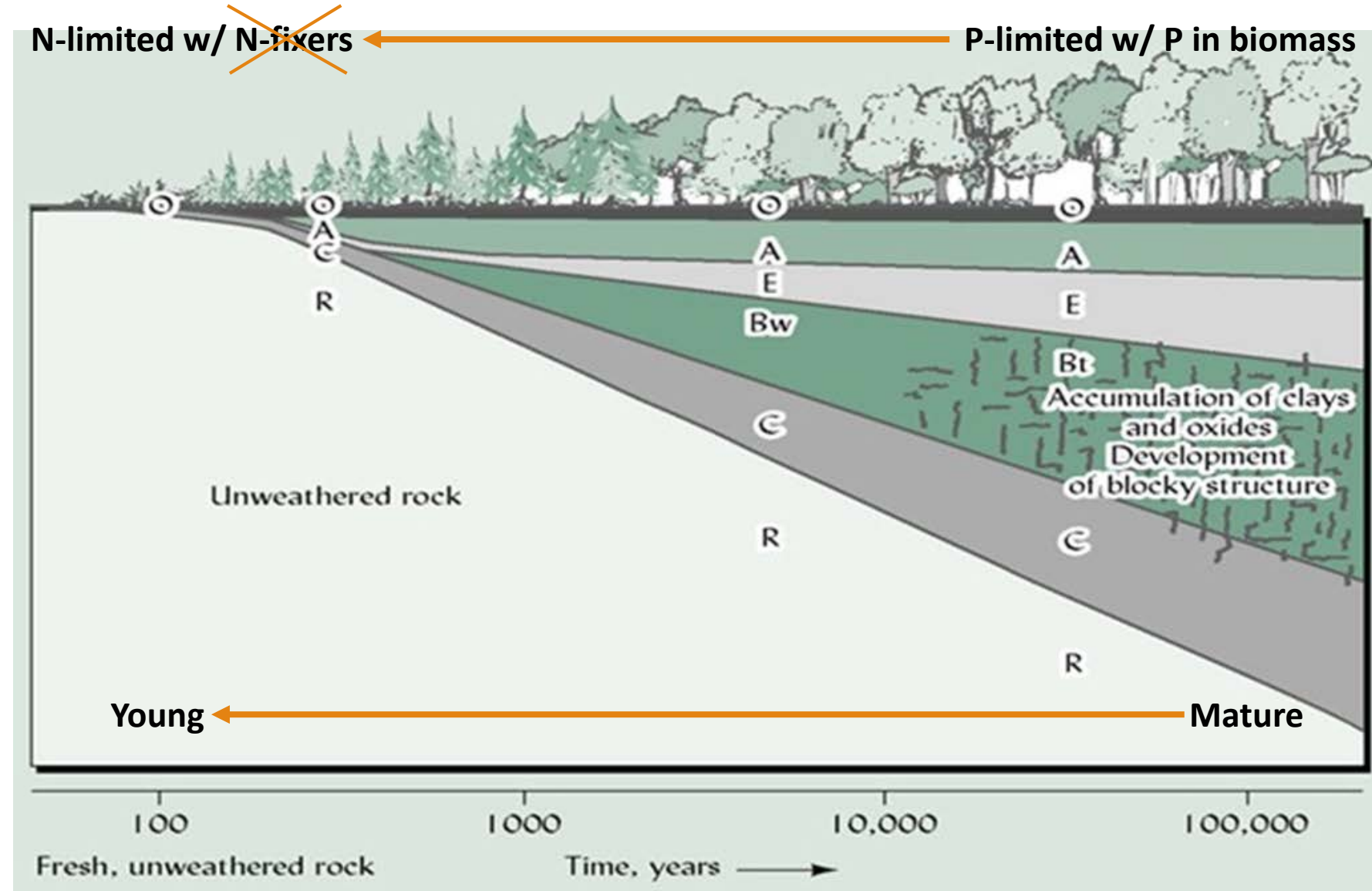
Nutrient Limitation – Disturbance

What happens after a major disturbance removes vegetation?

Succession and soil and ecosystem formation starts over

Contaminated sites?

High energetic costs of dealing with metals =
More nutrients?



Questions

Is nitrogen or a combination of nutrients limiting plant growth in metal-contaminated soil?

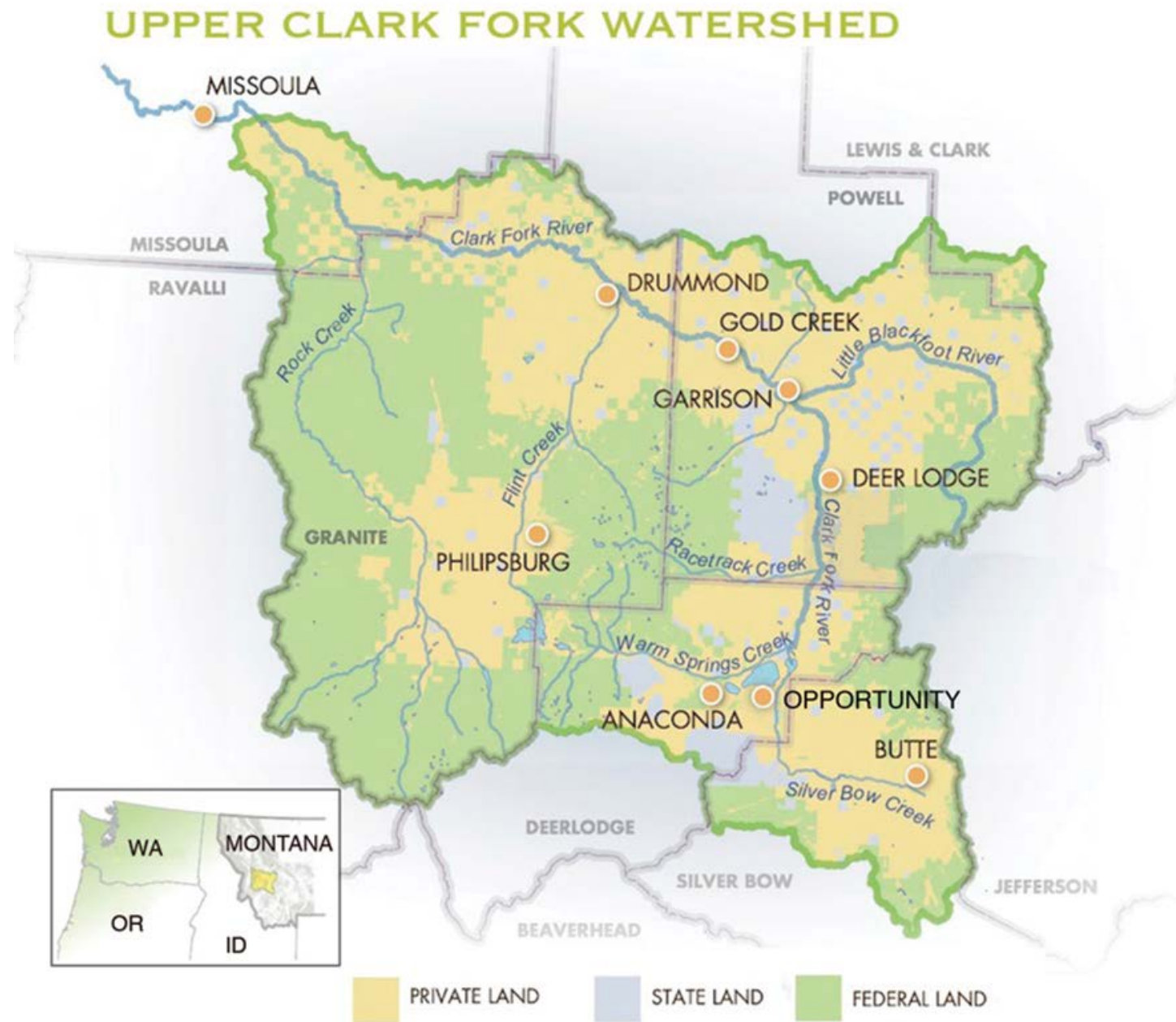
Do different plant species respond differently to different nutrient combinations?

What, if any, are the management implications?



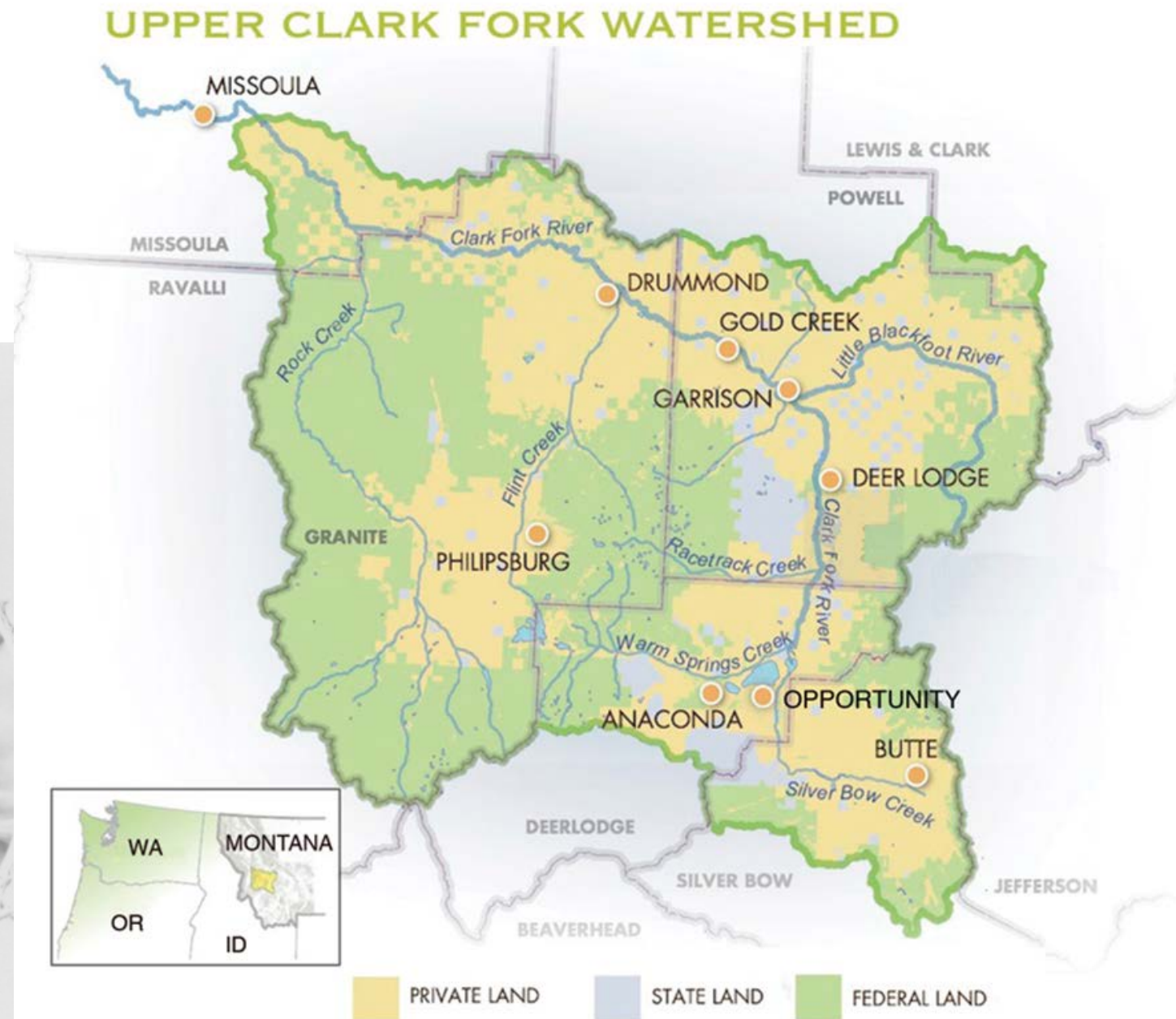
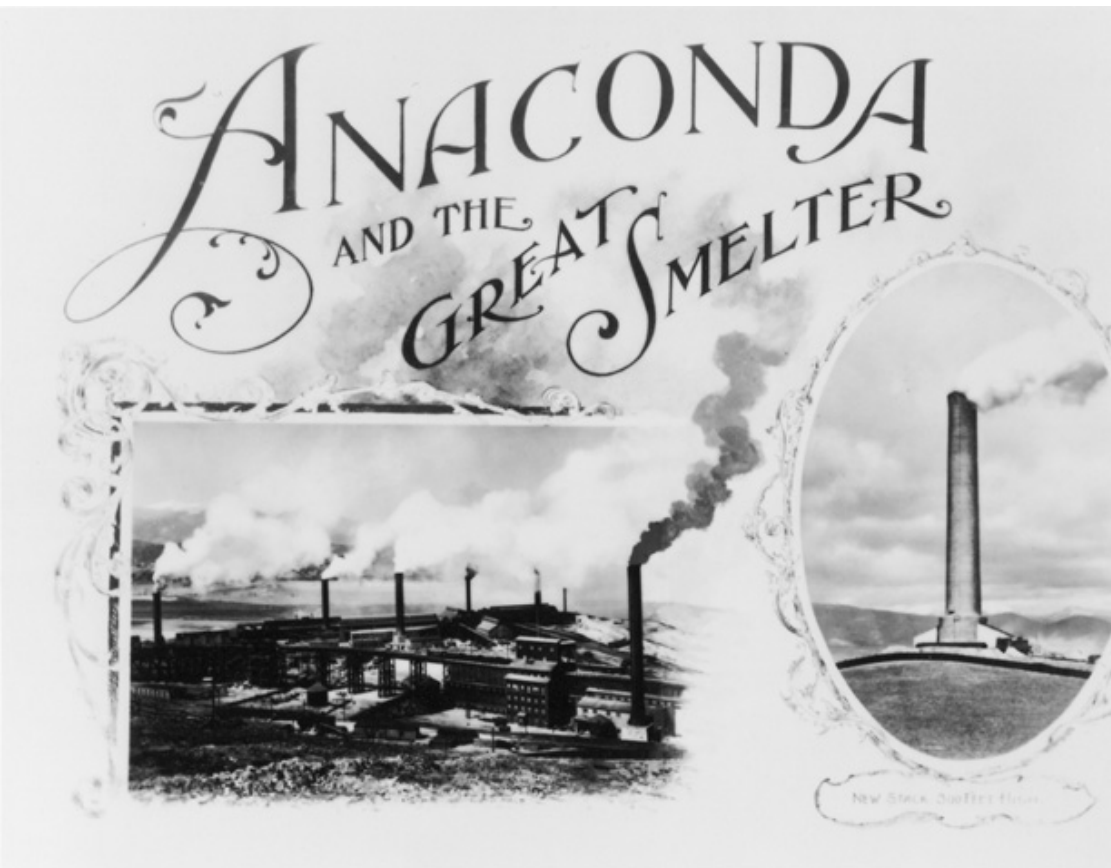
UCFRB

150+ year mining legacy:



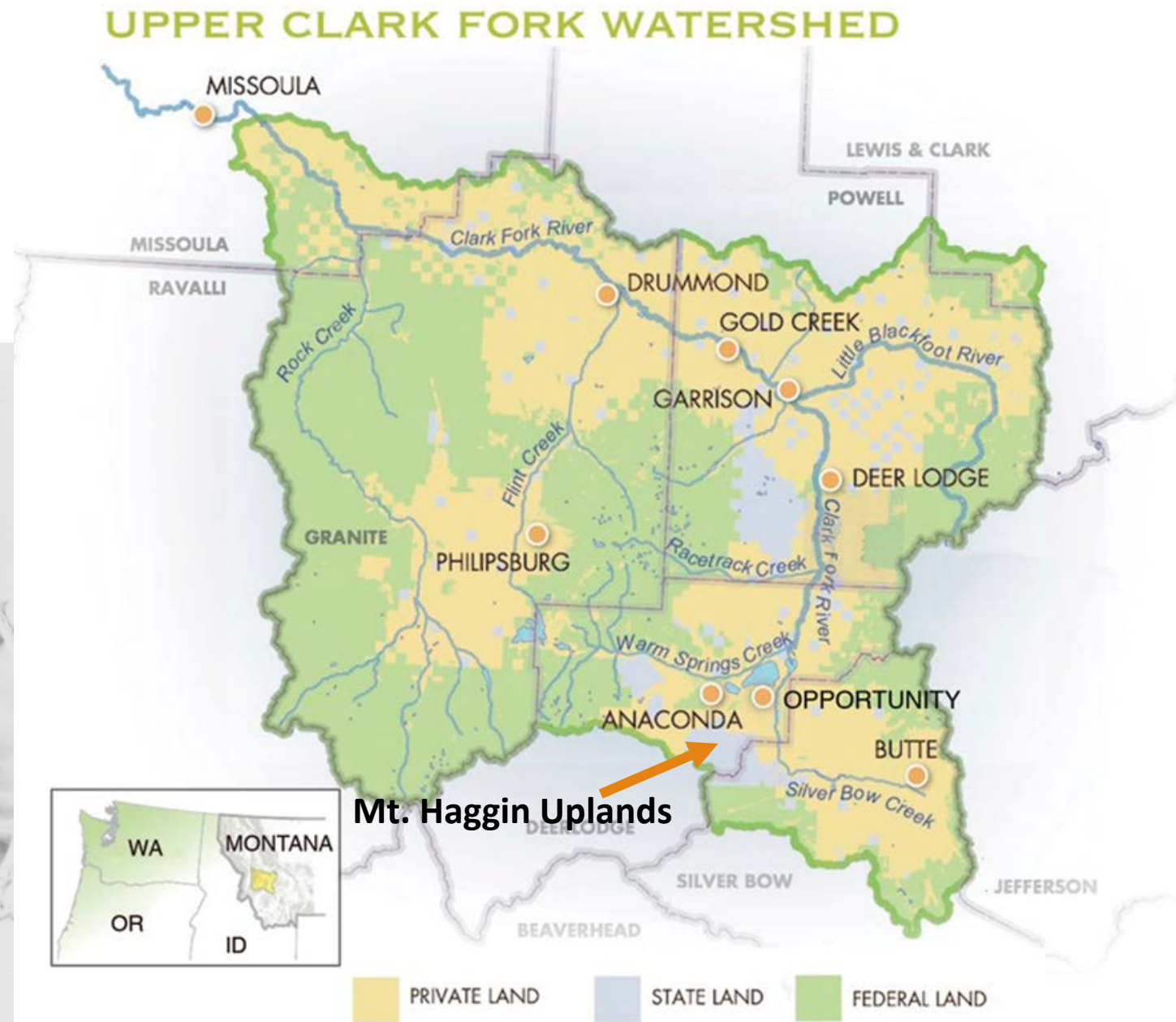
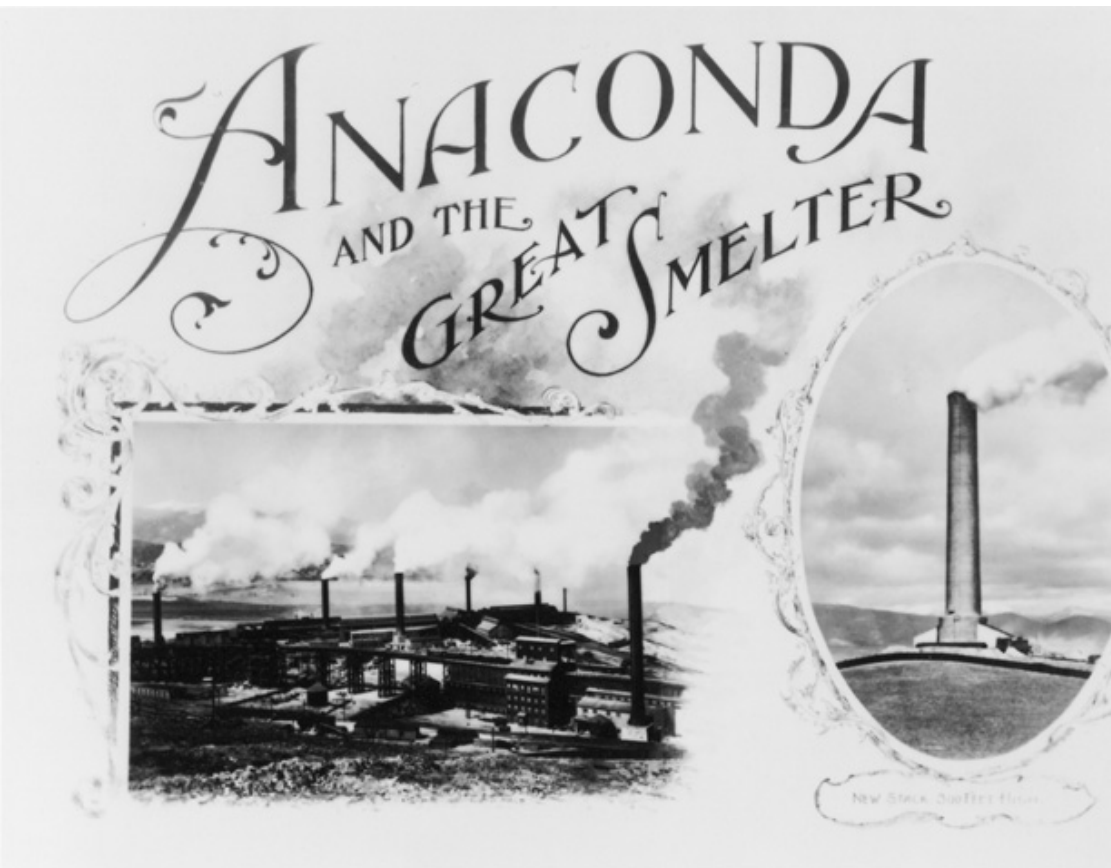
UCFRB

150+ year mining legacy:

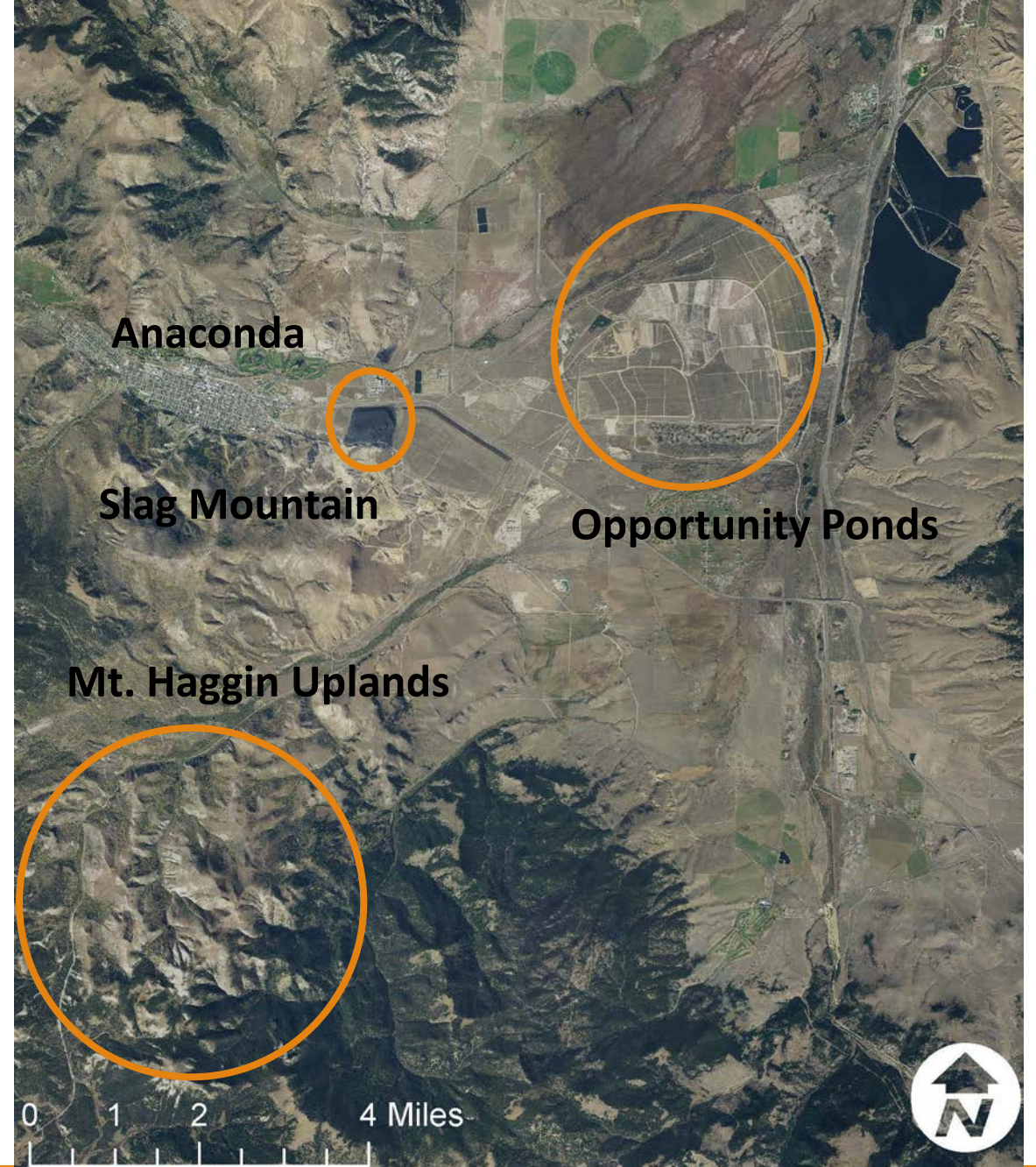


UCFRB

150+ year mining legacy:



Anaconda Smelter Site



Mt. Haggin Uplands

**~100 years of smelting – Washoe Smelter
Stack 1928**



Mt. Haggin Uplands

**~100 years of smelting – Washoe Smelter
Stack 1928**



+

**Large-scale timber sales – French Gulch
1906**



Mt. Haggin Uplands



=



~9 sq. miles - Mt. Haggin Injured Area

Study Site and Design

5 Blocks:

Control

Seed Only – Native mix

K + Micro

P

N

PK + Micro

NK + Micro

NP

NPK + Micro

Sustane

10 grams Nutrient/m²



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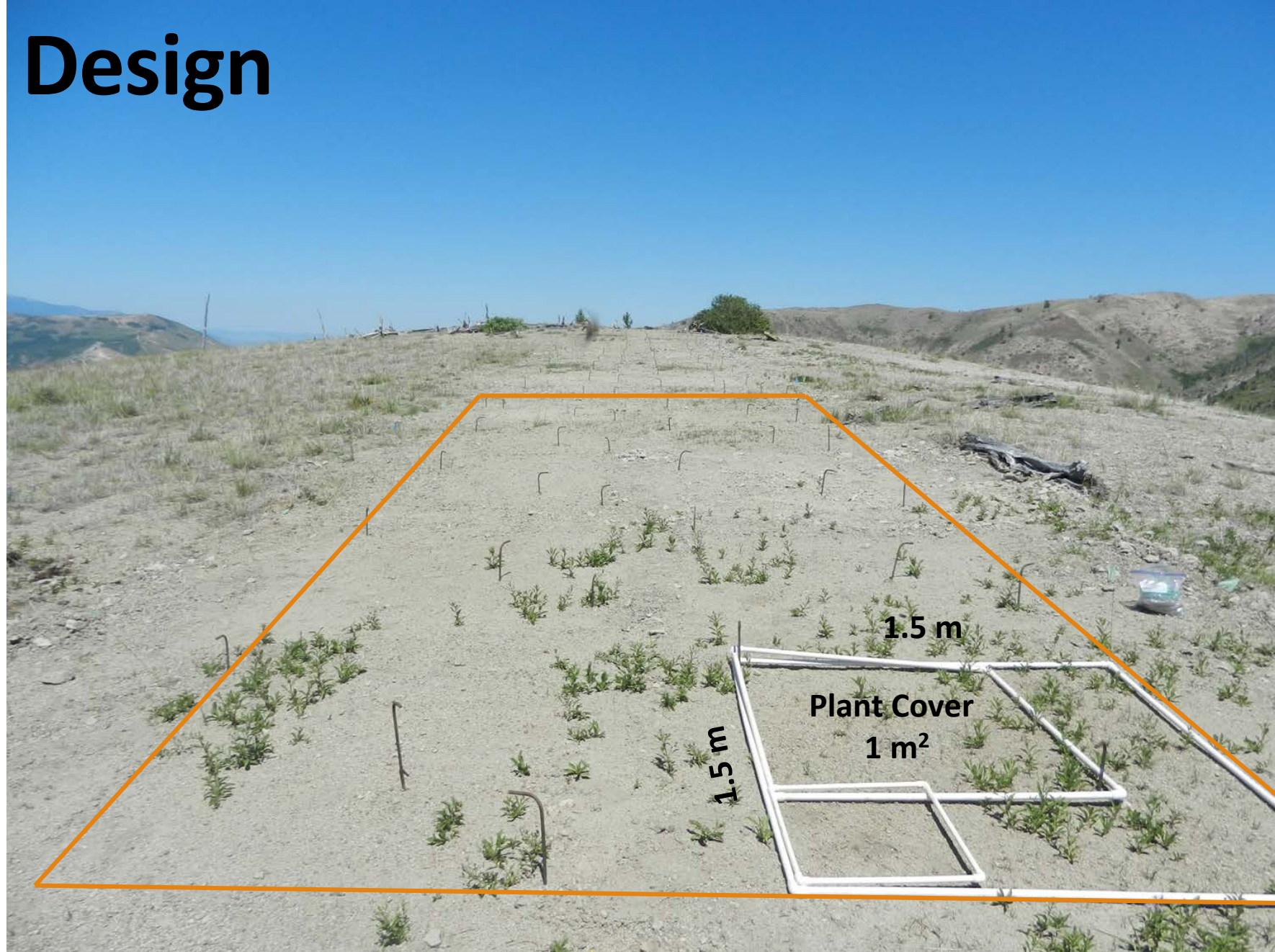
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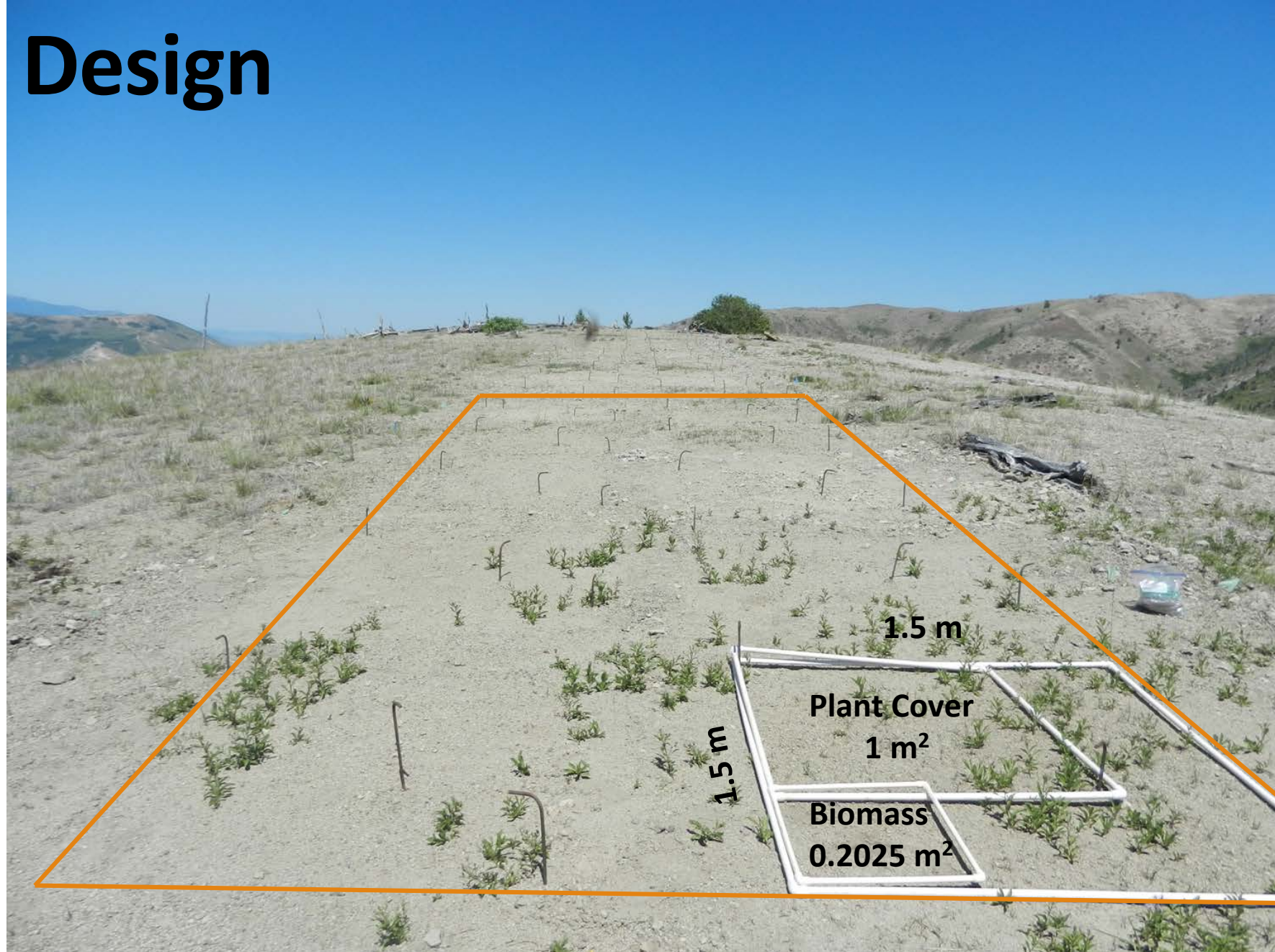
NK + Micro

NP

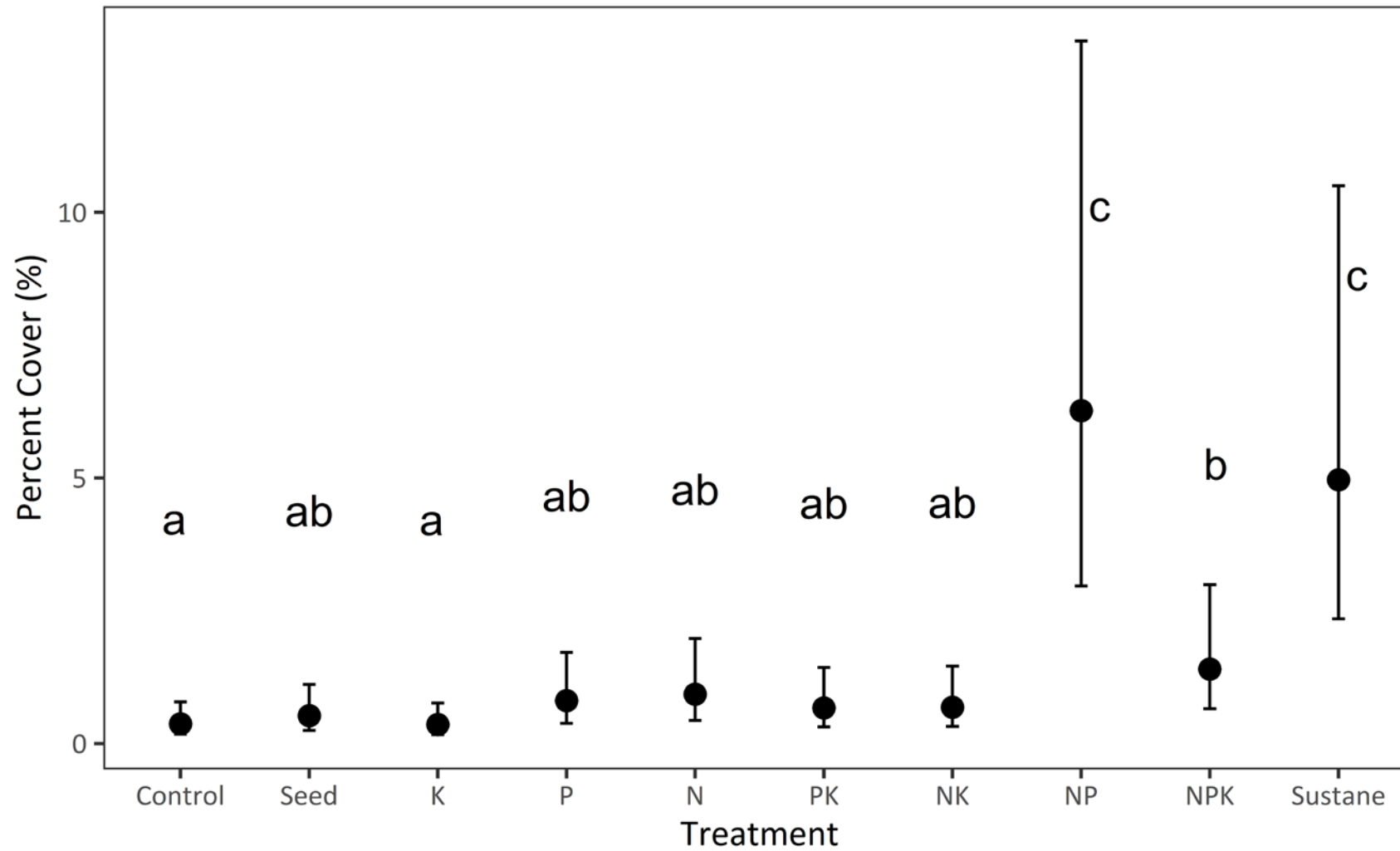
NPK + Micro

Sustane

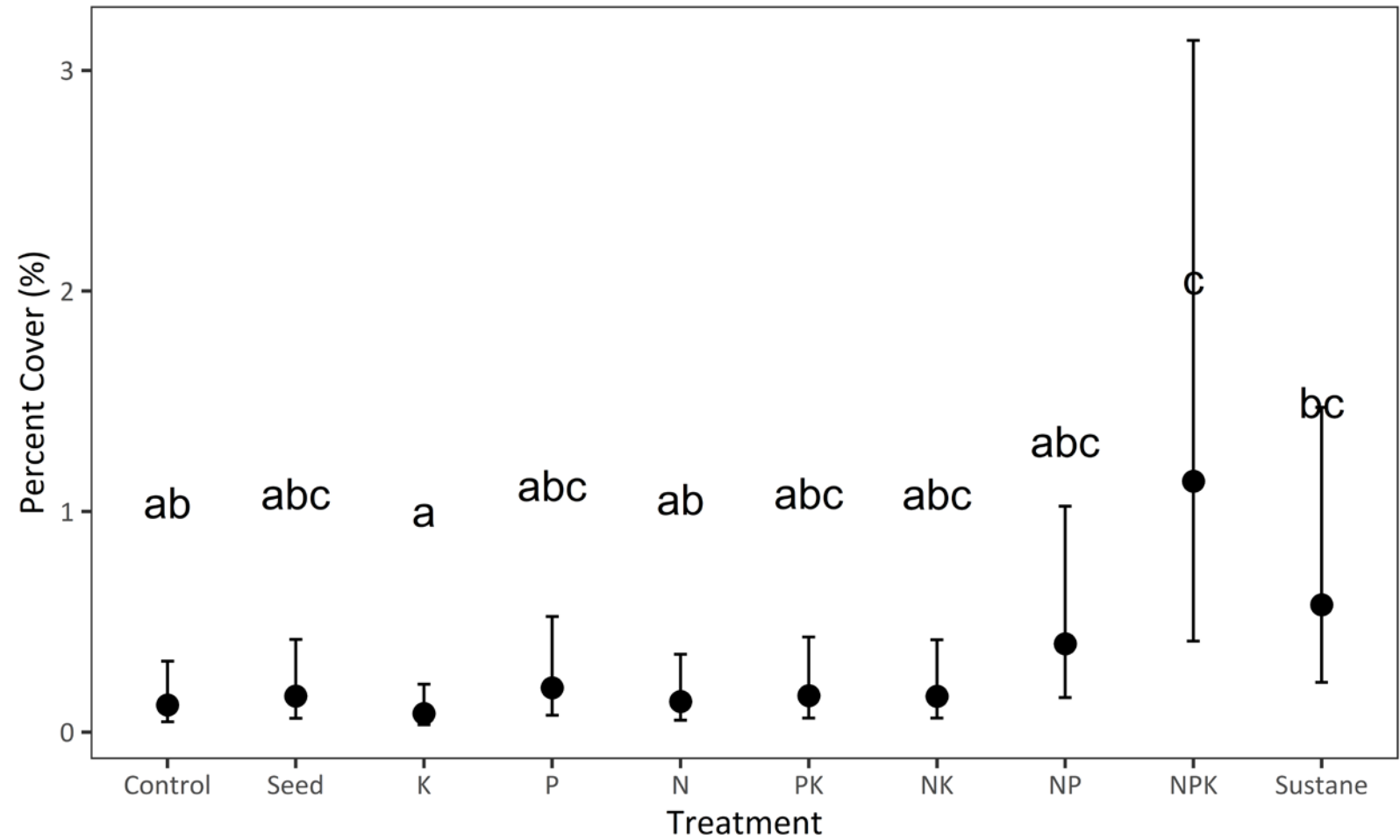
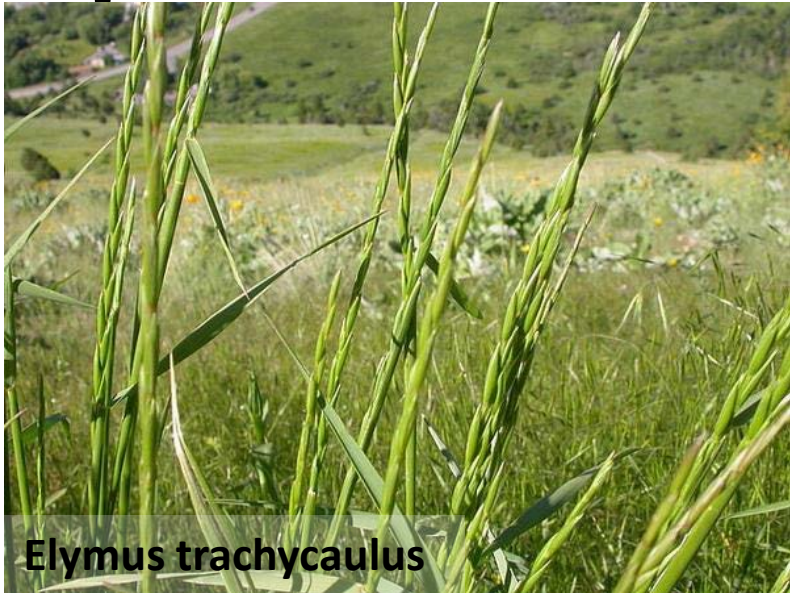
10 grams Nutrient/m²



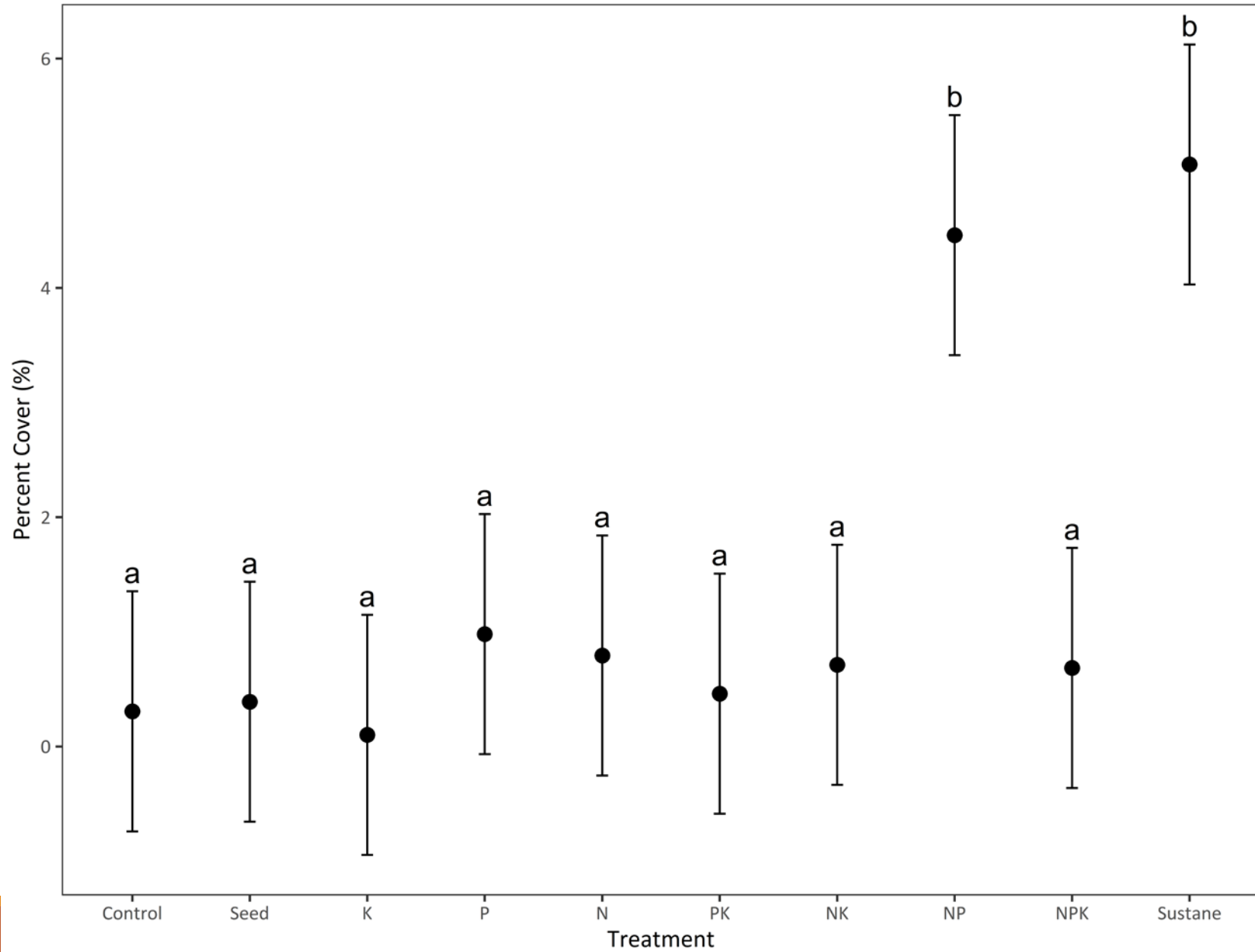
Total Cover (Grass + Forb + Tree)



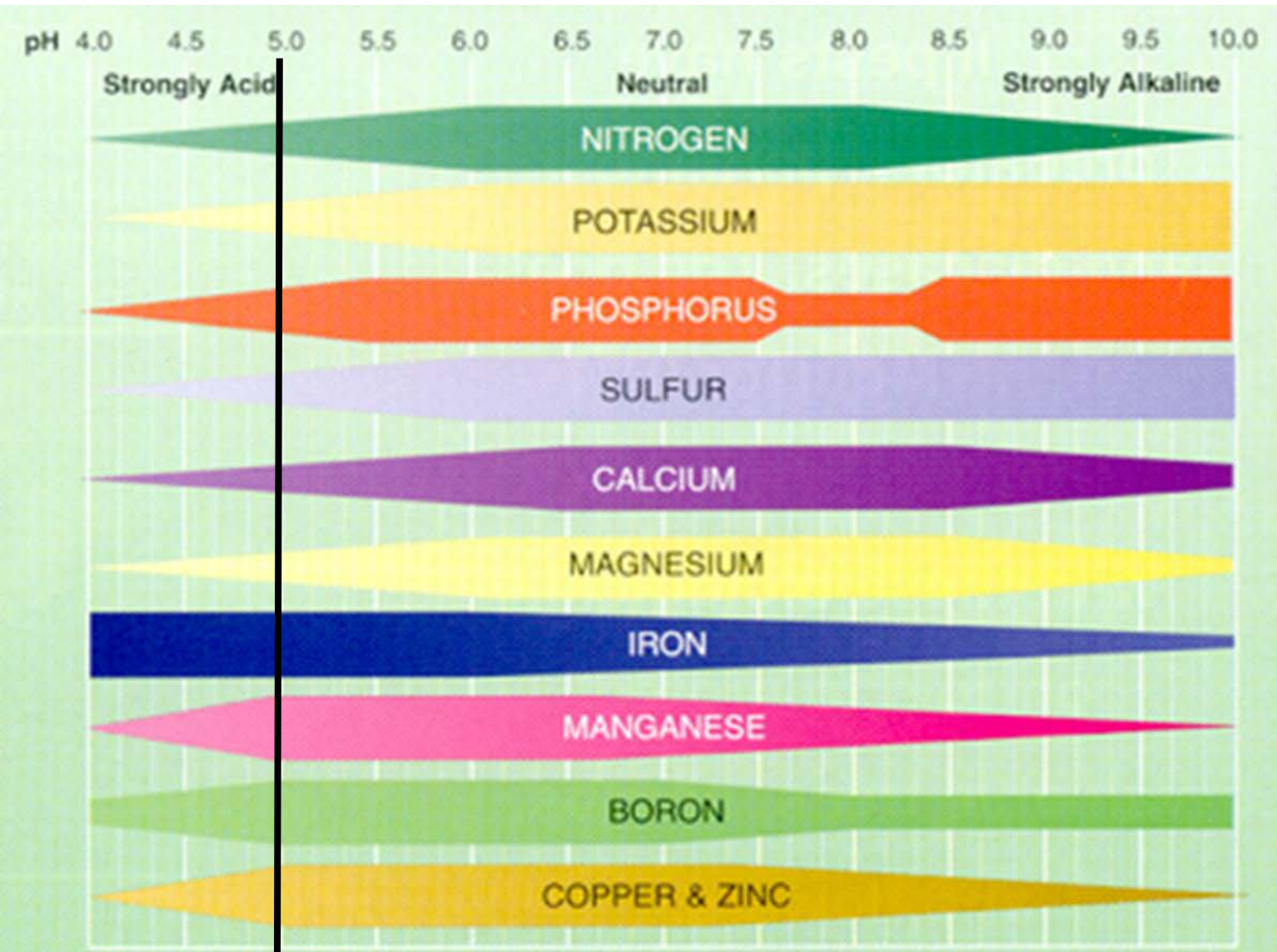
Response of Native Grass



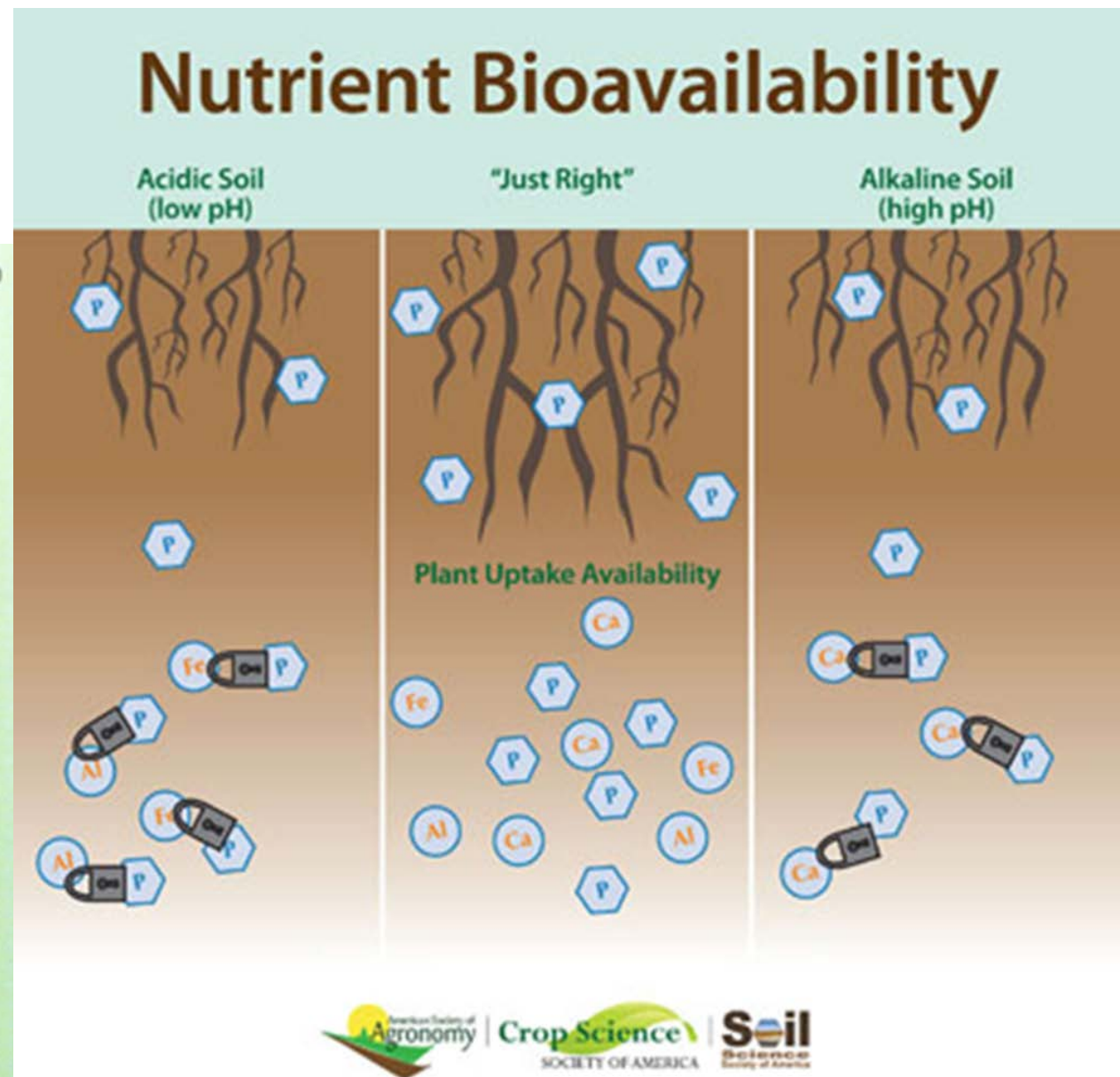
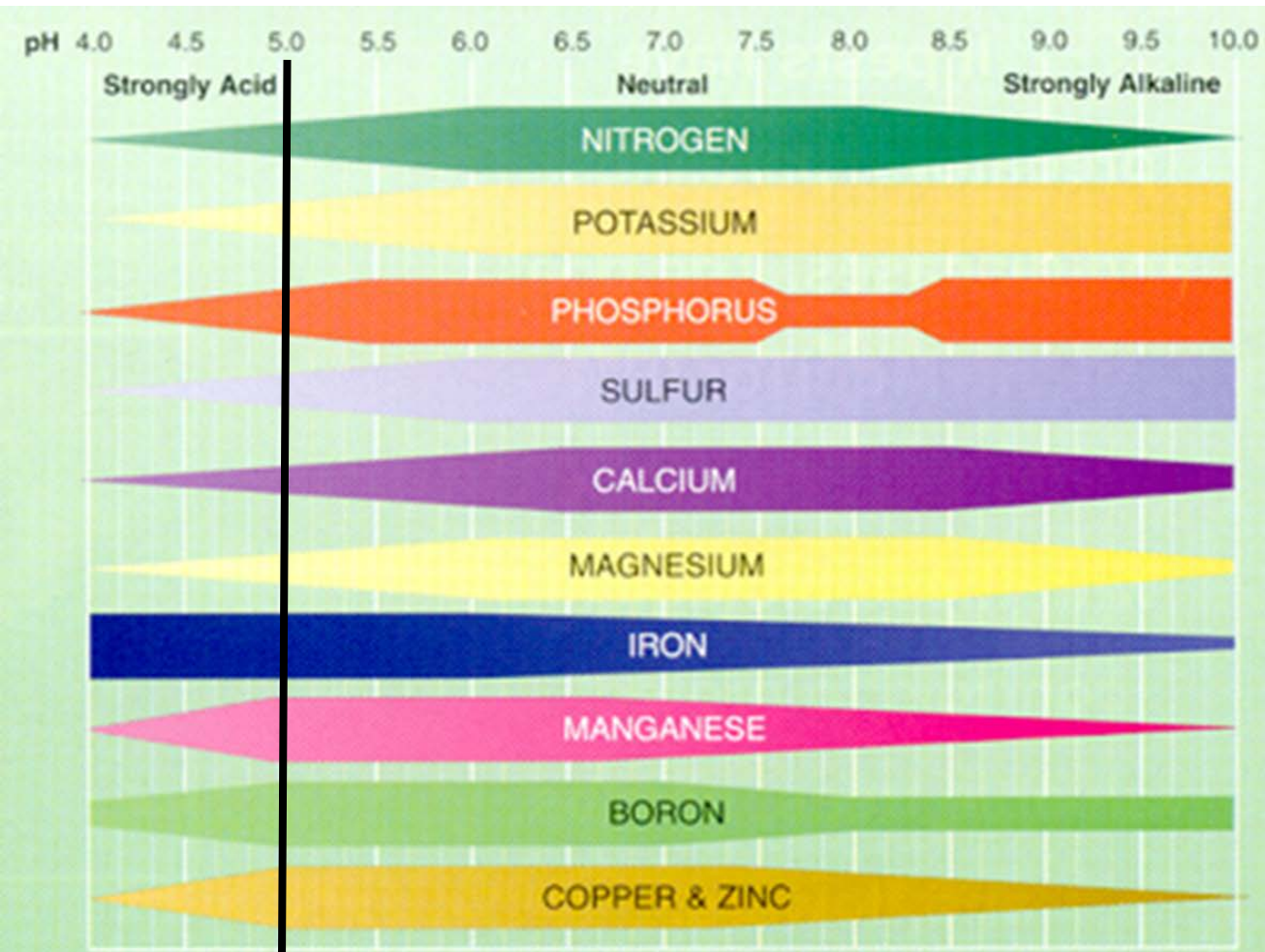
Response of Red Top (*Agrostis stolonifera*)



Importance of Soil pH



Importance of Soil pH



Concluding Thoughts

N + P response > N and P alone

Different species appear to be responding differently to nutrient additions

Is this an early response of the plant community?

The use of multiple nutrient fertilizer is important in establishing plants in metal-contaminated soil

