# Do metal mixture insults to the soil invisible majority reduce ecosystem service quality?

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Ecosystem Services

- Ecosystem services: As defined by the United Nations Environmental Program (UNEP) are the benefits people obtain from ecosystems.
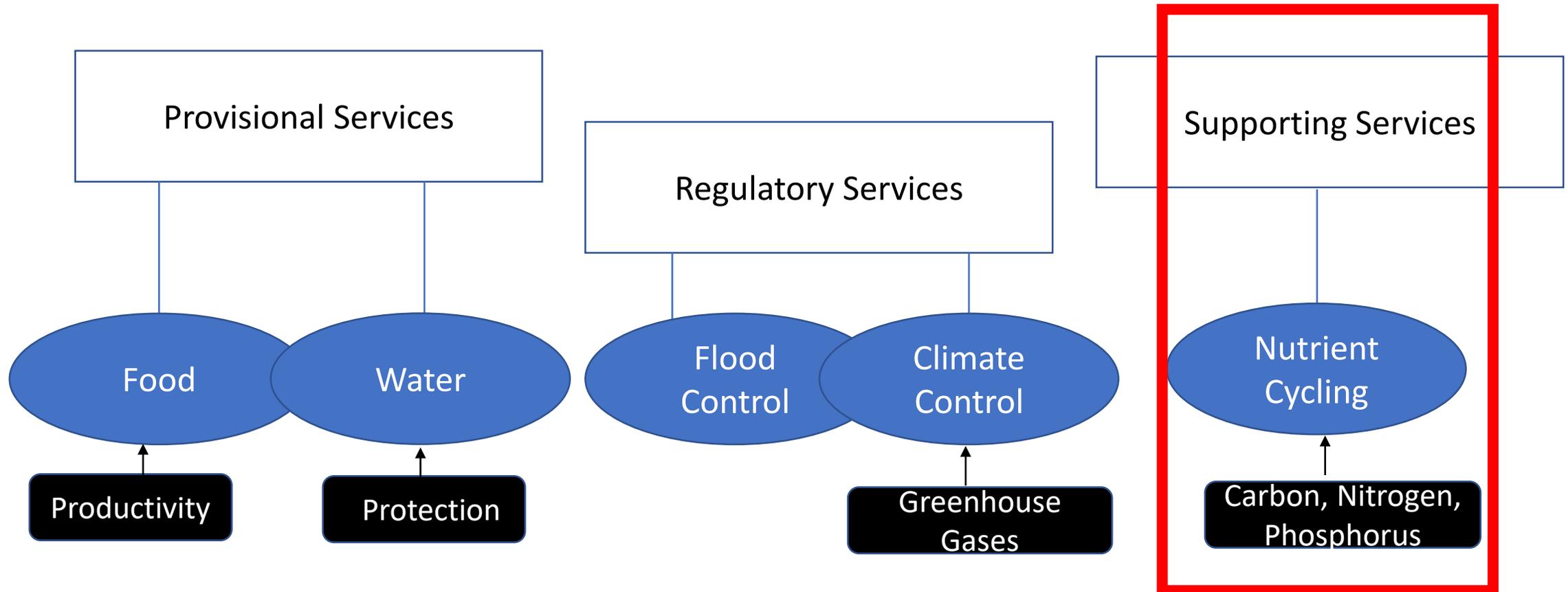
Nutrient Cycling as an Ecosystem Services (ES)

Primary producers

Protist predators

Immobilized nutrients
Root exudates, dead/live plant, animal and microbial biomass

Phages/viruses

Bacteria

Mineralized nutrients
NH_3, NH_4, NO_3, PO_4, PO_3, CO_2

Dissolved organic matter

TRENDS in Biotechnology
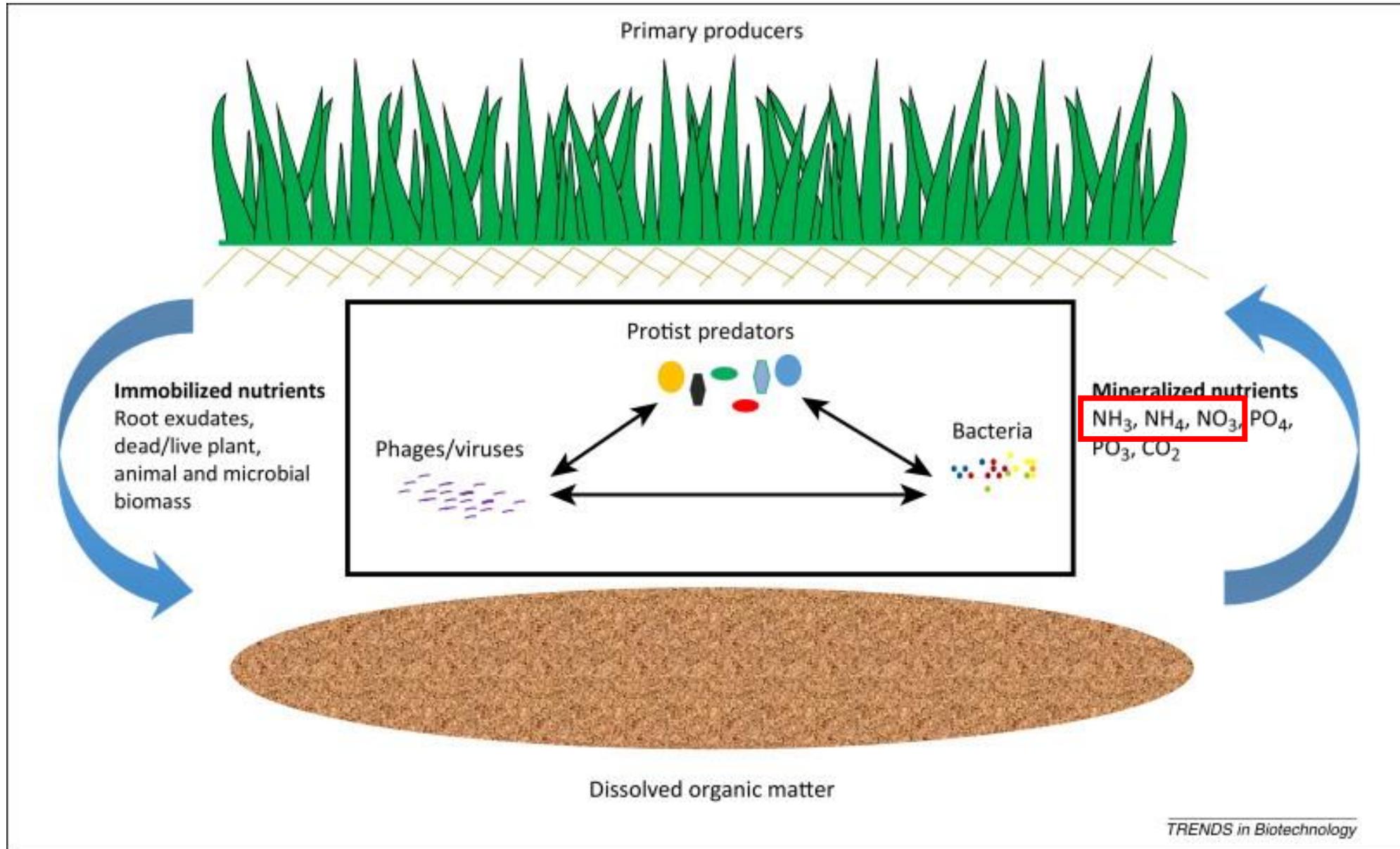
Nitrogen Cycle
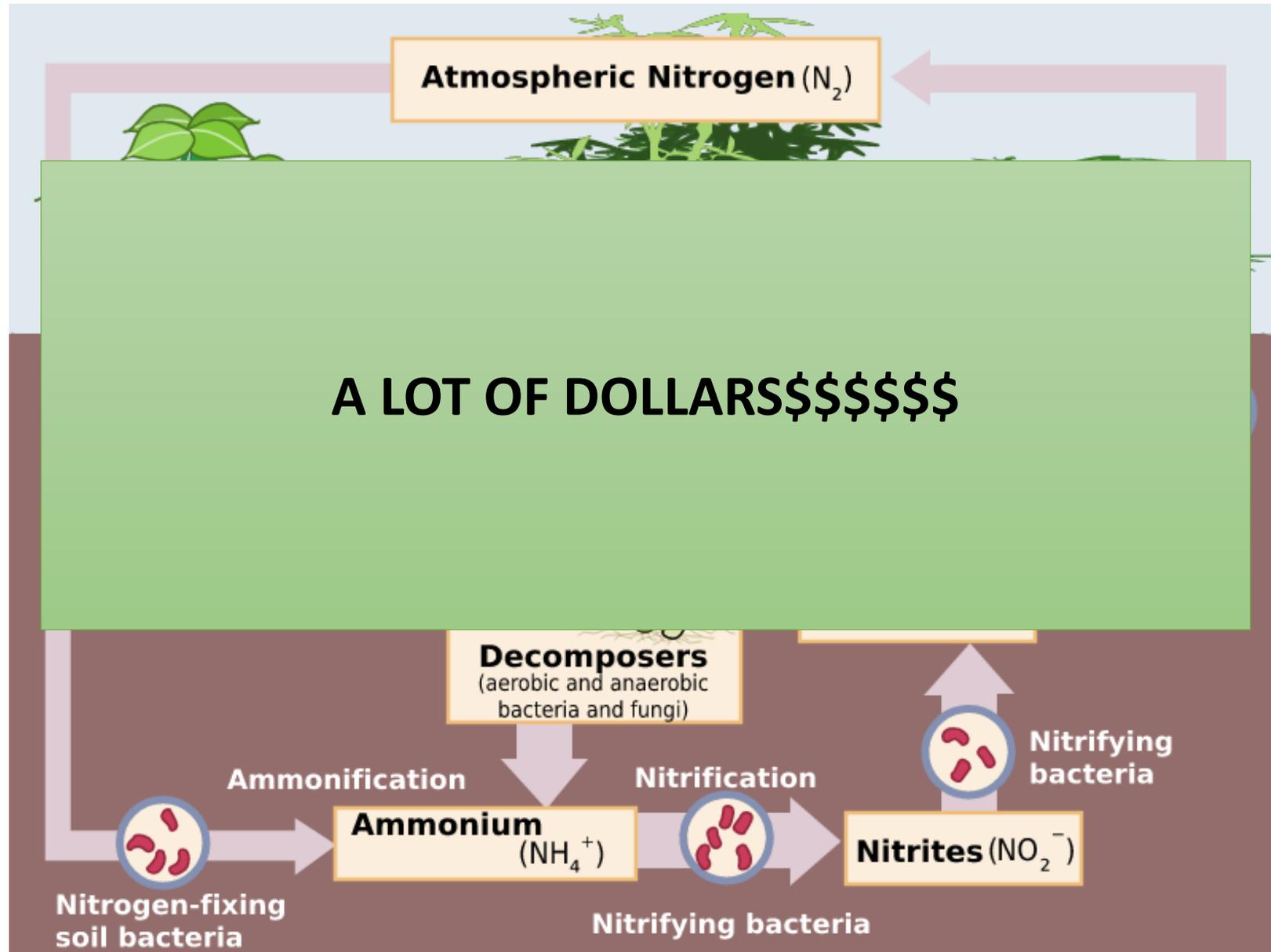
What is the economic value of these services?

Relationship between soil properties vs Ecosystem Services
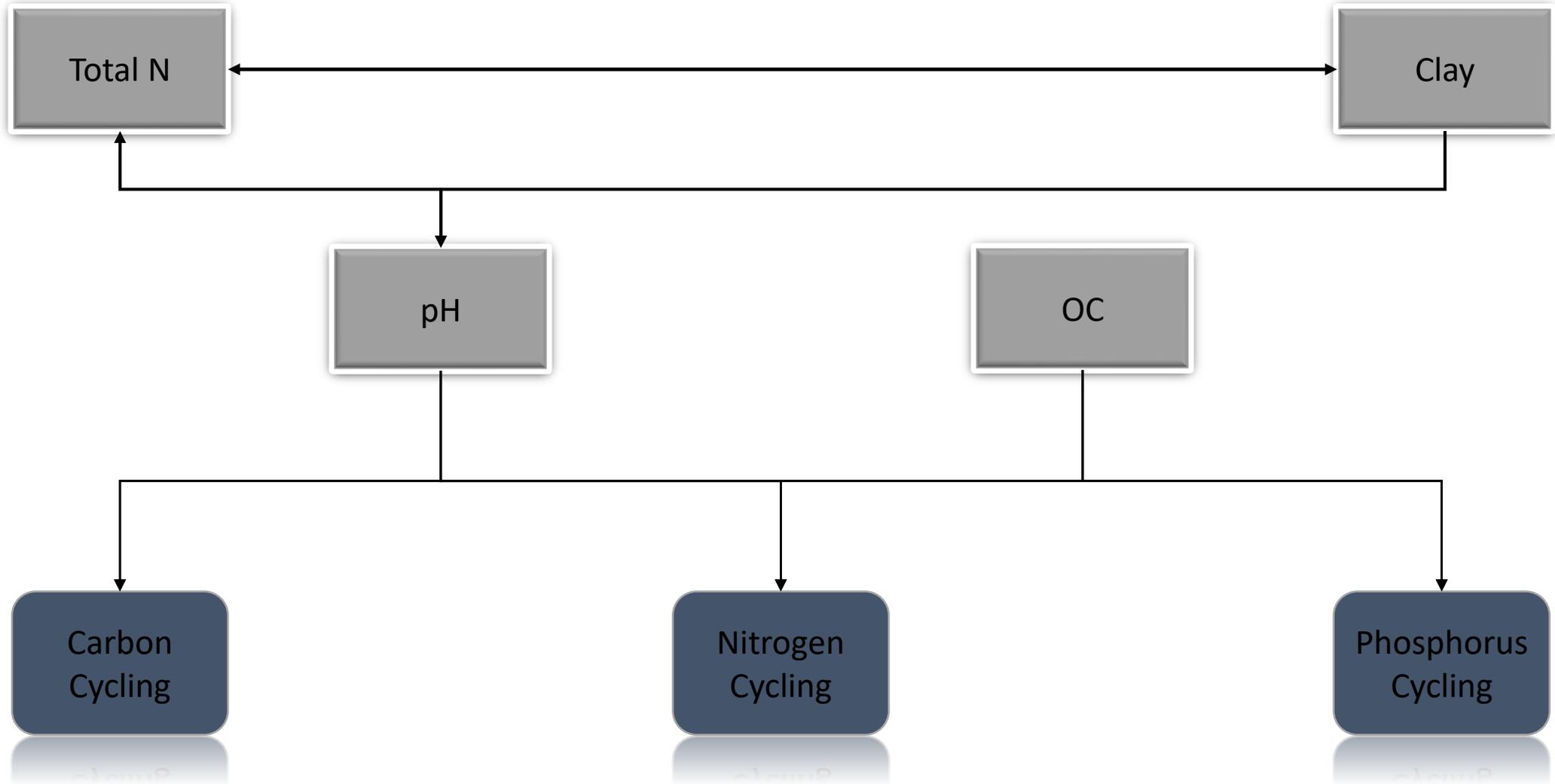
Metals inhibit soil enzymatic activities

Phosphatase Dose Response
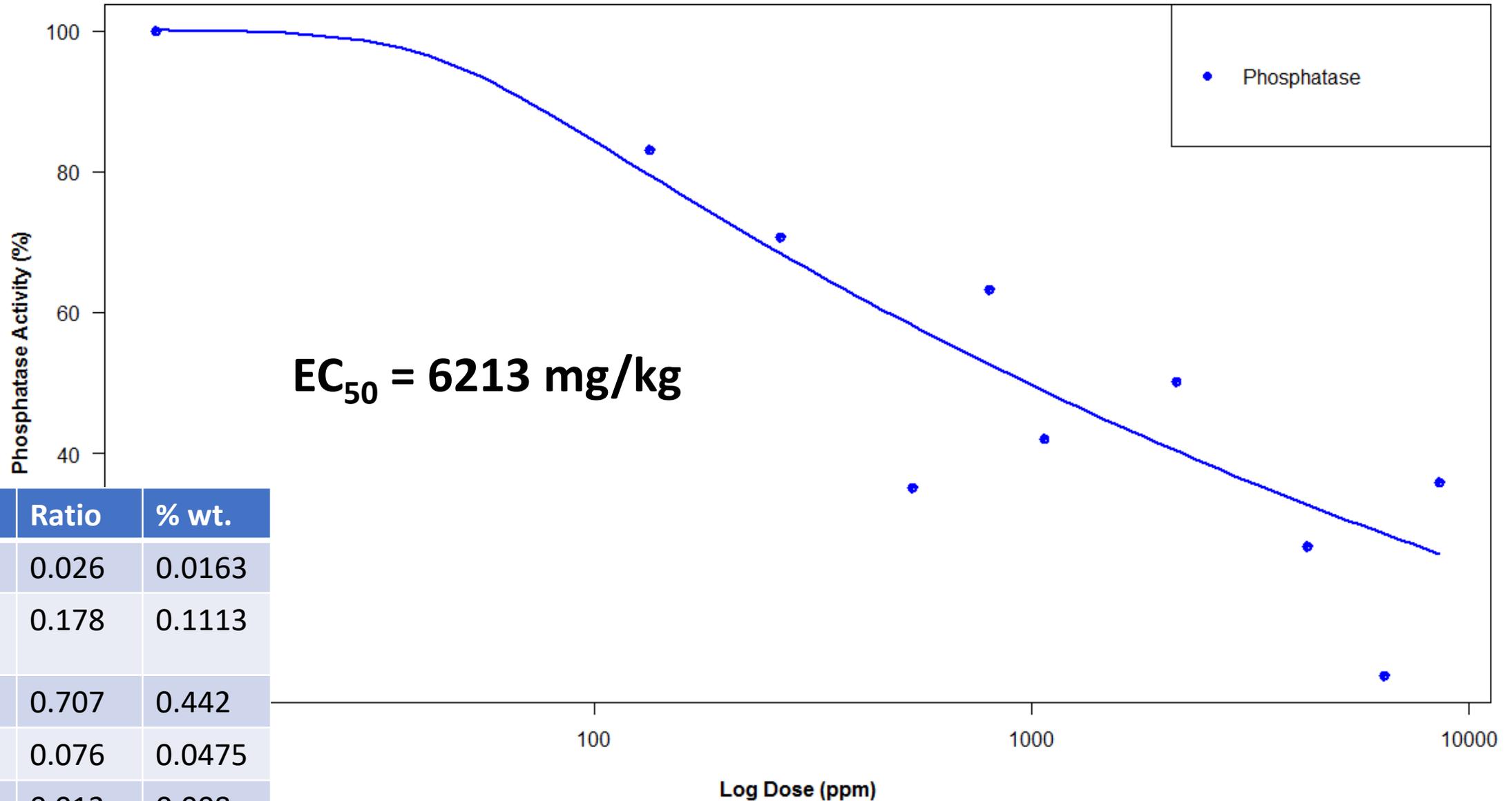
EC_{50} = 6213 mg/kg

Metal	Ratio	% wt.
Lead	0.026	0.0163
Copper	0.178	0.1113
Nickel	0.707	0.442
Zinc	0.076	0.0475
Cobalt	0.013	0.008

Objective and Hypothesis Testing

- **To determine whether sub lethal metal mixture concentrations to soil microbes impair ecosystem service quality.**

H_0: Sub lethal metal mixture concentrations to soil microbes do not impair ecosystem service quality.

Materials and Methods

- 47 Soils with varying properties.
- Representing different Canadian ecological zones.

Soil Properties	pH	%Clay	%OC	Total-N mg/10cm²/24h
Average	6.8	2.4	4.2	2.0
Standard Deviation	0.8	1.4	33.7	5.3
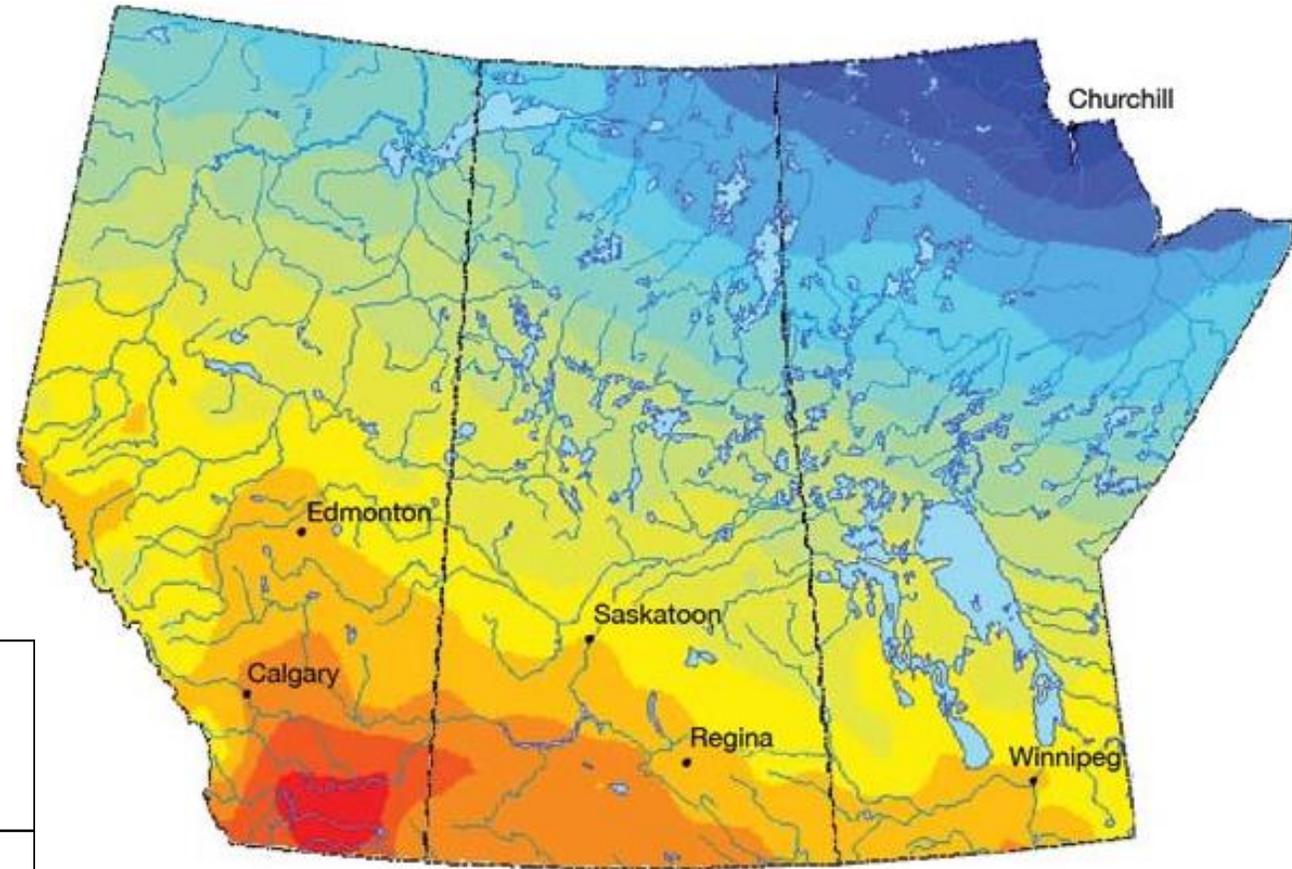
Fig. Map of Study Area

Experimental Design

Metal	% wt
Lead	0.0163
Copper	0.1113
Nickel	0.442
Zinc	0.0475
Cobalt	0.008

No Grass

E. lanceolatus

E. lanceolatus

0%

0%

0.625% wt

0.625% wt

400g Soil

400g Soil

400g Soil

400g Soil
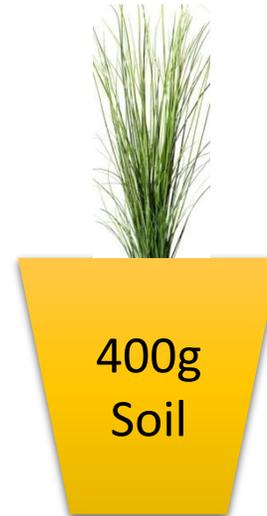
A

B

C

D

Ecosystem Services Measured

- Ammonia monooxygenase activity (Nitrogen Cycling)

- Beta Glucosidase (Carbon Cycling)

- Acid phosphatase (Phosphorus Cycling)

- Plant crude protein (E. lanceolatus)

- Climate Regulation

- Groundwater Protection
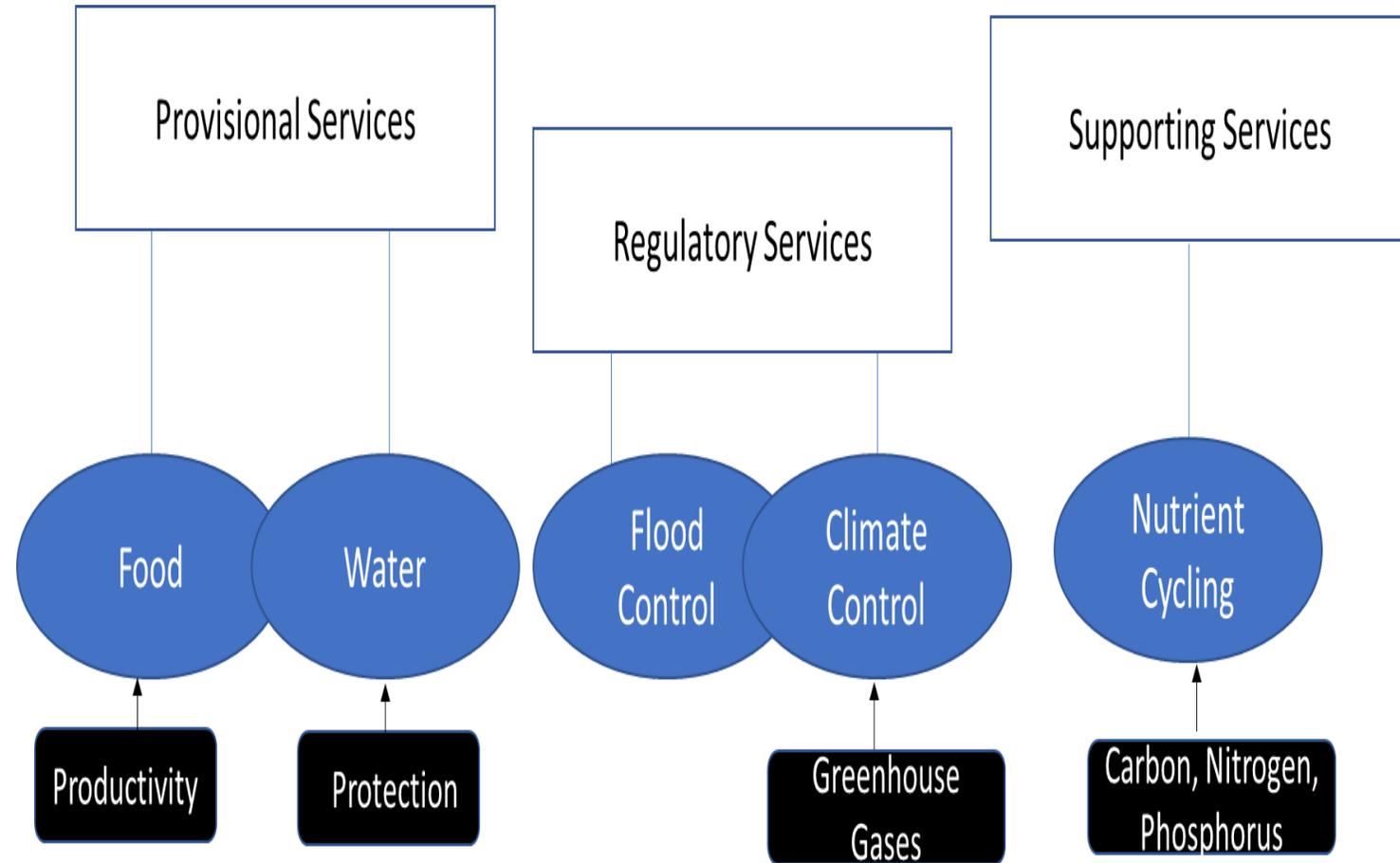
Ecosystem Services Measured

- Ammonia monooxygenase activity (Nitrogen Cycling)

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- ~~Plant crude protein (E. lanceolatus)~~

- ~~Climate Regulation~~

- ~~Groundwater Protection~~
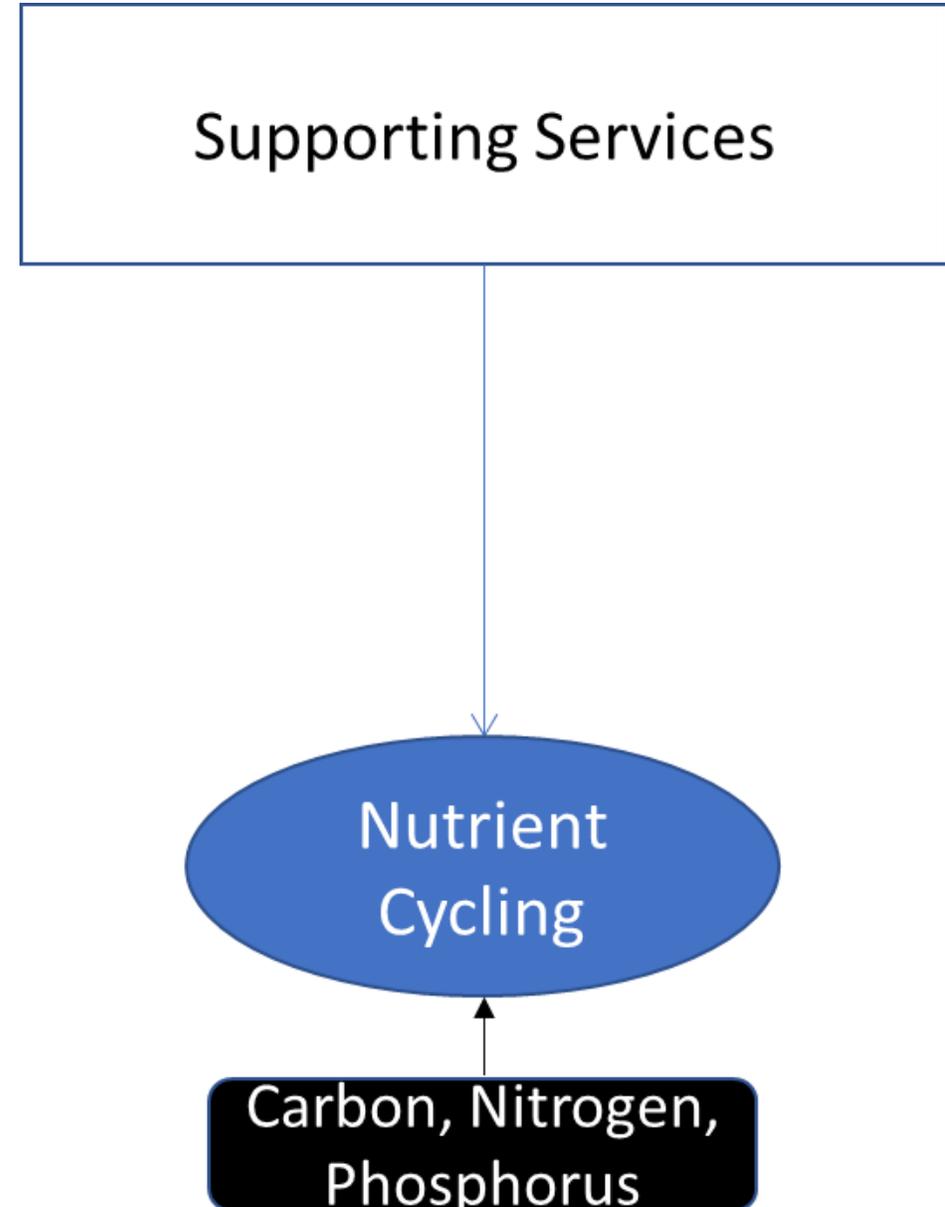
Results
Data was analyzed using R, Excel and Mplus (Structural Equation Modelling).

Glucosidase Activity (C Cycling)
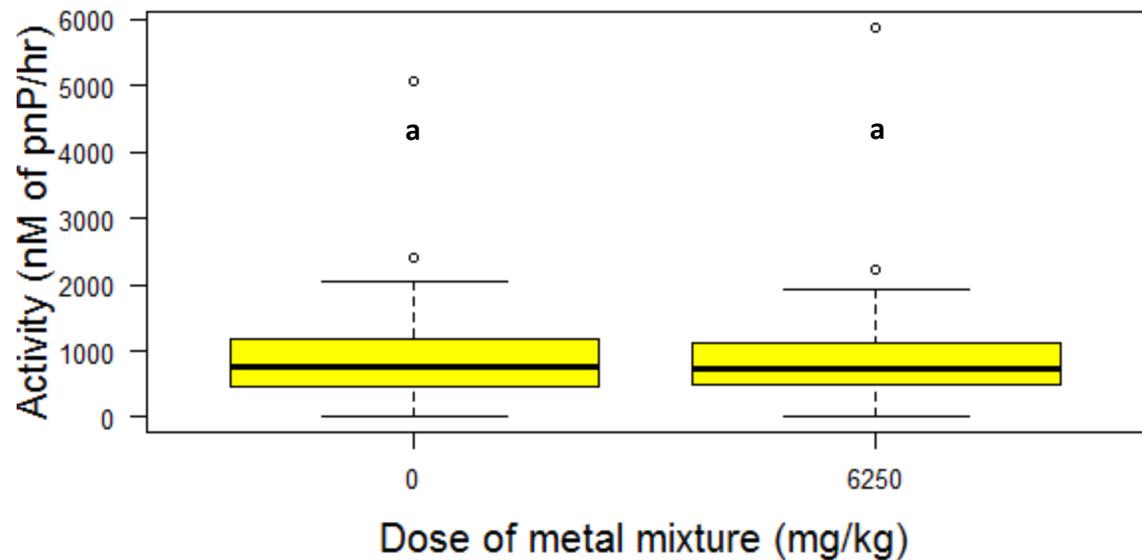
Phosphatase Activity (P Cycling)
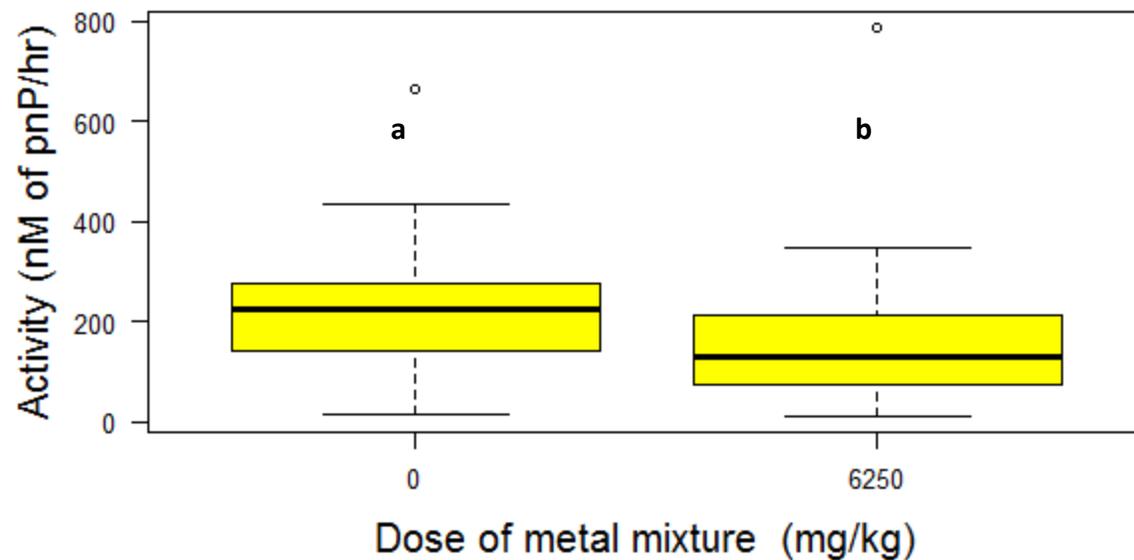
AMO Activity (N Cycling)
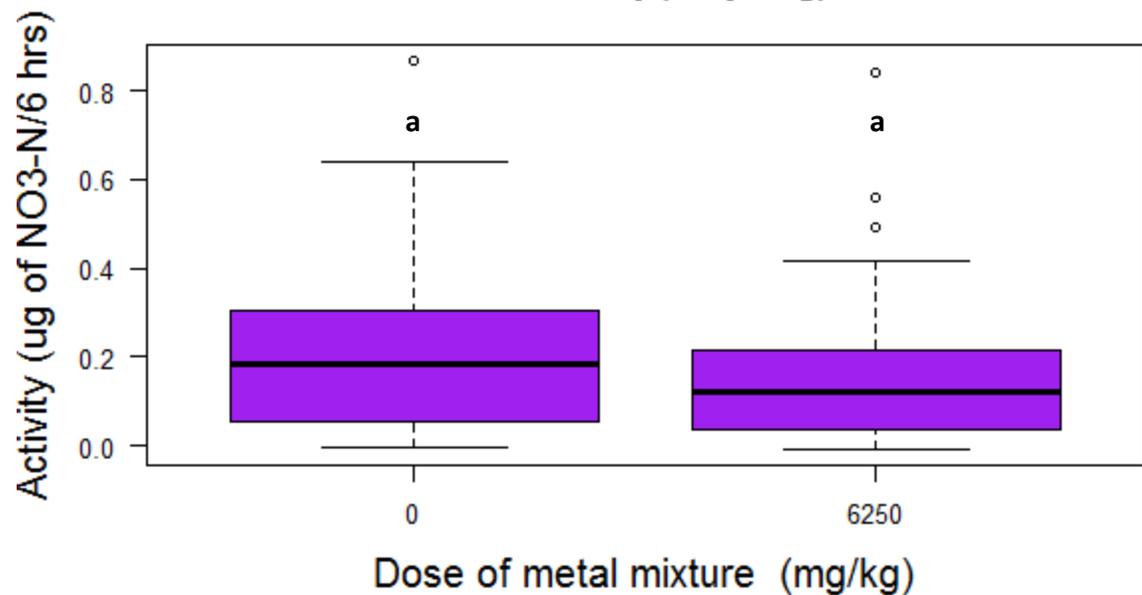
p value< 0.01

Glucosidase vs Phosphatase Activity in Dosed soils

$y = 0.11x + 59.141$
$R^2 = 0.5983$
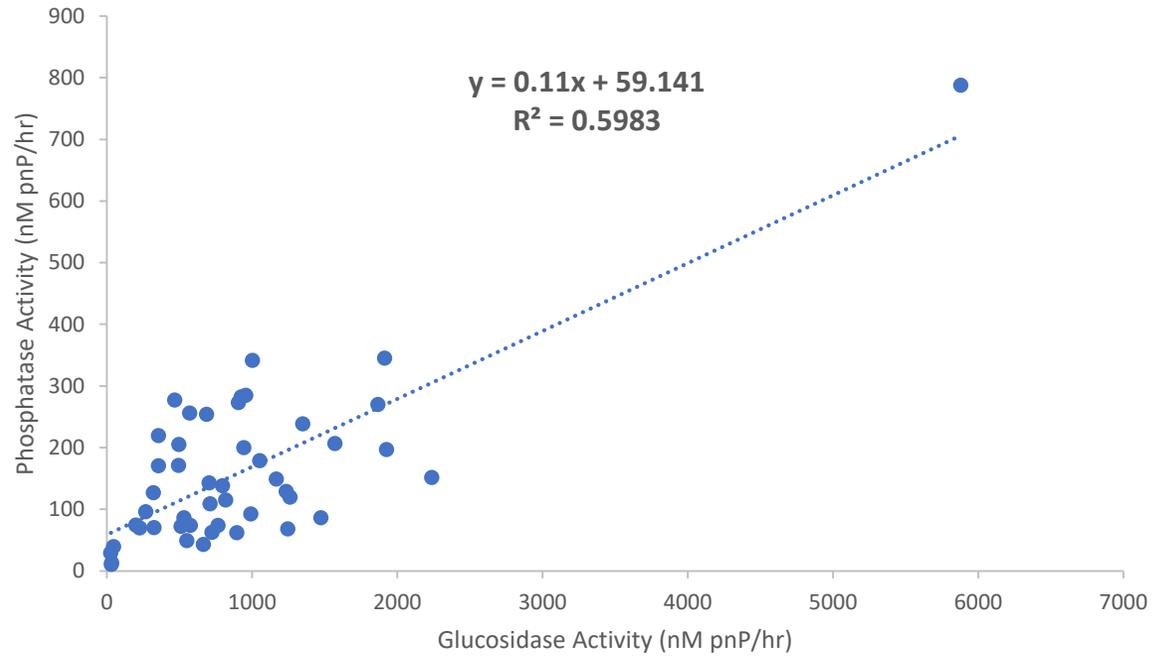
Glucosidase vs AMO Activity in Dosed soils

$y = 0.0001x + 0.0648$
$R^2 = 0.2967$
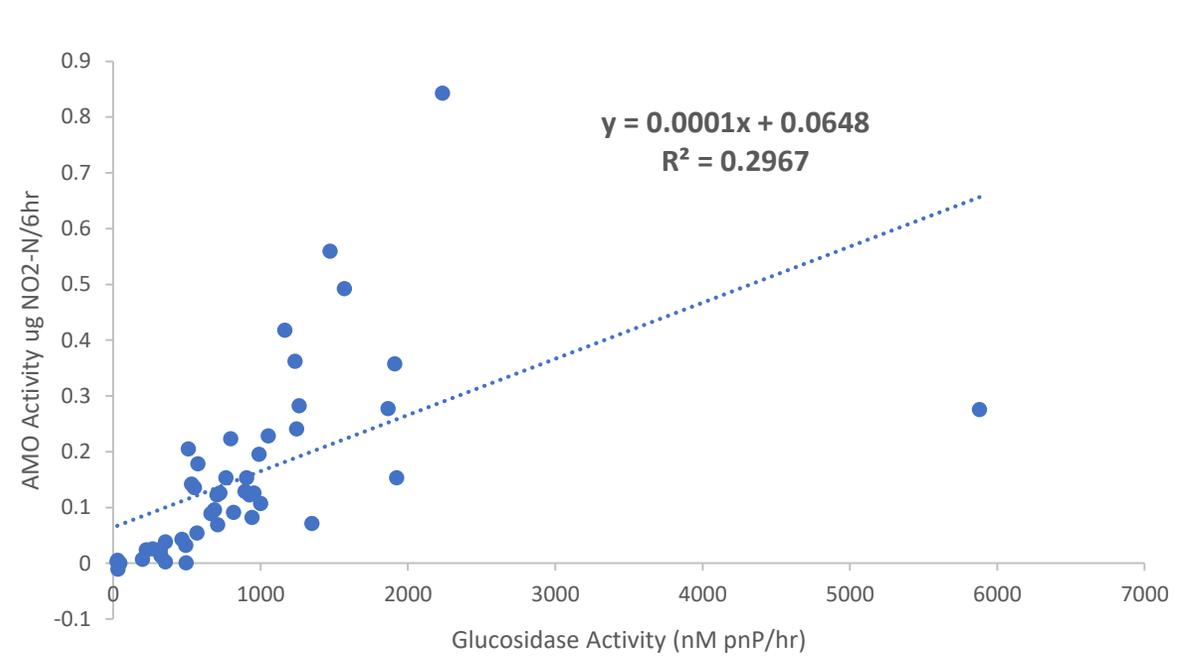
Phosphatase vs AMO Activity in Dosed soils

$y = 0.0002x + 0.1234$
$R^2 = 0.026$
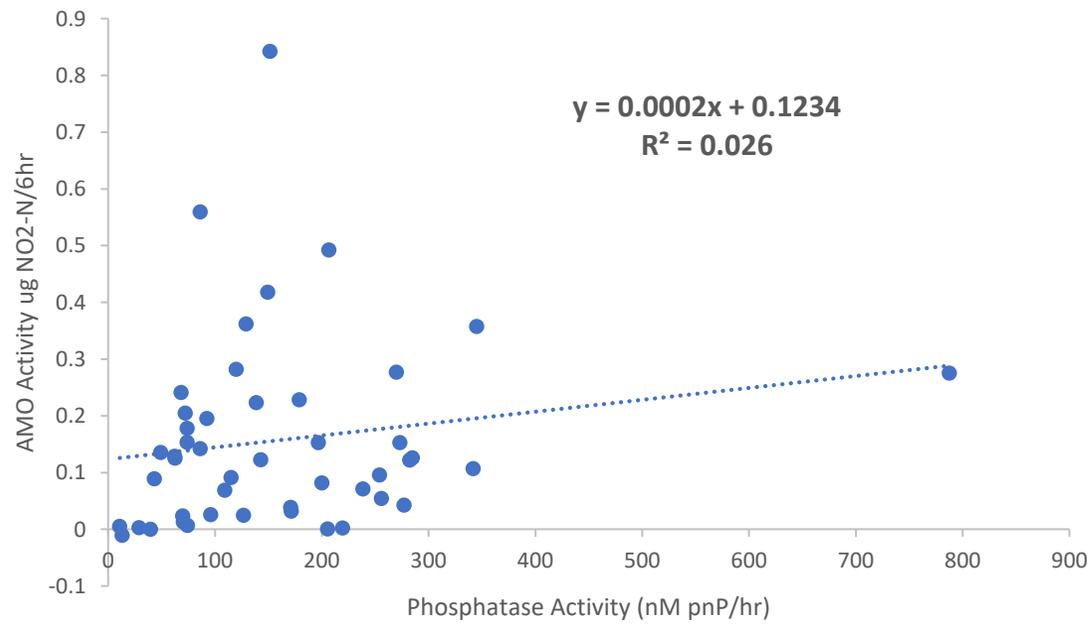
Changes in conceptual model
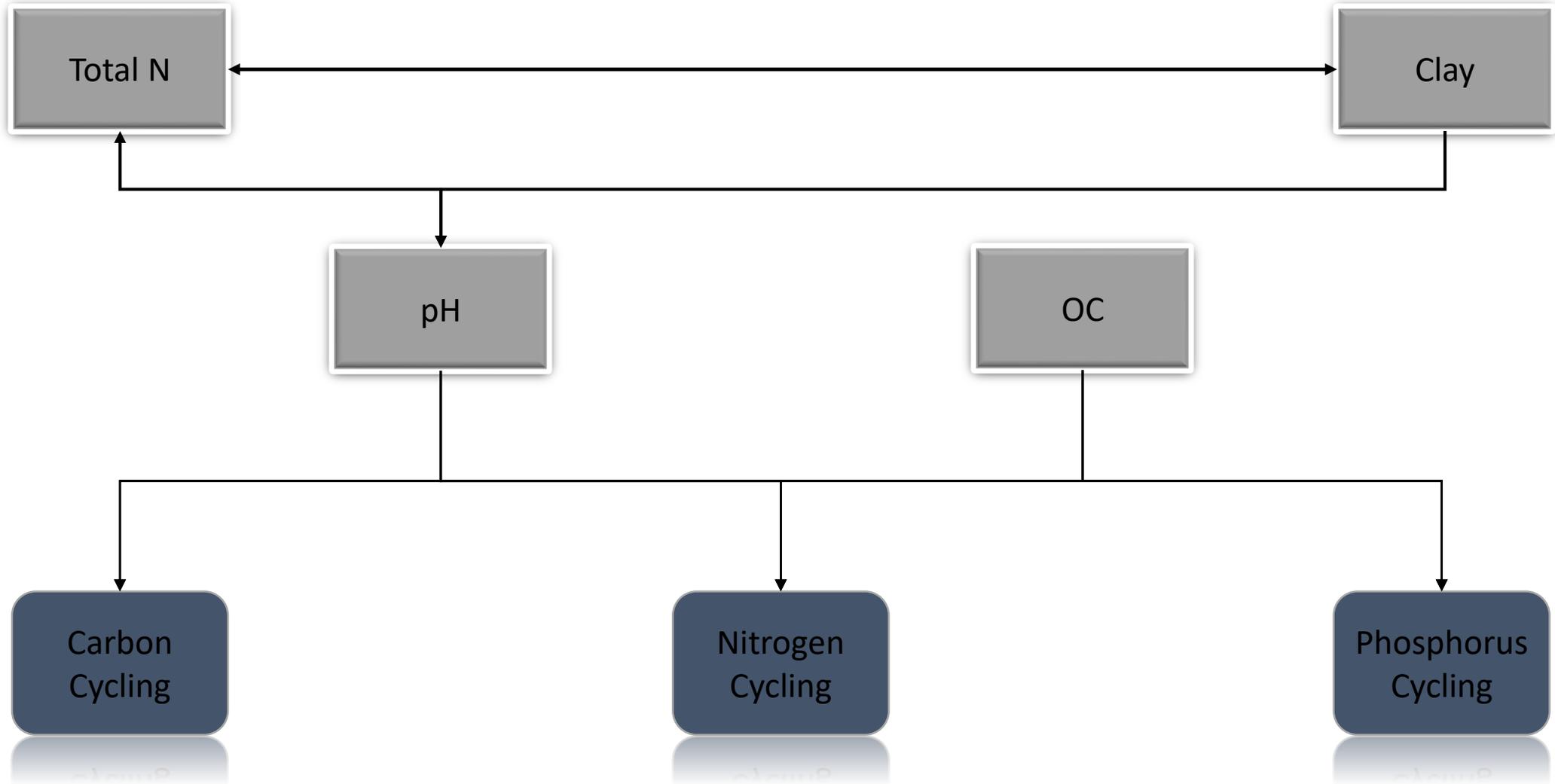
Models tested

- Compared differences in soils with and without metals.

- Compared differences in soils with and without grasses.

- Compared differences in soils with grasses -/+metals.

Models tested

- ~~Compared differences in soils with and without metals.~~

- Compared differences in soils with and without grasses.

- Compared differences in soils with grasses -/+metals.

Models tested

- ~~Compared differences in soils with and without metals.~~

- ~~Compared differences in soils with and without grasses.~~

- Compared differences in soils with grasses -/+metals.

Compares differences in soils with *E. lanceolatus* -/+metals

Total N

Clay

Glucosidase vs Phosphatase Activity in Dosed soils

y = 0.11x + 59.141
R² = 0.5983

Phosphatase Activity (nM pnP/hr)

Glucosidase Activity (nM pnP/hr)

0.75

-0.58/-0.4

Carbon Cycling

Phosphorus Cycling
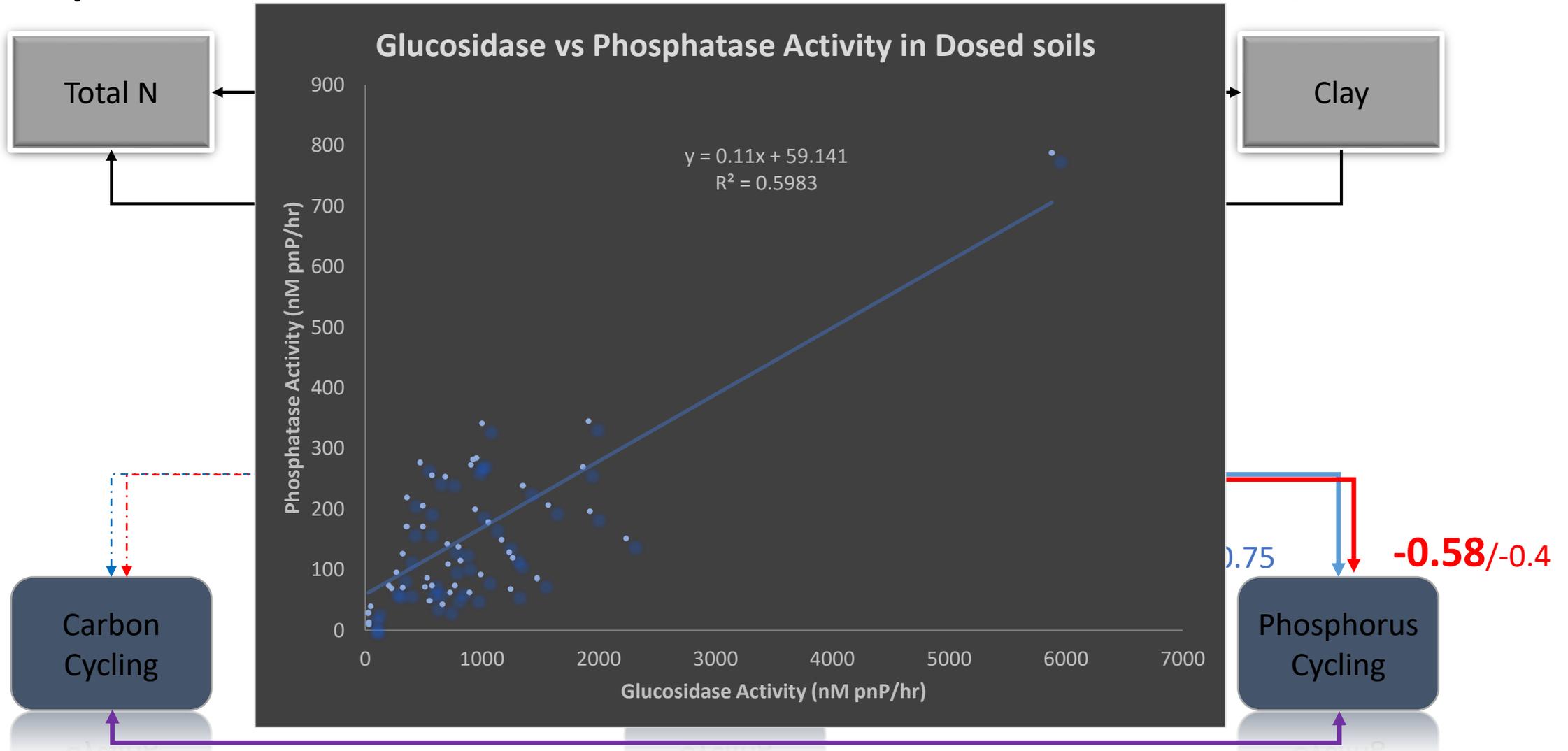
0.2/0.4

p **value<.05**

Conclusions

- Metal mixtures reduce the quality of Ecosystem Services by;

❑ increasing the relationship between pH and P cycling.

❑ increasing the relationship between OC and P cycling.

❑ increasing the co-relationship between P and C cycling.

Acknowledgements

Committee Members

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Team

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Questions?