Mechanics of Soil Carbon Sequestration by Nitrogen Deposition

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Context

- Fog ‘88, Berg &Matzner ‘97:
  - 100+ studies indicate that cellulosic plant material decomposes faster with added N, whereas rates for lignified/humified material tend to slow.
- Nadelhoffer et al. ‘99:
  - Belowground C sequestration in response to N deposition about equal to that aboveground.
- Carreiro et al. ‘00, Sinsabaugh et al. ‘01:
  - Cellulolytic activity stimulated by N deposition
  - Phenol oxidase activity variably affected
  - Litter mass loss response directly related to phenol oxidase response

Context

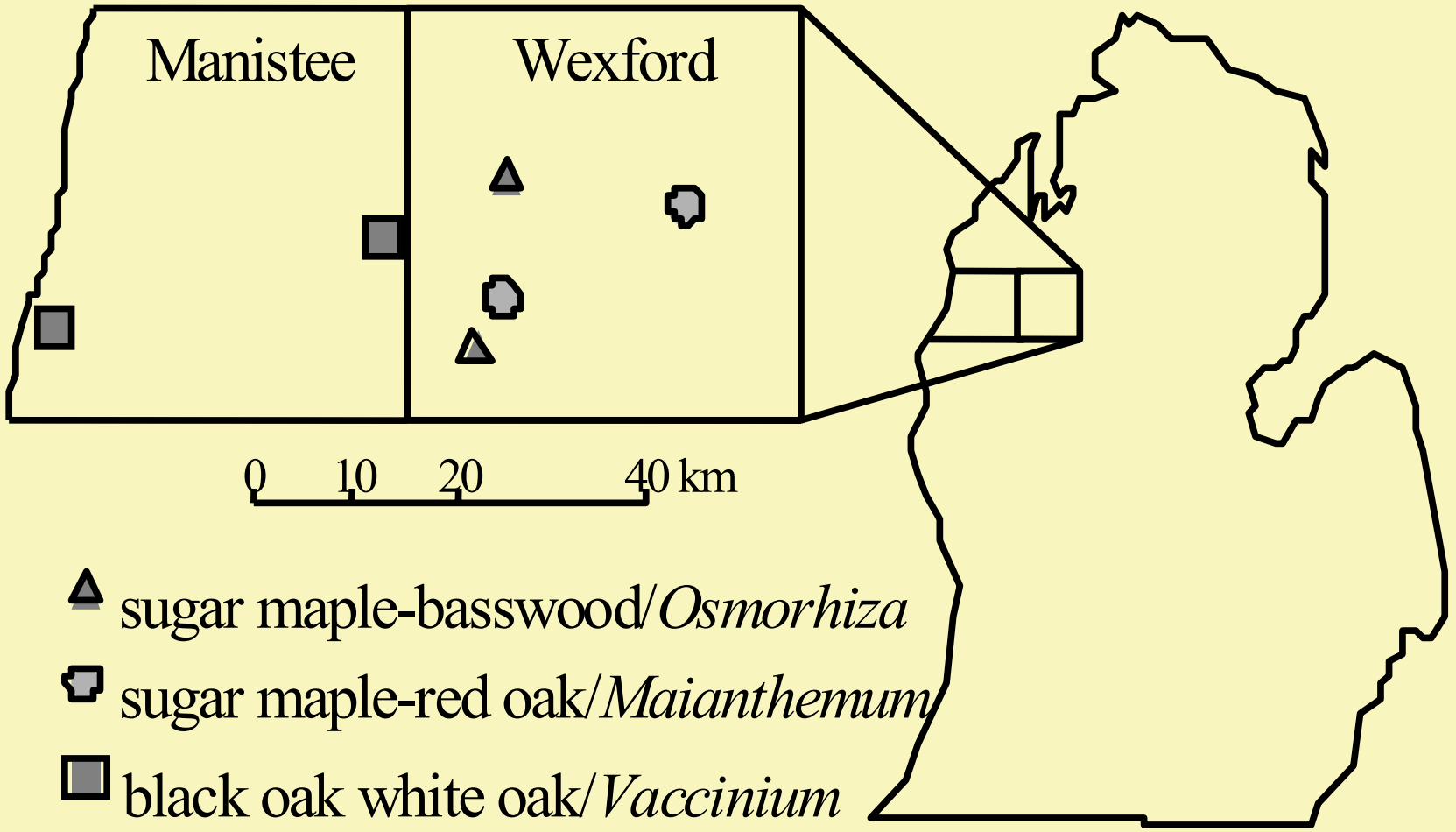
- Saiya-Cork et al. ‘01:
  - Phenol oxidase activity in mineral soil, as well as litter, is repressed by N deposition
- Conventional wisdom:
  - N inhibition of decomposition results from suppression of lignin peroxidase expression by white rot basidiomycetes.

The Questions

- Does N deposition affect the storage of carbon in the soil by acting directly on microbial communities?
  - How does N deposition alter microbial community activity and composition?
  - Is the N effect “important”?

Experimental Design

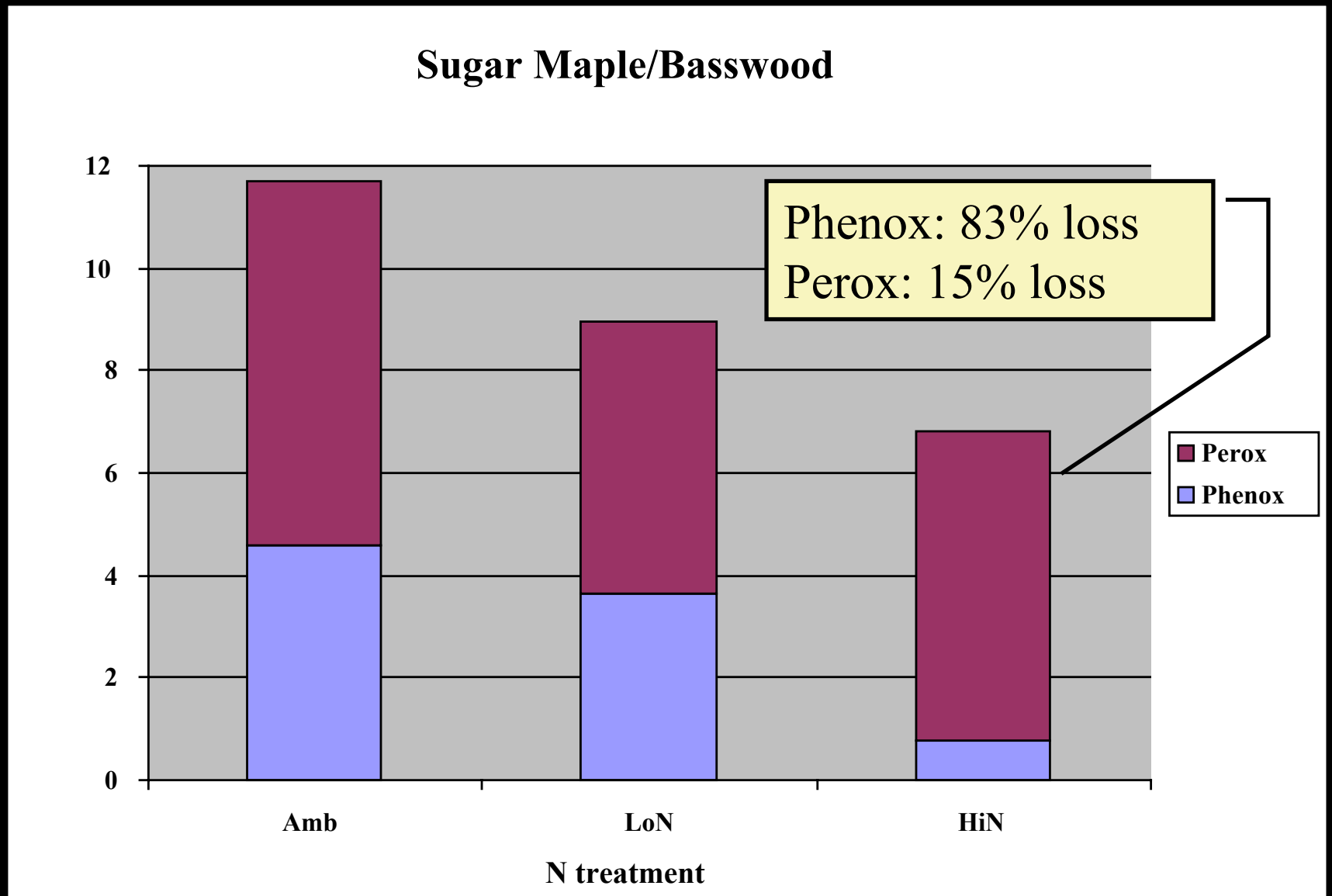
- Three forest types, representative of northern temperate forest
  - Sugar maple, basswood
  - Sugar maple, red oak
  - White oak, black oak
- Three replicate stands (aged 90 y) for each community type
- Within each stand, three 10x30 m plots
- Treatments
  - Ambient, 30 kg N ha^{-1} y^{-1}, 80 kg N ha^{-1} y^{-1}

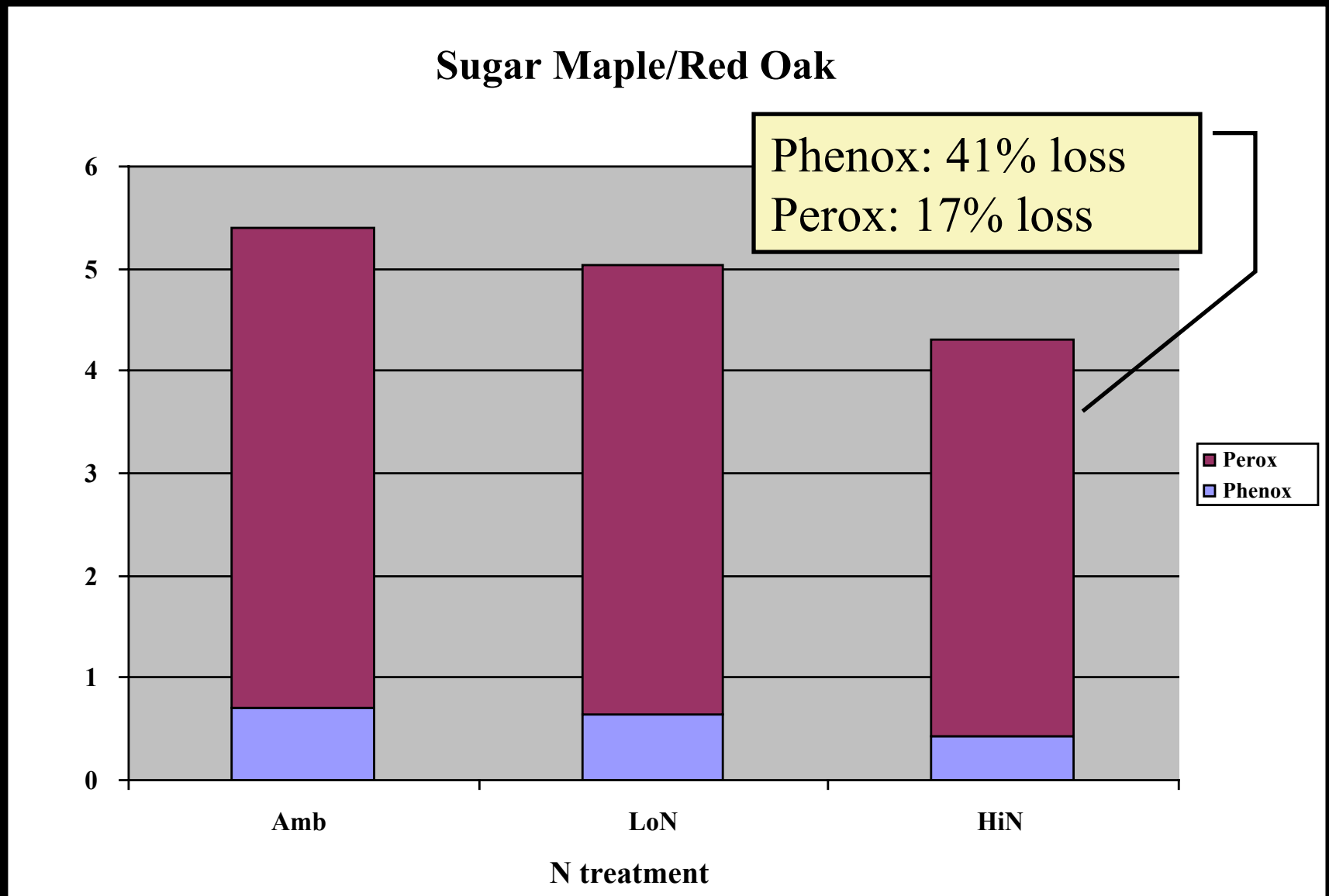

Manistee
Wexford
0 10 20 40 km
sugar maple-basswood/*Osmorhiza*
sugar maple-red oak/*Maianthemum*
black oak white oak/*Vaccinium*

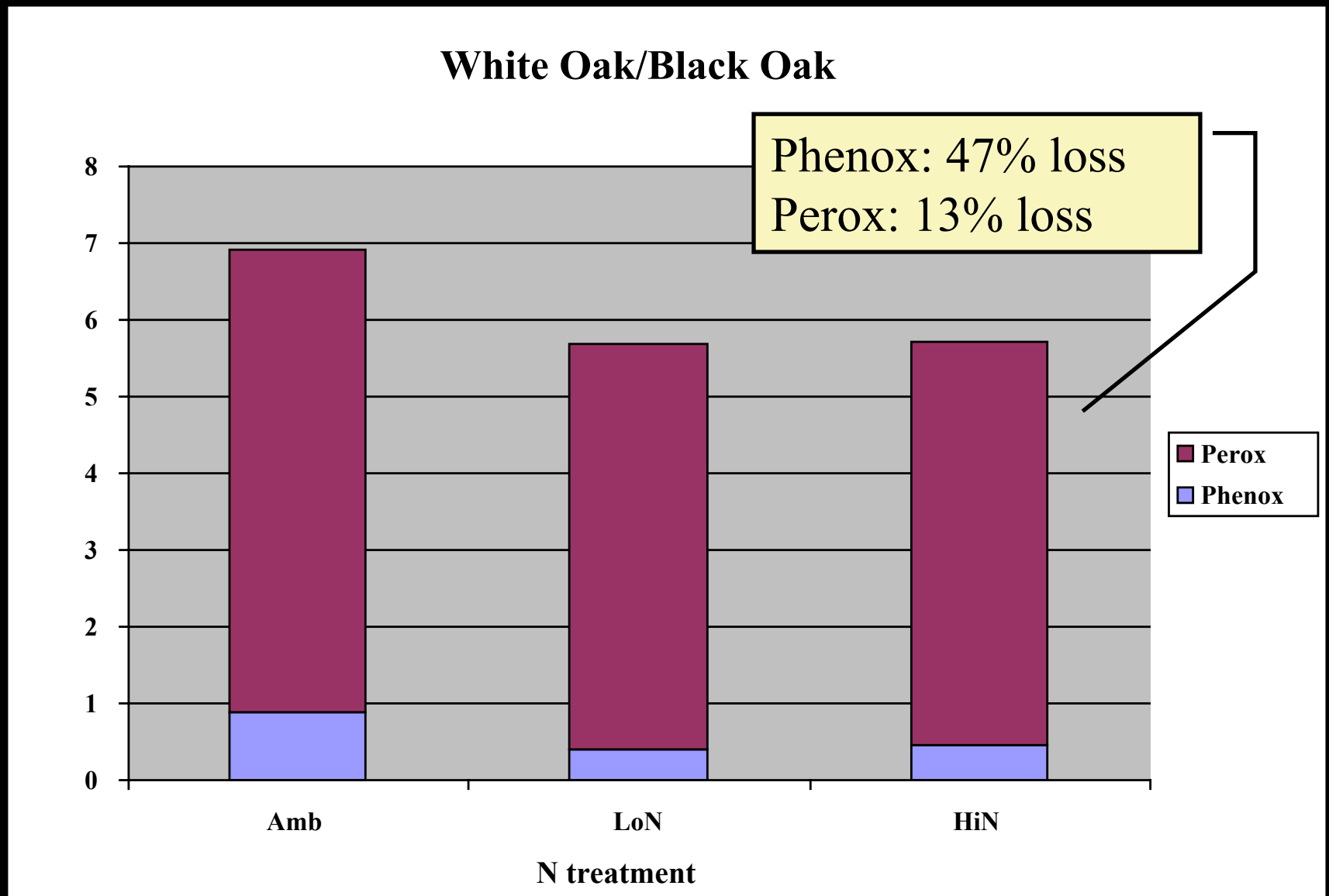

Black Oak-White Oak/*Vaccinium*

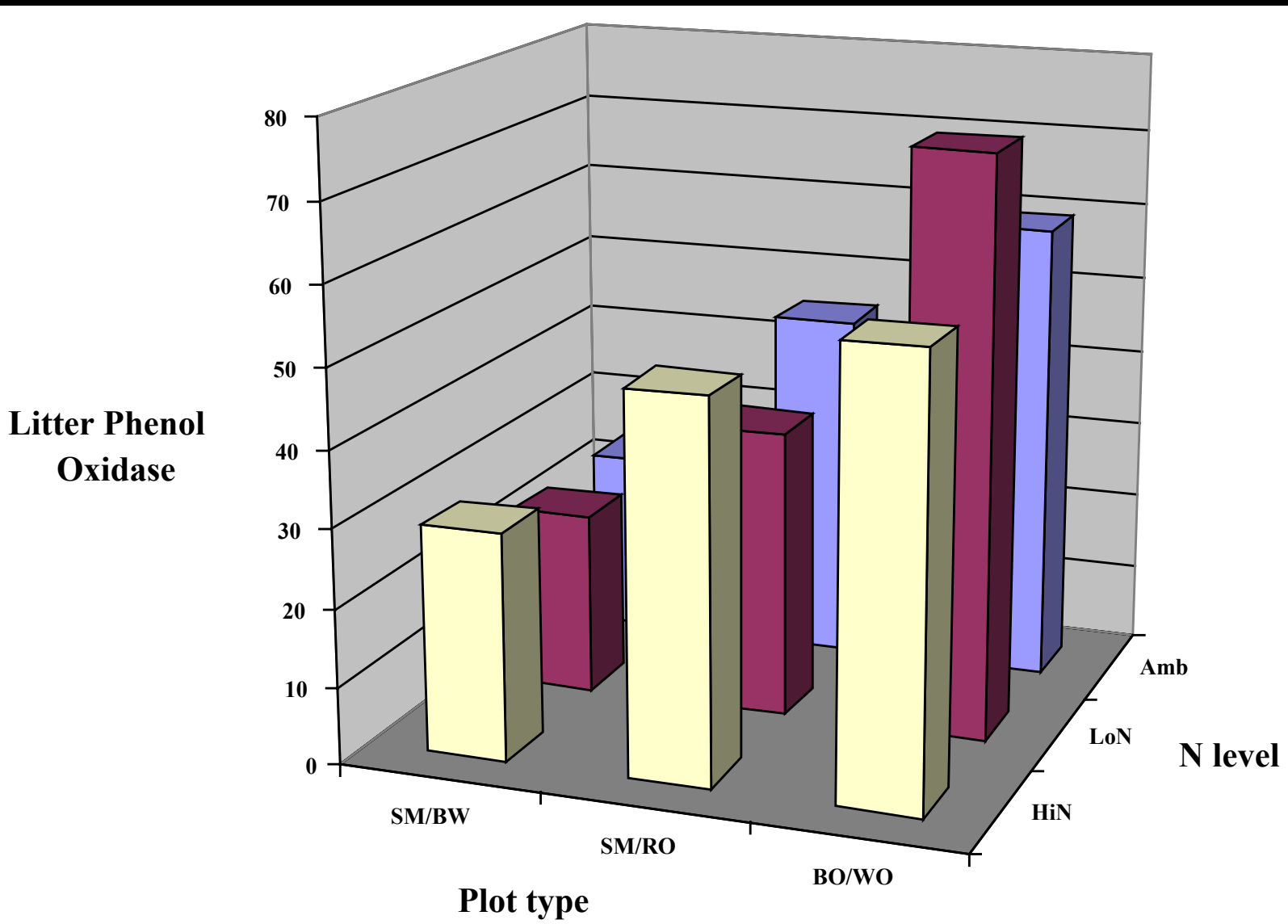
2001 Season

- April: establish plots, begin N amendments
- May, June, August, October: assay soil and litter for oxidative activities
  - Phenol oxidase, peroxidase, glucose oxidase, glyoxal oxidase, cellobiose dehydrogenase
- Analyze microbial community composition
  - Phospholipid fatty acid profiles


Sugar Maple/Basswood
12
10
8
6
4
2
0
Amb
LoN
HiN
N treatment
Phenox: 83% loss
Perox: 15% loss
Perox
Phenox


Sugar Maple/Red Oak
Phenox: 41% loss
Perox: 17% loss
6
5
4
3
2
1
0
Amb
LoN
HiN
N treatment
Perox
Phenox


White Oak/Black Oak
Phenox: 47% loss
Perox: 13% loss
8
7
6
5
4
3
2
1
0
Amb
LoN
HiN
N treatment
Perox
Phenox


Litter Phenol Oxidase
80
70
60
50
40
30
20
10
0
SM/BW
SM/RO
BO/WO
Plot type
Amb
LoN
HiN
N level

Upcoming

- Tracer studies
  - 13C vanillin, 13C cellobiose thru PLFA
    - If glycosidase activity goes up and oxidative activity goes down is sugar and phenol metabolism uncoupled?
- Quantify canopy litterfall rates
- Litterbag study
  - Follow litter cohorts over time

Significance

- Belowground processes mediate ecosystem response to global productivity stimulants (atm CO2, N dep)
- N deposition directly affects microbial activities
- N suppression of oxidative activity is a general phenomena, not confined to basidiomycetes
- Unknowns:
  - Does N retard SOM degradation or simply reconfigure C and N flowpaths?
  - If SOM degradation slows is additional carbon stored in the system or exported as DOC?