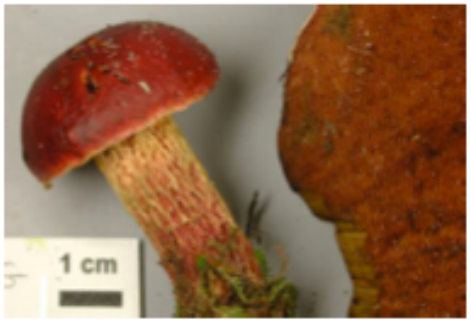
Nitrogen Deposition Negatively Impacts the Diversity and Species Composition of Beneficial Ectomycorrhizal Fungi Associated with Oaks

Amanita brunnescens

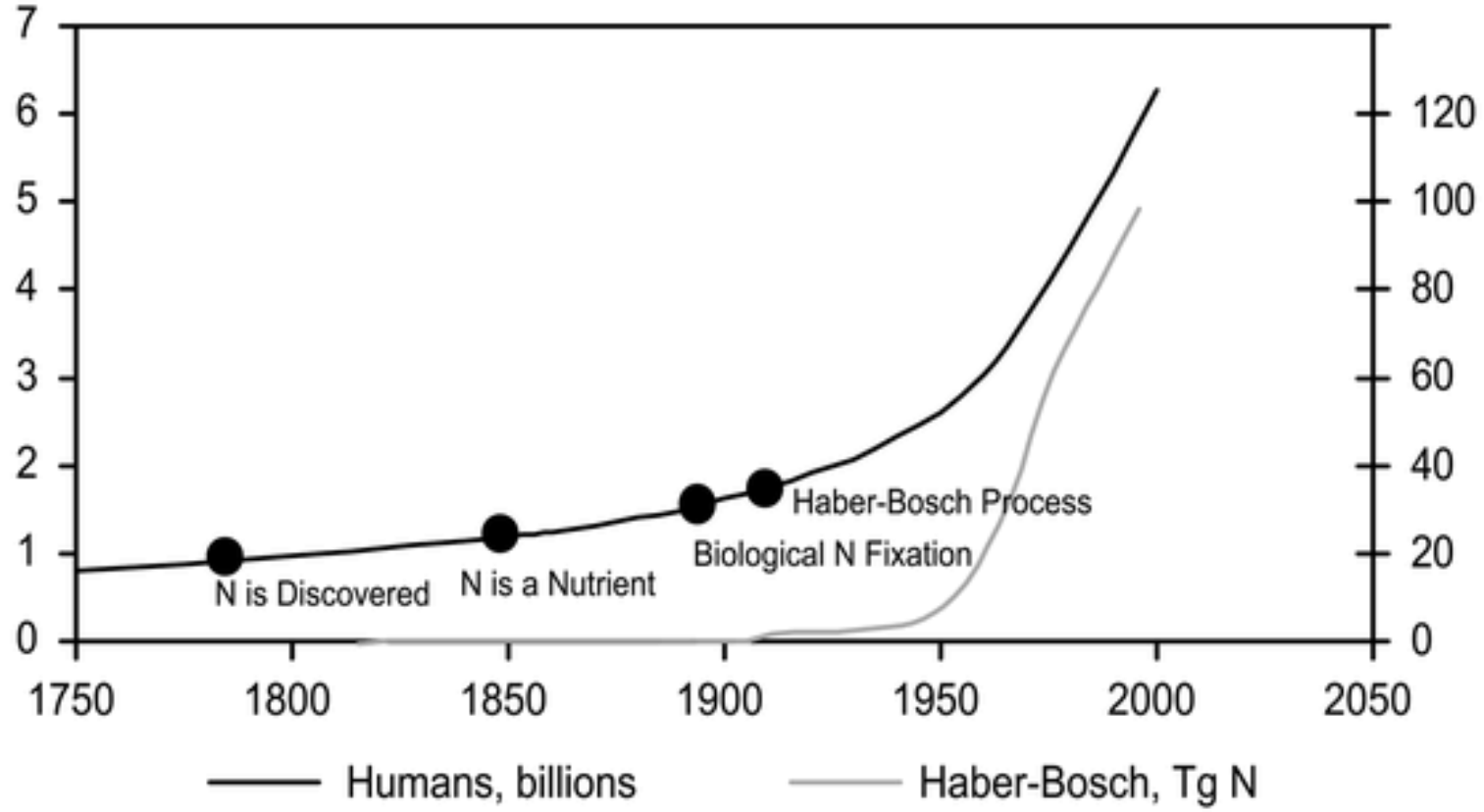
Hygrocybe marginata



Boletus frostii

Russula aeruginea

Gregory M. Mueller, Chicago Botanic Garden
Peter G. Avis, Indiana University Northwest
Patrick R. Leacock, Field Museum of Natural History



Ambio 2002

Humans **doubled** the amount of reactive N entering the ecosystems in ~50 years (Vitousek et al 1997)

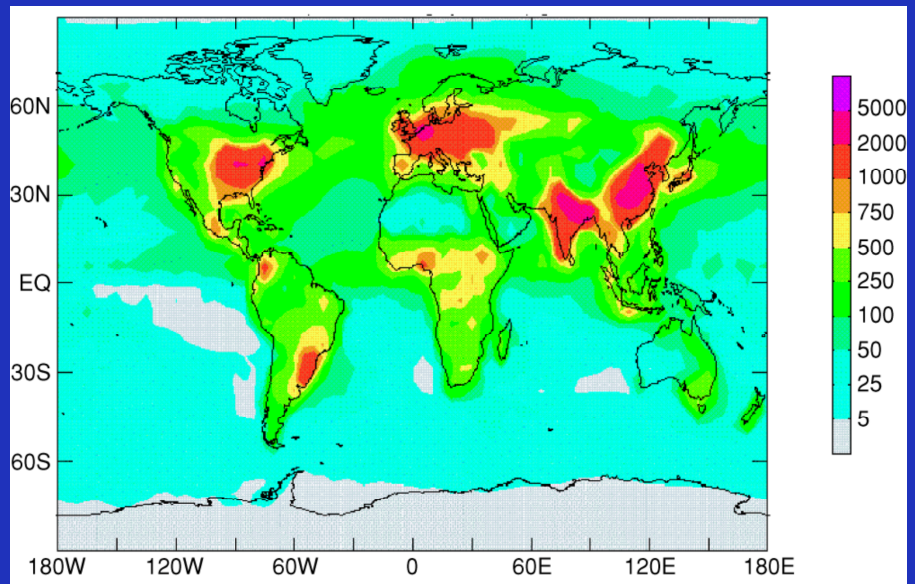


Figure 2b: Spatial patterns of total inorganic nitrogen deposition in early 1990s, mg N m^{-2} yr^{-1}.

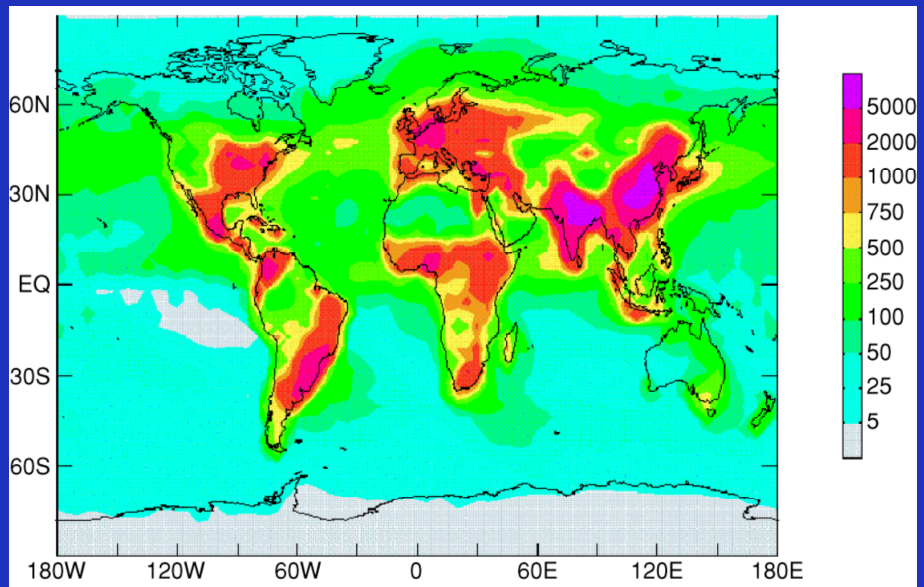


Figure 2c: Spatial patterns of total inorganic nitrogen deposition in 2050, mg N m^{-2} yr^{-1}.

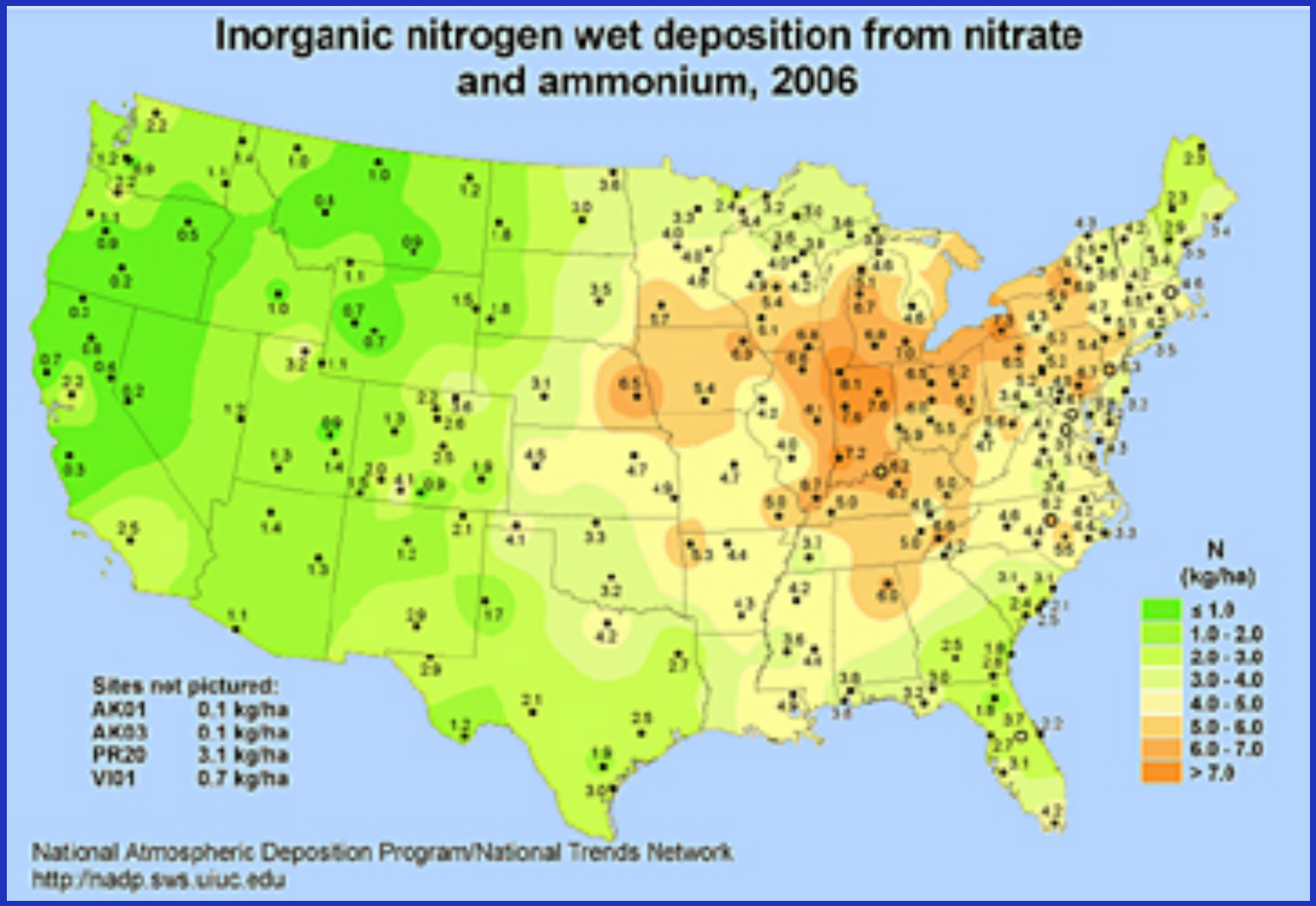
Galloway et al 2004
Biogeochemistry
See also initrogen.org

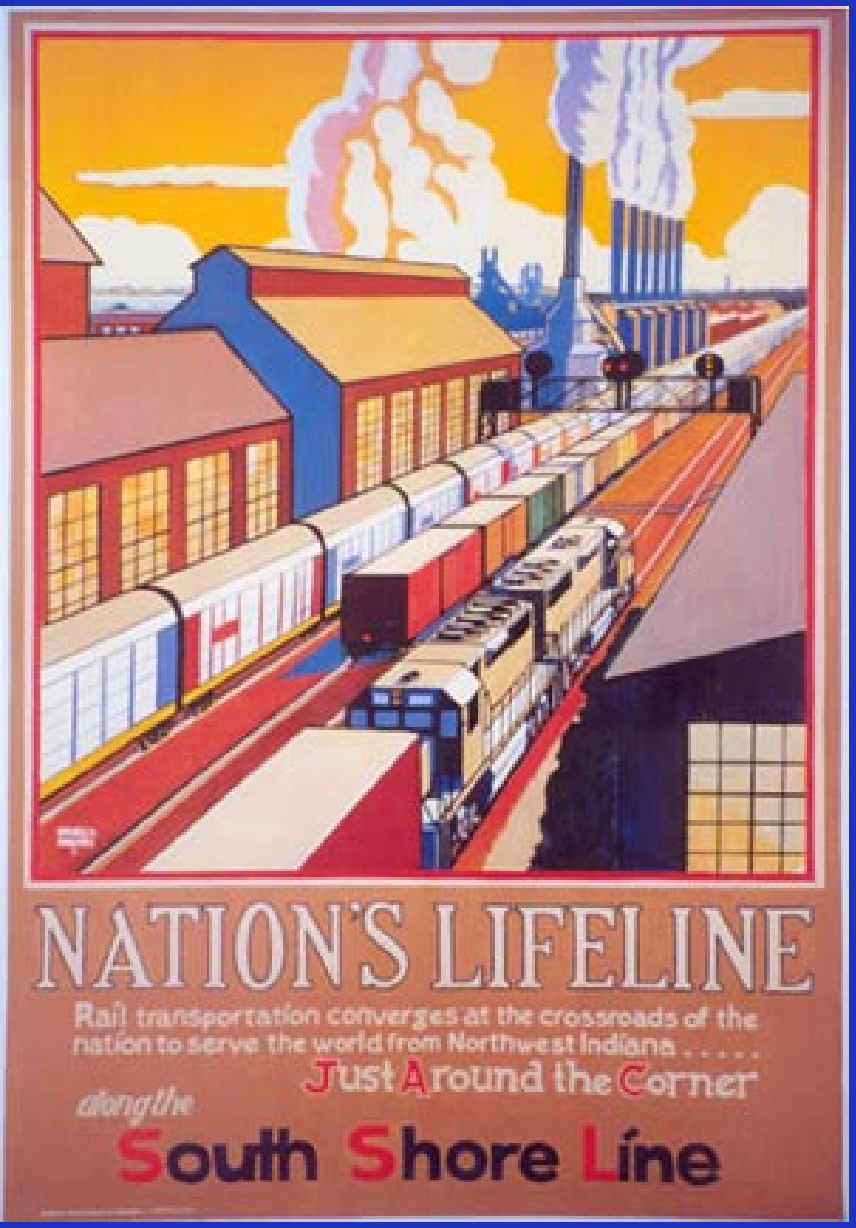
Increased nitrogen deposition has been reported to negatively impacts fungi, especially symbiotic species

However

Most reports are from pine dominated forests

There are limited data from Midwestern US

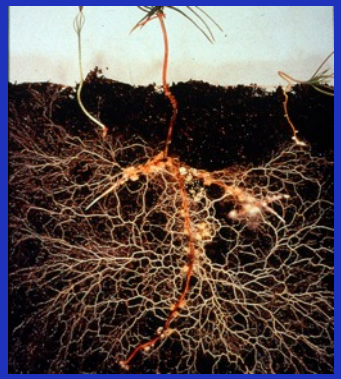

Inorganic nitrogen wet deposition from nitrate and ammonium, 2006
N (kg/ha)
≤ 1.0
1.0 - 2.0
2.0 - 3.0
3.0 - 4.0
4.0 - 5.0
5.0 - 6.0
6.0 - 7.0
> 7.0
Sites not pictured:
AK01 0.1 kg/ha
AK03 0.1 kg/ha
PR20 3.1 kg/ha
VI01 0.7 kg/ha
National Atmospheric Deposition Program/National Trends Network
http://nadp.sws.uiuc.edu


NATION'S LIFELINE
Rail transportation converges at the crossroads of the nation to serve the world from Northwest Indiana . . . . .
Just Around the Corner
along the
South Shore Line

Saprotrophic

Pathogenic

Ectomycorrhizal



Ectomycorrhiza: Mutualism between plant root and a fungus

Herbarium specimens provide the required baseline data to assess changes in species composition over time

Swallow Cliff Woods

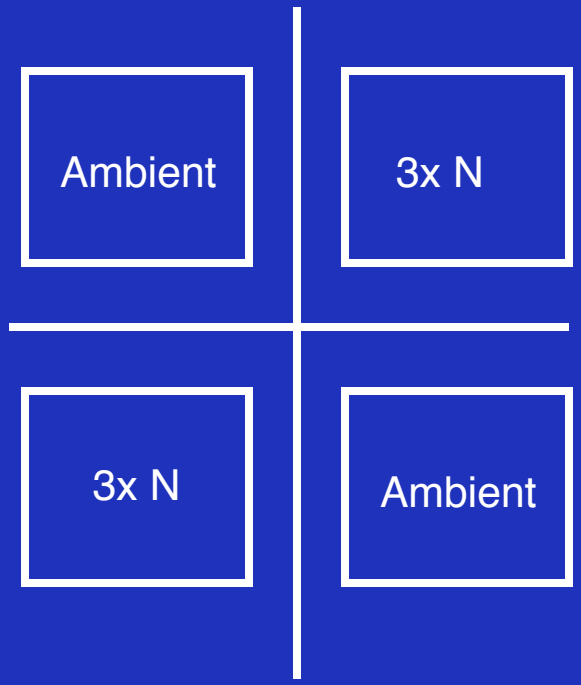
Lake Michigan
Cook
Porte
Illinois
India

Indiana Dunes

Experimental plan

Fertilization began July 2003. Each month we spray with a solution that contains the five year average of NO3 and NH4 that fell on the site according to the NADP web site.

0.1 ha census plots



Taking Soil Cores

Oak ectomycorrhizas from our study plots

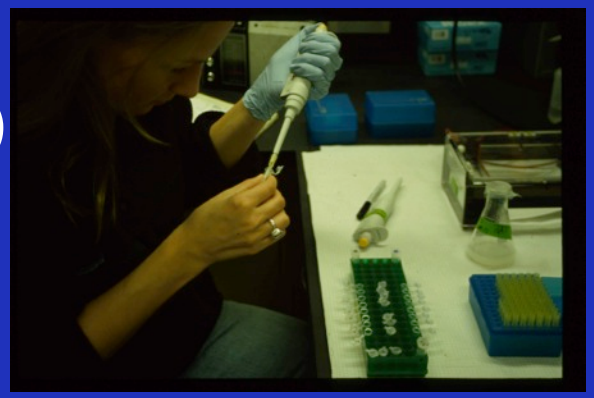
Soil Cores
(10k tips)

Mushroom Surveys

Collect oak roots

(100's of tips)

Molecular

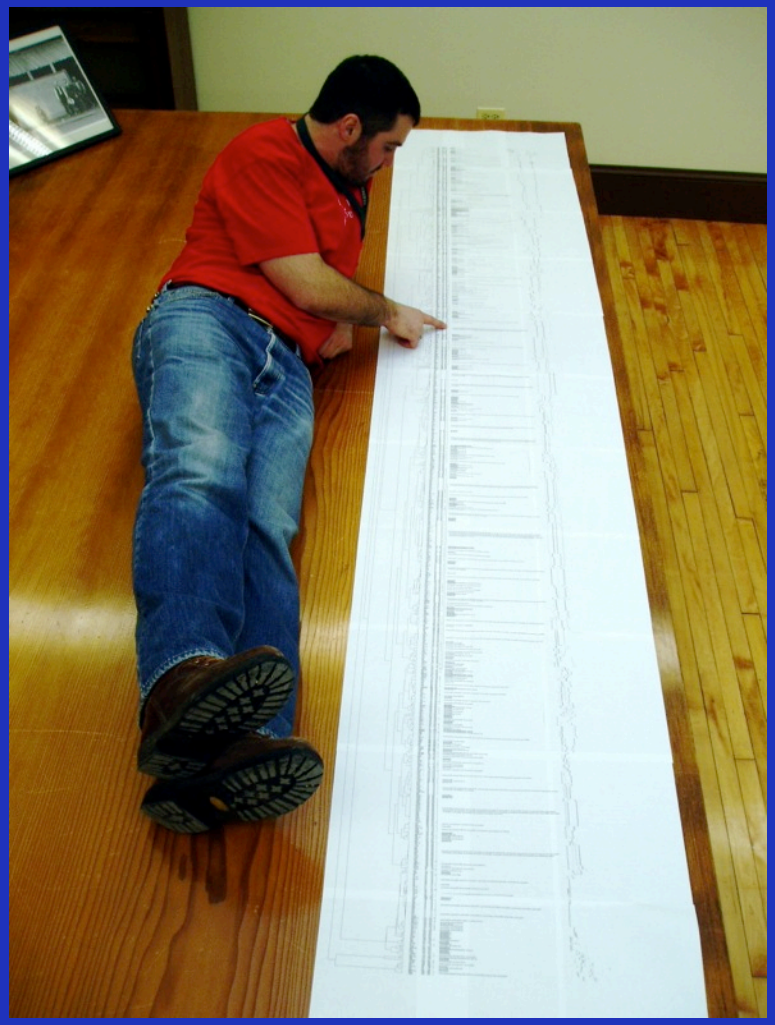


Morphological
(1000's of root tips)

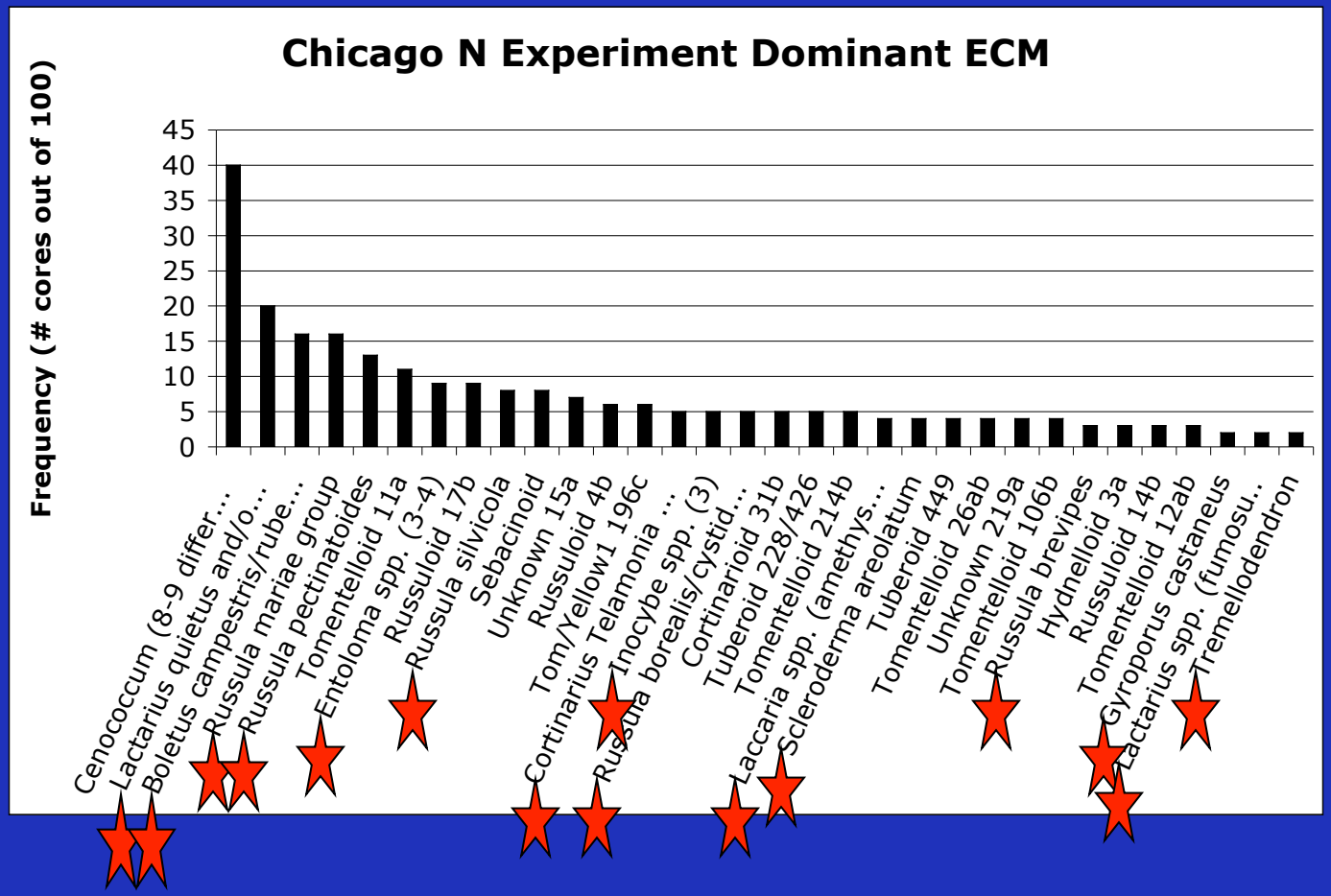
ITS PCR-TRFLP
Clone
Sequence
BLAST
Phylogeny

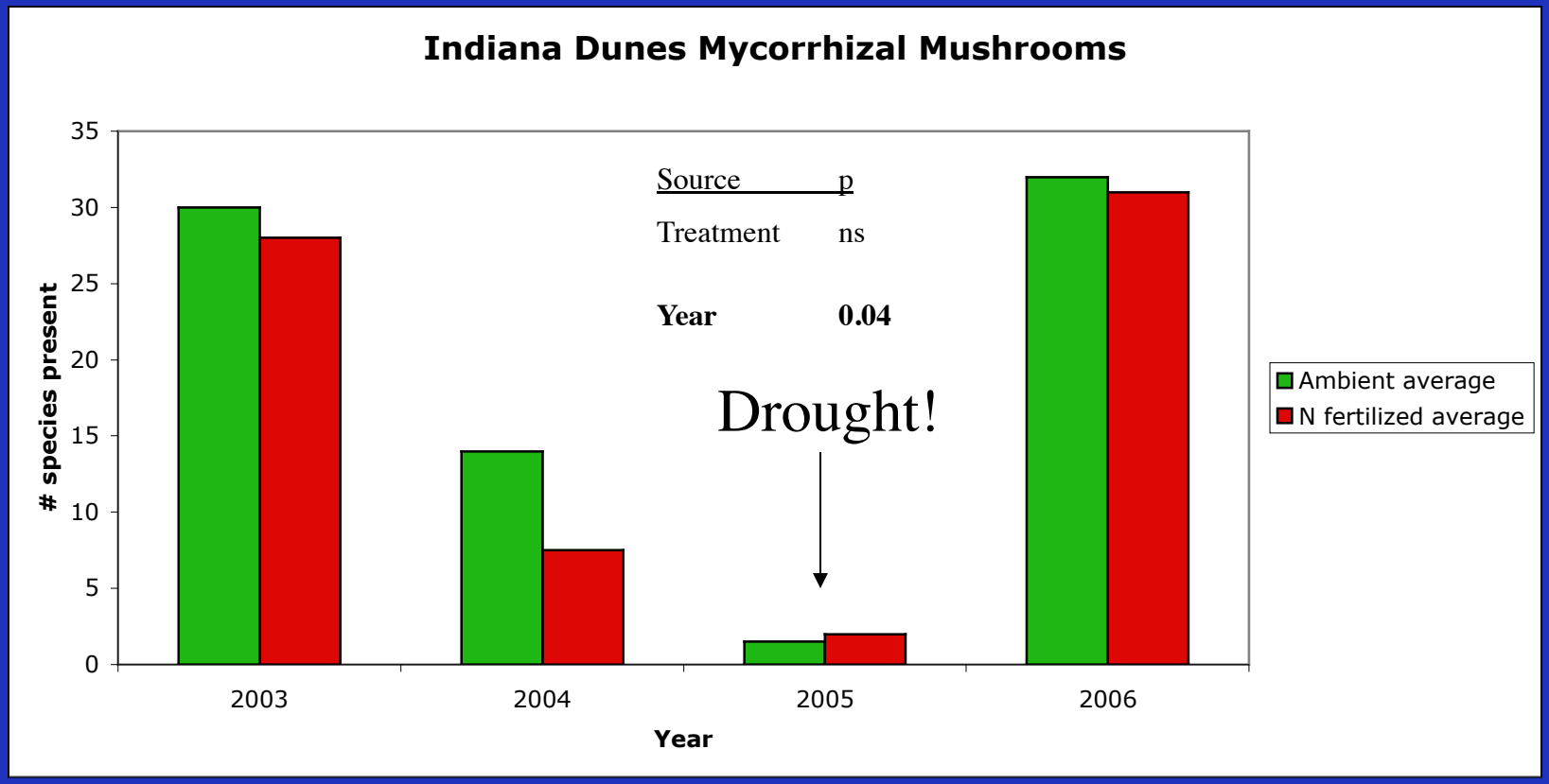
Species Identification

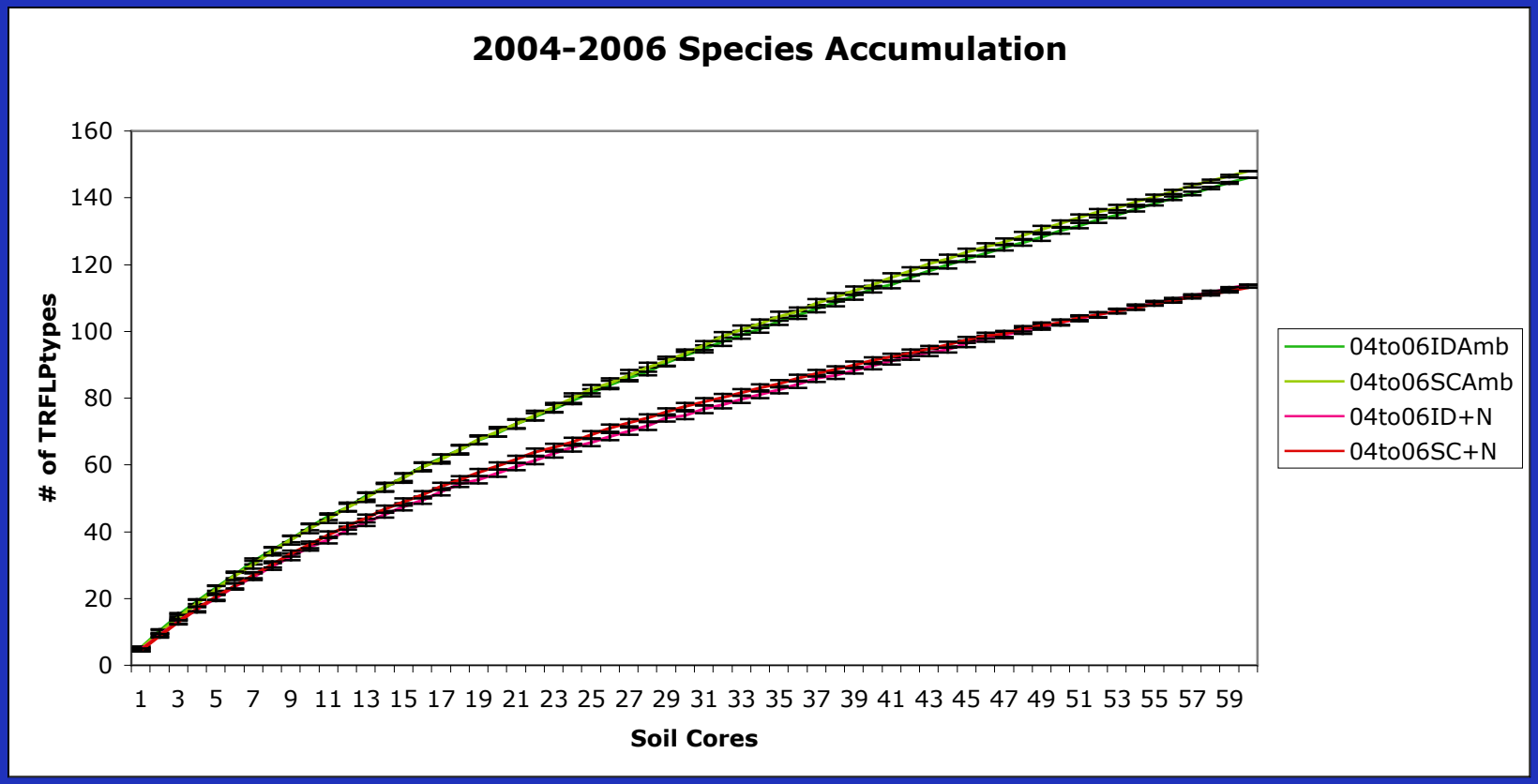
Three years, 5000 mushrooms,
15000 roots, 1500 PCRs, 300 species…



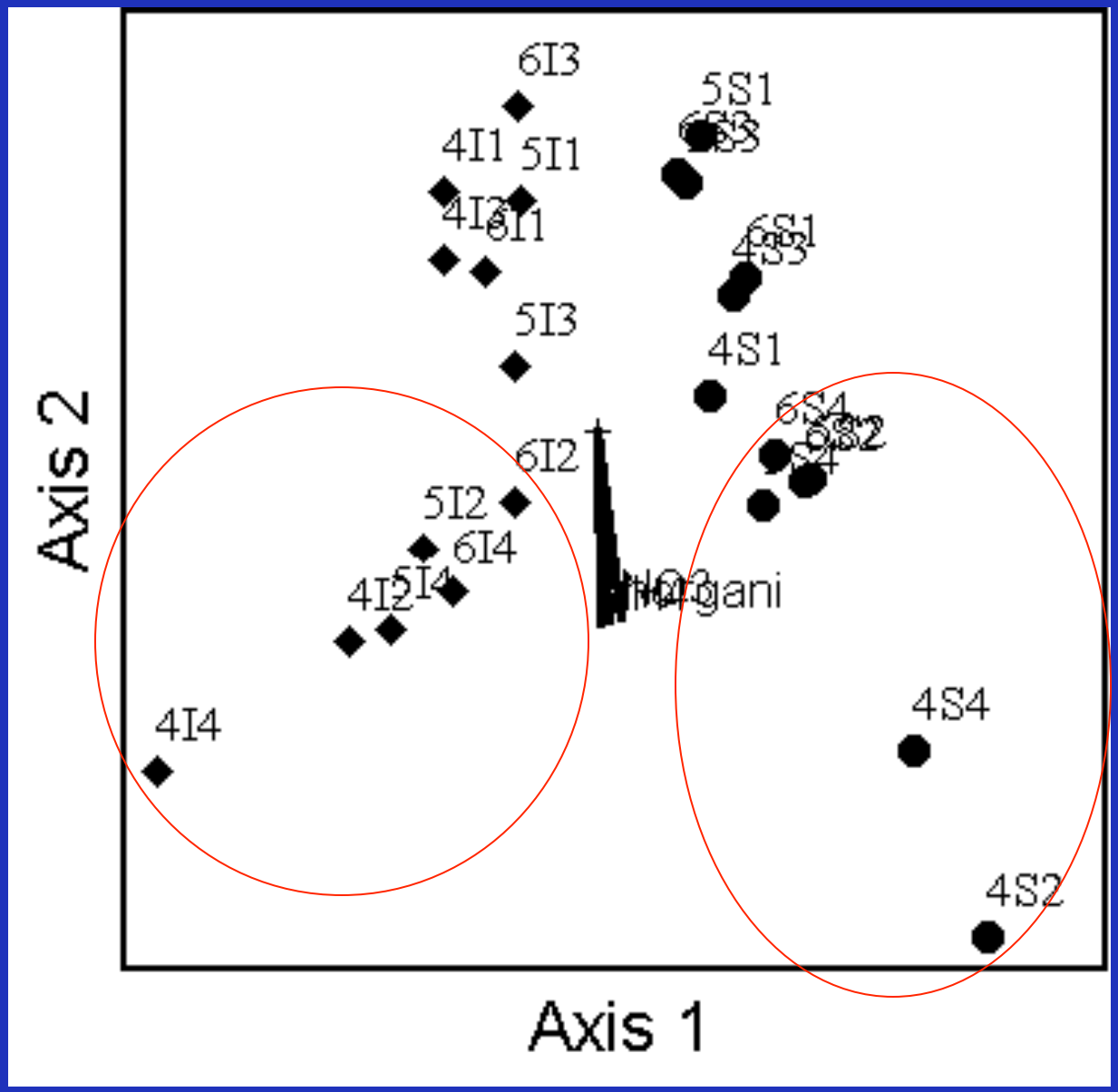
Below-ground ECM richness -- ~130 possible spp




Indiana Dunes Mycorrhizal Mushrooms
35
30
25
20
15
10
5
0
species present
2003
2004
2005
2006
Year
Source p
Treatment ns
Year 0.04
Drought!
Ambient average
N fertilized average


2004-2006 Species Accumulation
# of TRFLPtypes
0
20
40
60
80
100
120
140
160
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59
Soil Cores
04to06IDAmb
04to06SCAmb
04to06ID+N
04to06SC+N

CCA Ordination



Number of individuals of the *Russula amoenolens* complex by treatment

	2003	2004	2005	2006	2007	2008		total
Control	14	1	5	10	20	6		56
N+	13	0	7	21	28	6		75

Next Steps

Resample and analyze root data using next generation sequencing protocols to:

- Assess longer-term effects of increased nitrogen deposition at Indiana Dunes Plots (fertilization 10 years)
- Assess potential legacy effects at Swallow Cliff Plots where we stopped fertilizing

Further analyze sporocarp and root data to identify species in addition to *Russula amoenolens that* are positively impacted

Examine biology of *Russula amoenolens* complex to better understand its response to increased nitrogen

Summary and Conclusions

Mushrooms and other fungi play critical roles in the environment as decomposers, pathogens, and beneficial symbionts

Human activity, such as anthropogenic nitrogen deposition, can have a negative impact on fungal diversity and community composition

It is still not clear how this change in the fungal community will impact plant, but data are emerging showing that loss of fungal diversity may have negative effects on plant communities.