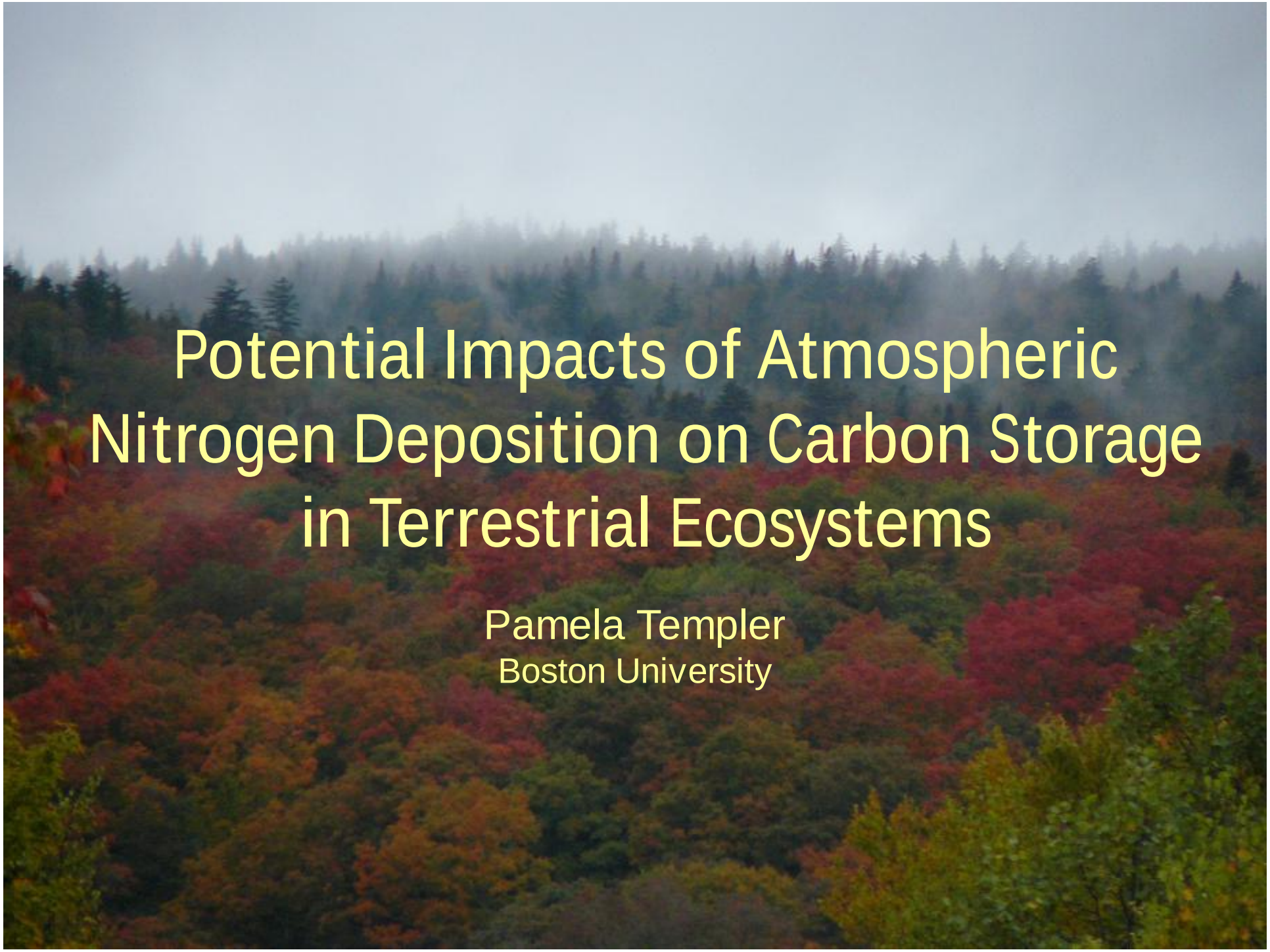
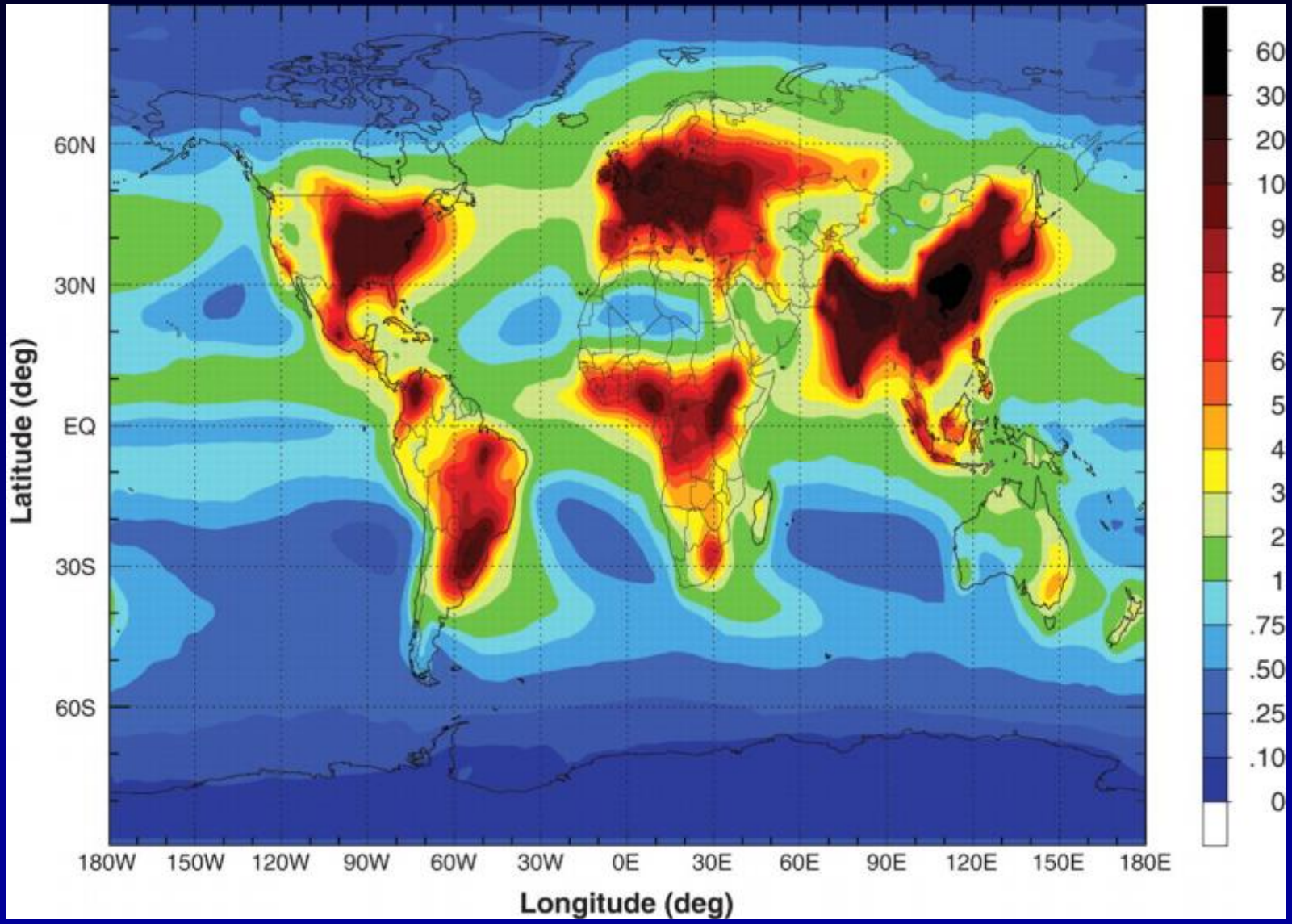


Potential Impacts of Atmospheric Nitrogen Deposition on Carbon Storage in Terrestrial Ecosystems

Pamela Templer
Boston University

Atmospheric N Deposition

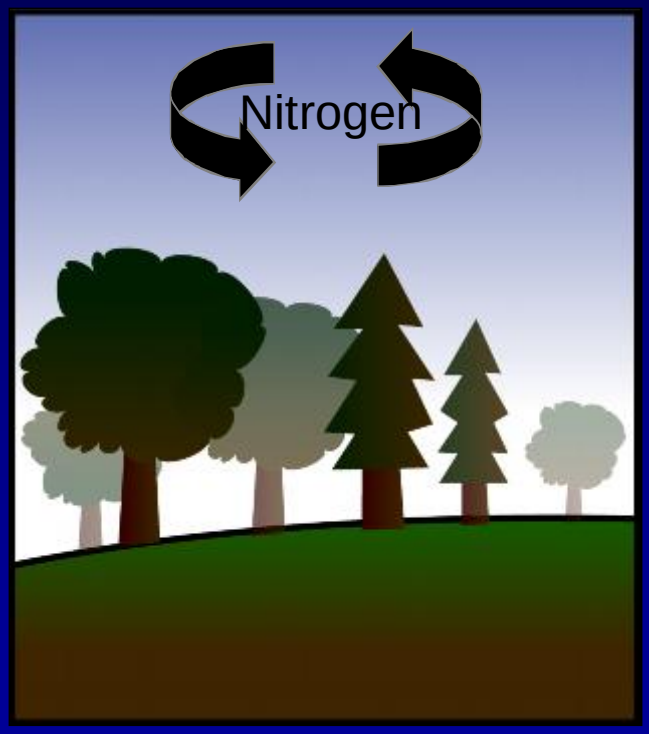
kg N ha^{-1} yr^{-1}



Galloway et al. *Science*. 2008. 320:889-892

N Deposition and Carbon Storage

Atmospheric N deposition
initially stimulates growth



(1) Greater CO_2 Uptake

(2) Smaller CO_2 Loss (Accumulation of soil C)

(3) Greater allocation to woody biomass

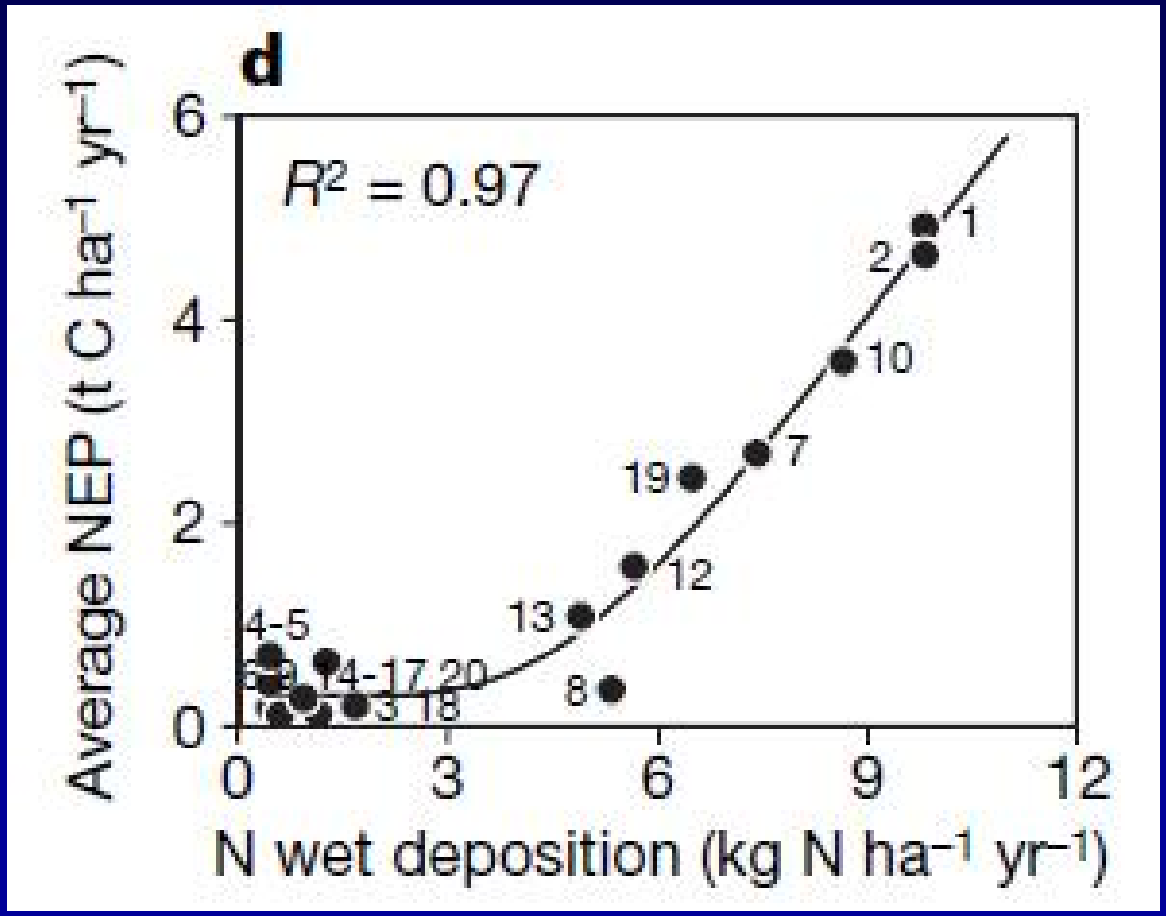
N Deposition and Carbon Storage

- Current understanding
- Meta-analysis of ^{15}N tracer studies

nature Vol 447 | 14 June 2007 | doi:10.1038/nature05847

The human footprint in the carbon cycle of temperate and boreal forests

Federico Magnani[1], Maurizio Mencuccini[2], Marco Borghetti[3], Paul Berbigier[4], Frank Berninger[5], Sylvain Delzon[4], Achim Grelle[6], Pertti Hari[7], Paul G. Jarvis[2], Pasi Kolari[7], Andrew S. Kowalski[4], Harry Lankreijer[8], Beverly E. Law[9], Anders Lindroth[8], Denis Loustau[4], Giovanni Manca[10]†, John B. Moncrieff[2], Mark Rayment[2], Vanessa Tedeschi[3], Riccardo Valentini[10] & John Grace[2]



725 kg C per kg N in wet deposition

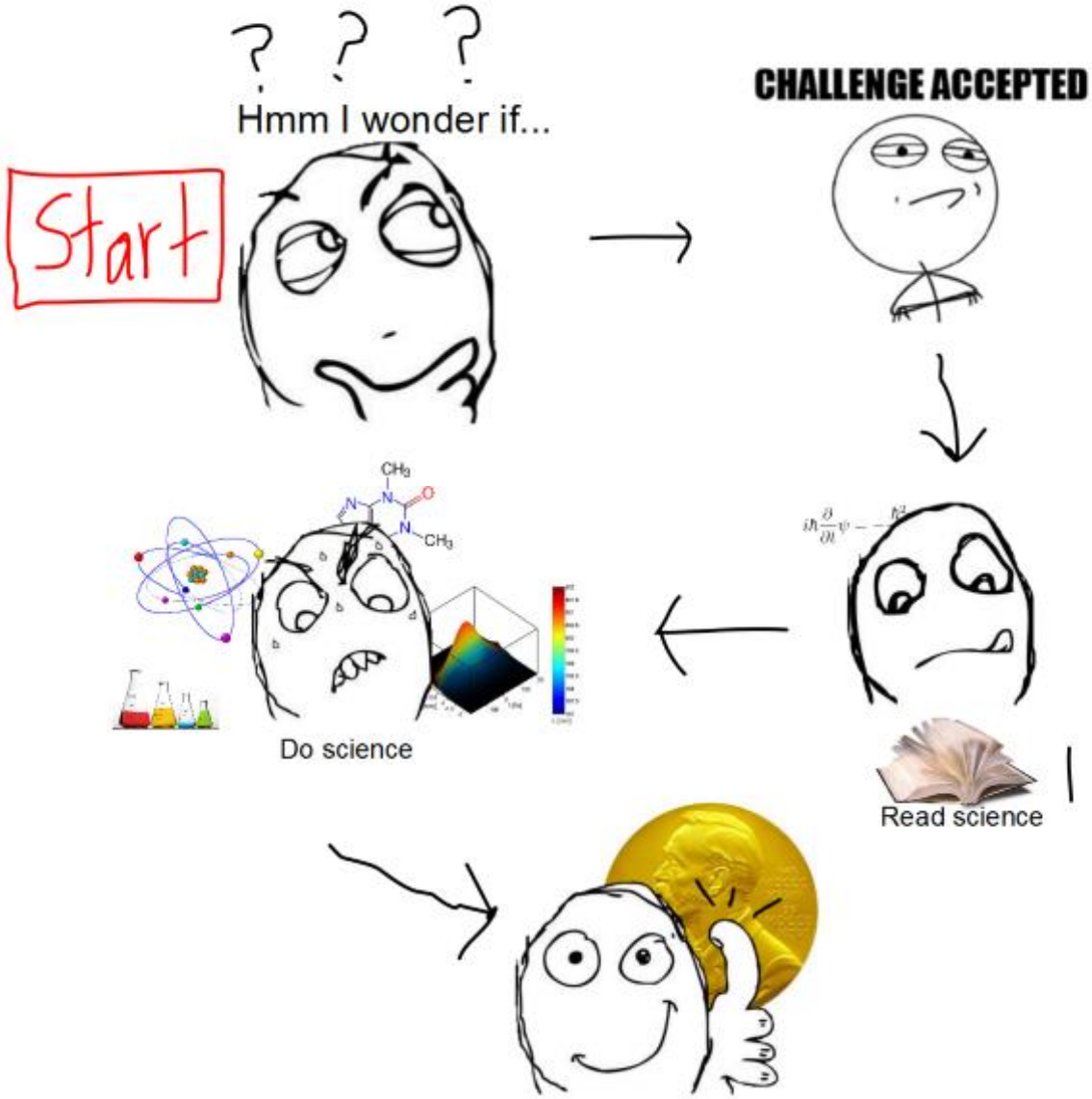
(470 kg C per kg N total deposition)

Response to Magnani et al. (2007):

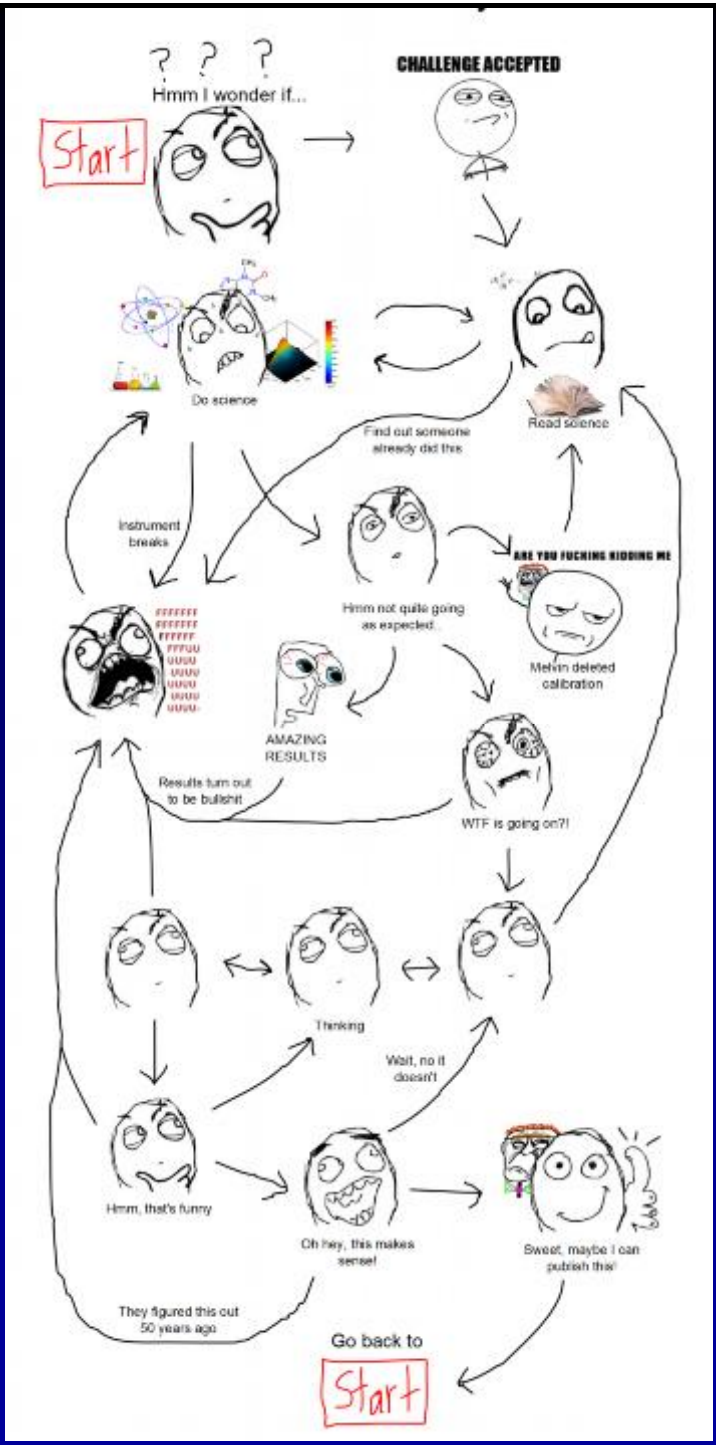
"What this article does is bears out a couple of truths that I have tried to pound into people's head for years: Nature will always find a way to survive. We cannot destroy it. We don't have the means. We don't have the intelligence, nor do we have the desire….So whatever damage we do the world, nature finds a way to accommodate it, correct it, so forth and so on."

http://www.rushlimbaugh.com/home/estack_12_13_06/nature_finds_a_way_to_survive.guest.html

Public Perception of Science



electroncafe.files.wordpress.com/2011/05/sciencerage.png



Science in Reality

electroncafe.files.wordpress.com/2011/05/sciencerage.png

De Schrijver et al. Response

NATURE|Vol 451|14 February 2008 BRIEF COMMUNICATIONS ARISING

Nitrogen saturation and net ecosystem production

Arising from: F. Magnani *et al. Nature* 447, 848–850 (2007)

Study ignores potential negative impacts of N deposition
~25% European forests included in study are N saturated

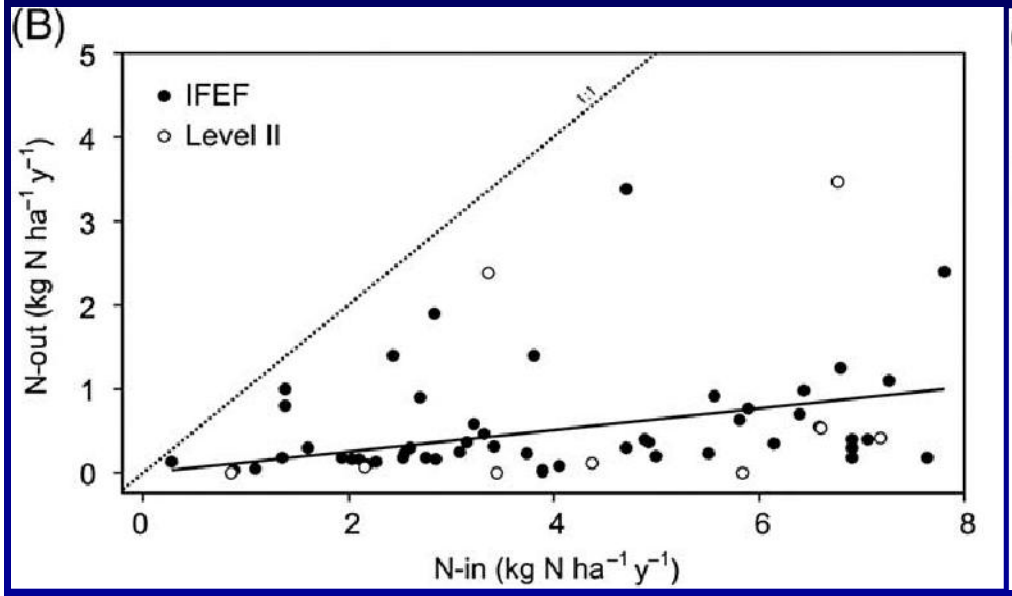
- Release of N_2O
- Reduced forest productivity and biodiversity
- Acidification of stream water
- Eutrophication

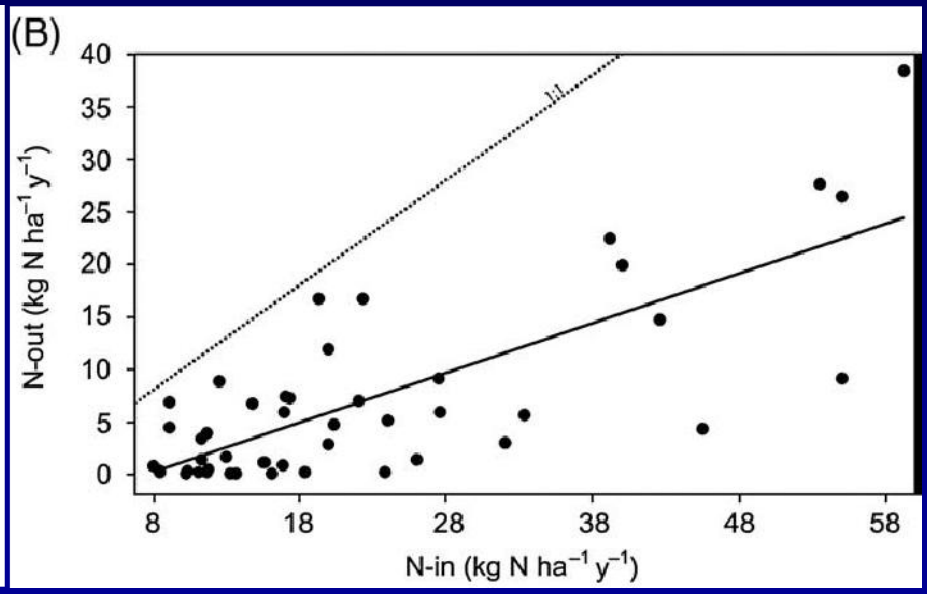
Benefits of Nitrogen Deposition Occur When N Retained in Ecosystem

SCIENCE OF THE TOTAL ENVIRONMENT 407 (2009) 1798–1808

Predicting dissolved inorganic nitrogen leaching in European forests using two independent databases☆

N.B. Dise[a,], J.J. Rothwell[a], V. Gauci[b], C. van der Salm[c], W. de Vries[c]*





> 8 kg N ha^{-1} yr^{-1} → Increased N leaching

De Vries et al. Response
to Magnani et al. 2008. *Nature*

Ecologically implausible carbon response?

Arising from: F. Magnani *et al. Nature* 447, 848–850 (2007)

- Magnani calculates that 470 kg C per kg total N deposition
- Assumes all N goes into high C:N wood
- Most N actually goes belowground (Nadelhoffer et al. 1999)
- Taking into account actual allocation of N →

  Only 30-70 kg C per kg N

nature geoscience

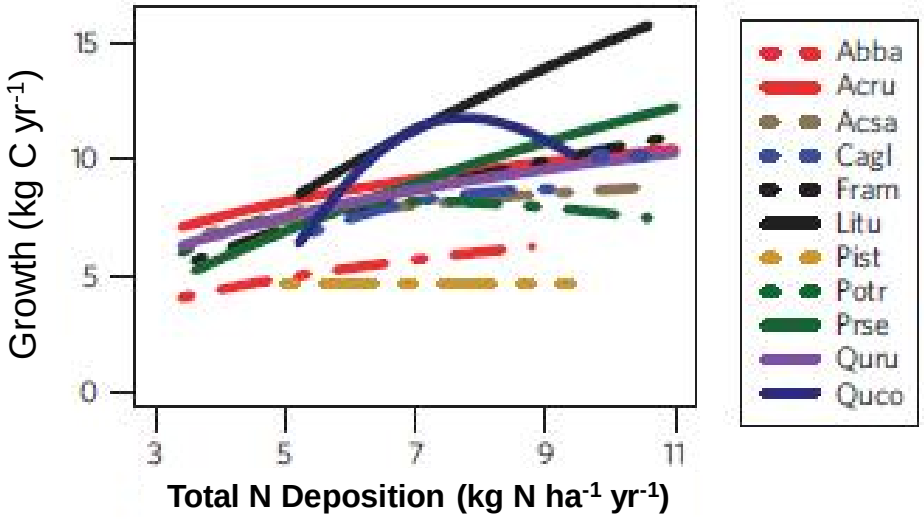
LETTERS

PUBLISHED ONLINE: 22 DECEMBER 2009 | DOI:10.1038/NGEO721

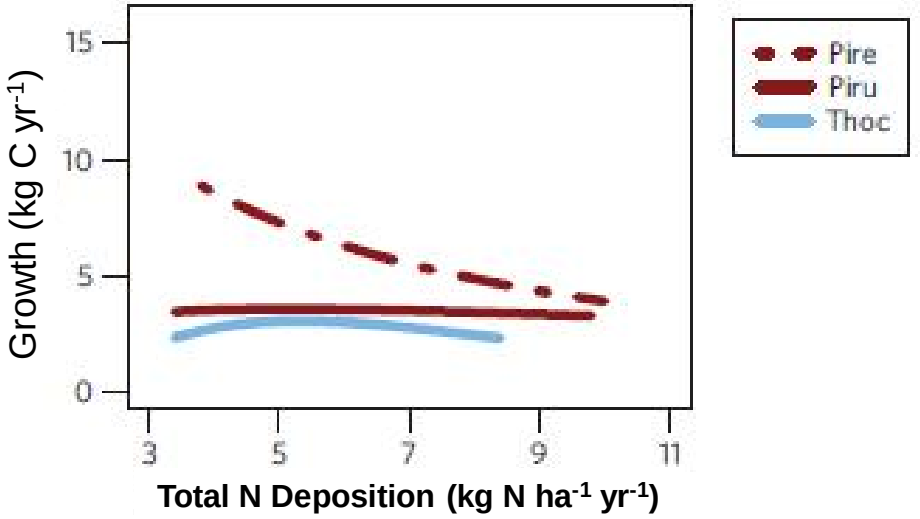
Increased tree carbon storage in response to nitrogen deposition in the US

R. Quinn Thomas[1]*, Charles D. Canham[2], Kathleen C. Weathers[2] and Christine L. Goodale[1]

Net Positive Response



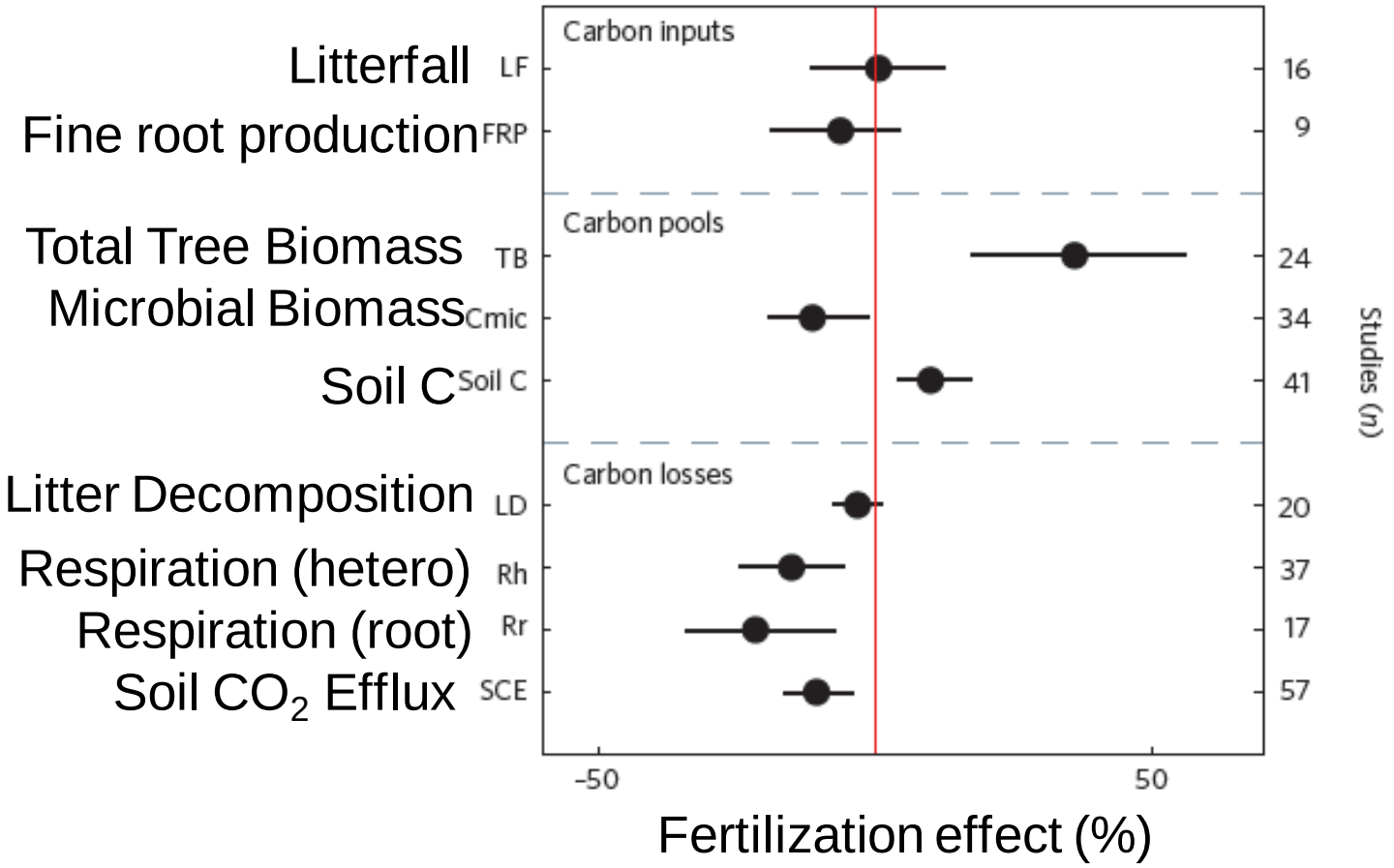
Net Negative Response



- Variable response among tree species
- Average: 61 kg C per kg total N deposition

Janssens et al. 2010

Nature Geoscience



- 20 Forest Studies
- Elevated N decreases rates of respiration by 16%
- Increases stability of SOM

Ecology Letters, (2009) **12**: 1103–1117 doi: 10.1111/j.1461-0248.2009.01351.x

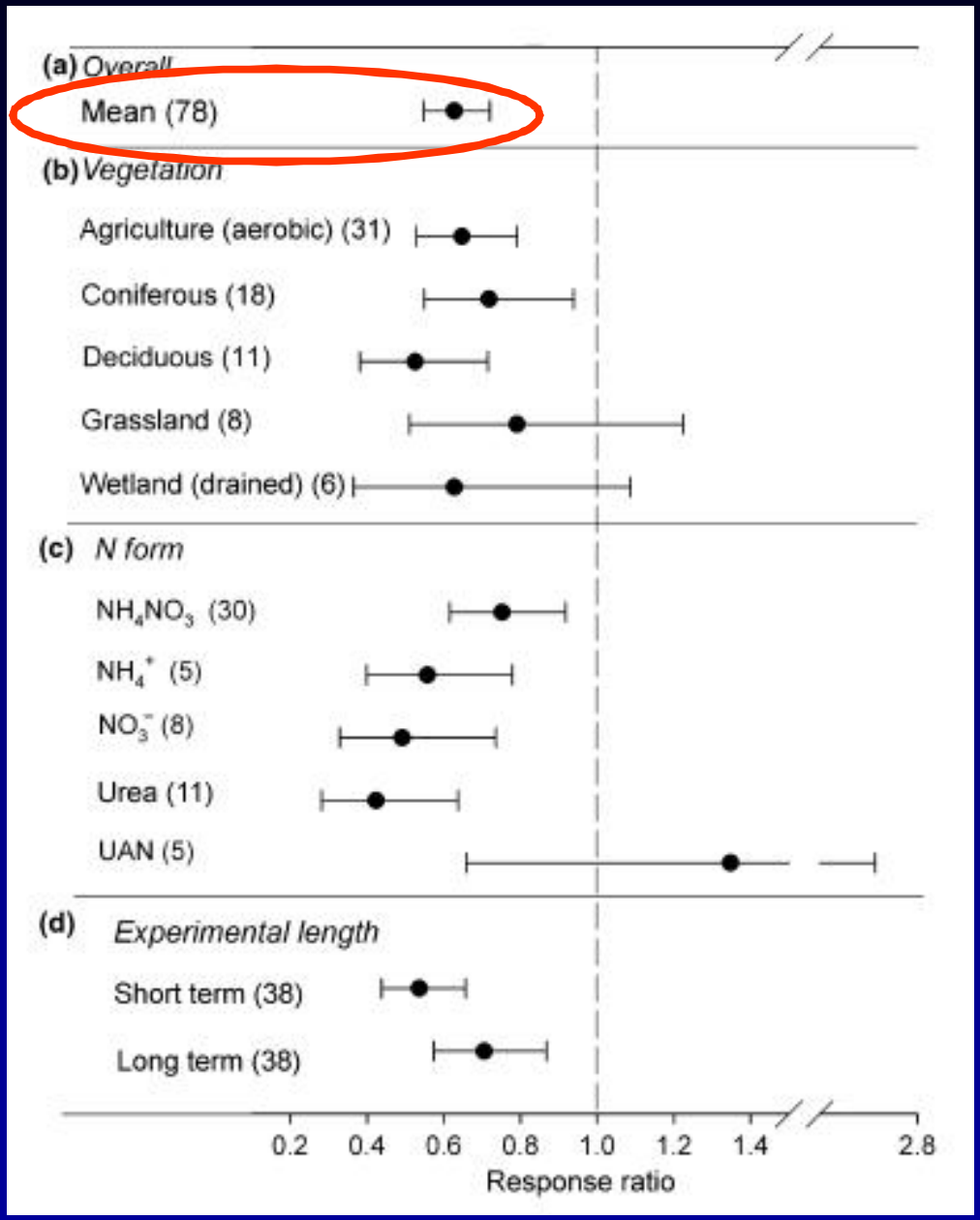
REVIEW AND SYNTHESIS

A review of nitrogen enrichment effects on three biogenic GHGs: the CO_2 sink may be largely offset by stimulated N_2O and CH_4 emission

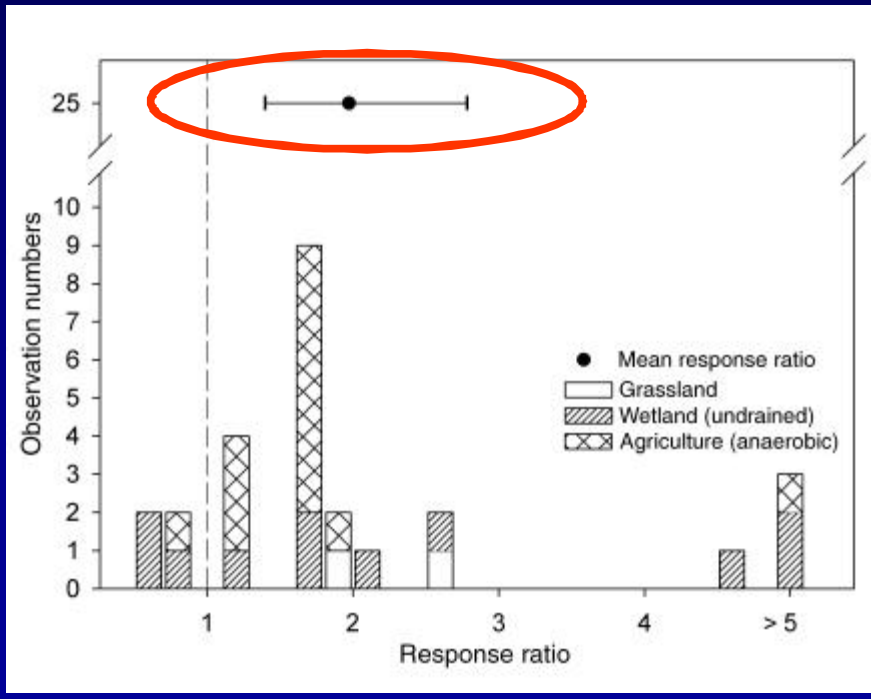
- Meta-analysis of 109 studies
- N additions increased C content forests by 6%

Liu and Greaver 2009. *Ecology Letters*

Impacts of N Addition on CH_4 Fluxes

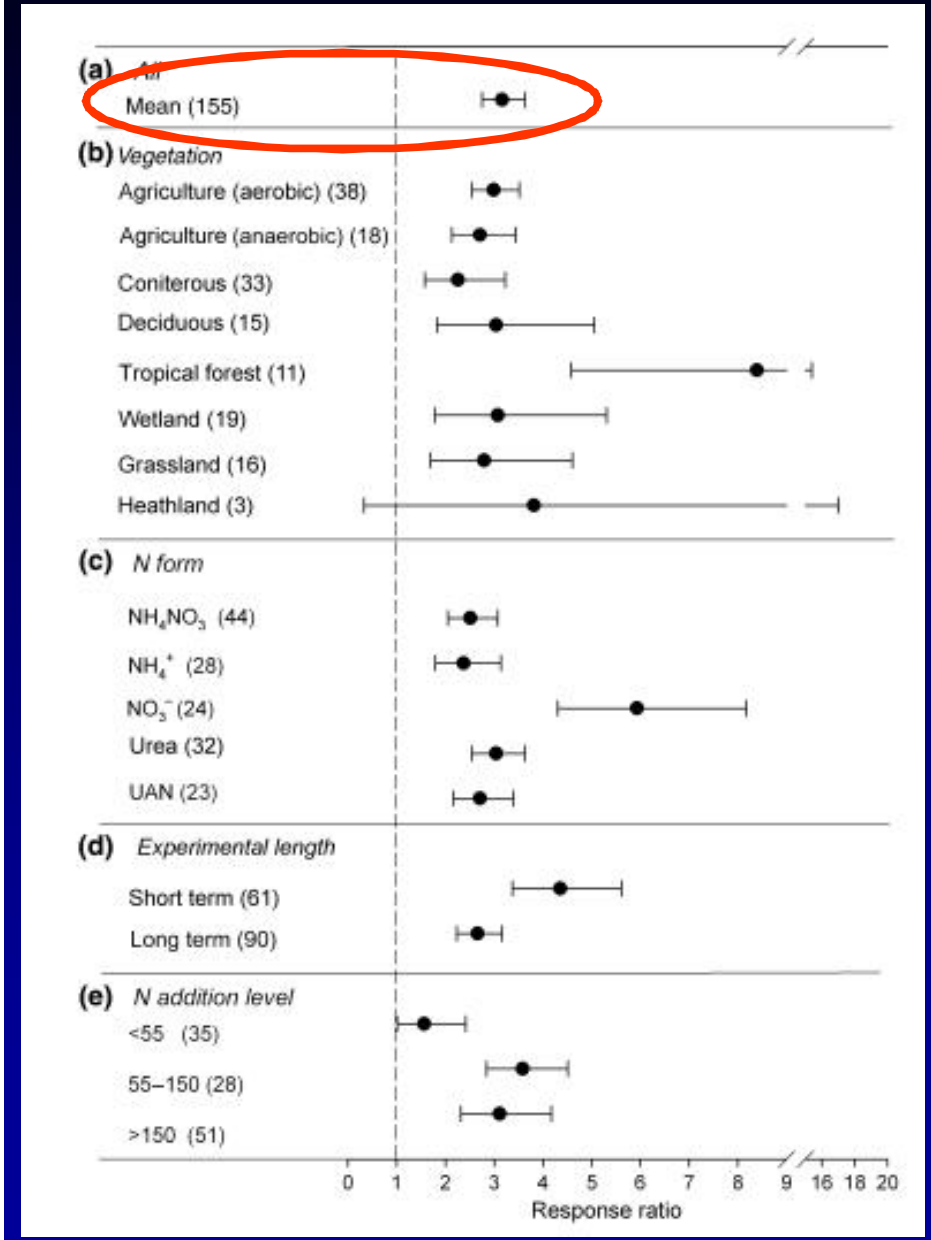


38% decrease CH_4 uptake
97% increase CH_4 emissions



Liu and Greaver 2009. *Ecology Letters*

Impacts of N Addition on N_2O Fluxes



216% increase N_2O emissions

Net effect of N addition:

- Increases global C terrestrial sink
- But, offset by 53-76% by increased CH_4 & N_2O emissions

Liu and Greaver 2009. *Ecology Letters*

N Deposition and Carbon Storage

- Current state of knowledge
- Meta-analysis of ^{15}N tracer studies

Fate of Nitrogen Inputs in Terrestrial Ecosystems: Meta-analysis of ^{15}N Tracer Studies

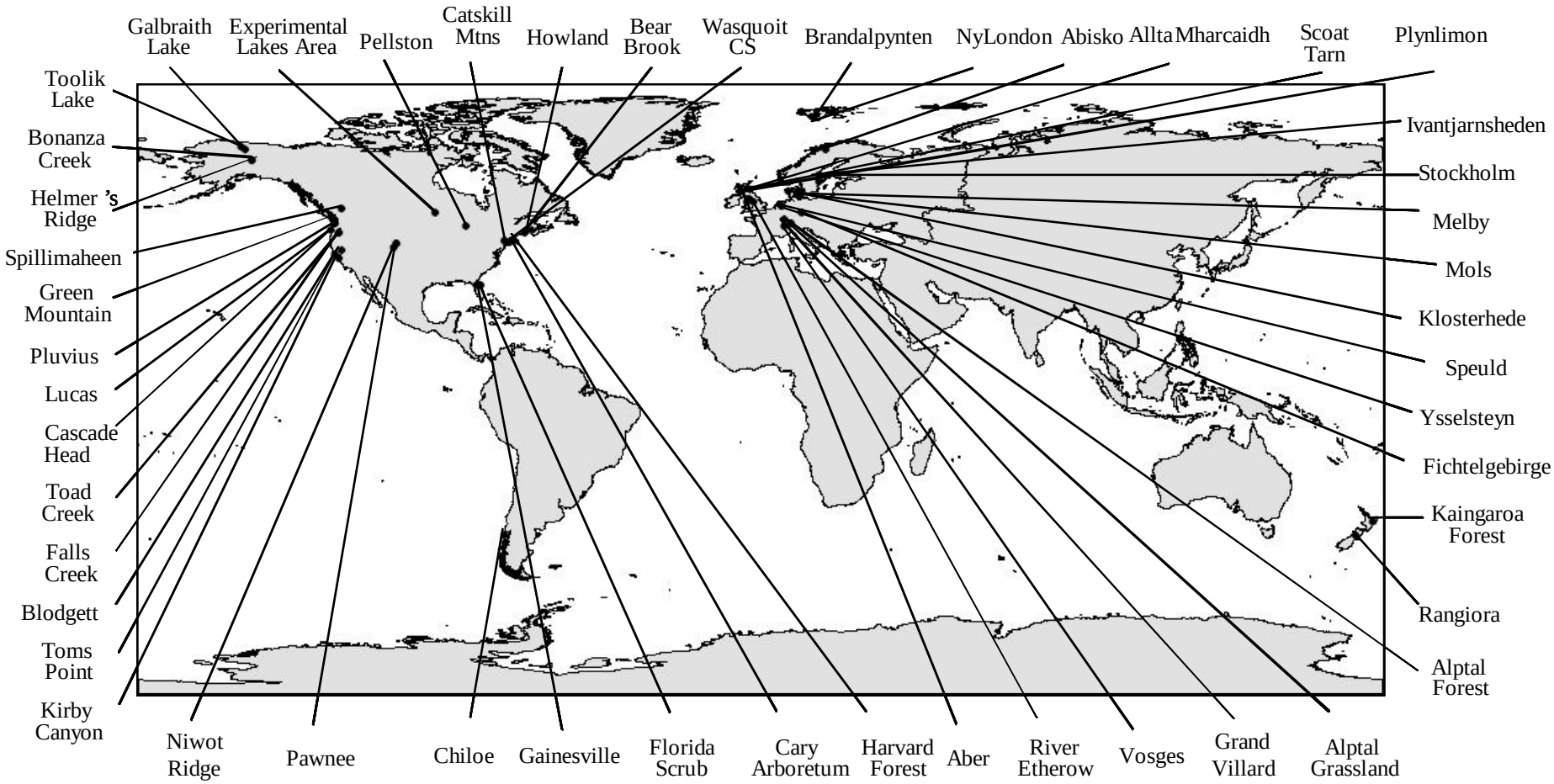
Templer PH , MC Mack, FS Chapin, LM Christenson,
J Compton, H Crook, B Currie, C Curtis, B Dail, C D'Antonio, BA
Emmett, H Epstein, C Goodale, P Gundersen, SE Hobbie, K Holland,
DU Hooper, BA Hungate, S Lamontagne, K Nadelhoffer,
CW Osenberg, SS Perakis, P Schleppi, J Schimel, IK Schmidt,
M Sommerkorn, J Spoelstra, A Tietema, WW Wessel, S Lamontagne, D Zak

Goal

To determine the fate of deposited nitrogen across a range of:

- climatic conditions
- N loading
- vegetation types

Distribution of Sites



N Deposition: <1.5 to 60 kg N ha^{-1} yr^{-1}

Ecosystem Types

What is the fate of deposited N within terrestrial ecosystems?

What is the effect of fertilizer N addition?

Conclusions from ^{15}N Tracer Meta-Analysis

- Most ^{15}N tracer accumulated belowground
- ^{15}N recovery in wood of shrublands (19%) > forests (3.3%)
- kg C per kg N: shrublands (125) > forests (46)
- Total C: 0.13 to 0.45 Pg C yr^{-1}

- With N fertilization:
  - Decreased forest ecosystem N retention
  - Increased C storage due to movement of N from low C:N soils to high C:N wood

Where do we go from here?

- Need better understanding:
  - Role of ecosystem type, species composition and distribution
  - N inputs (fixation) and losses (denitrification)
  - Interactions with other nutrients (P, Ca, Mg)
  - How interactions will change with climate
  - N deposition effects in non N-limited ecosystems such as tropics
  - Longer-term feedbacks: most studies examining fate of N occur within decade (exception = 20 years at Harvard forest)
  - Other controls on allocation

  - Models that reflect this understanding