Nitrogen level and water stress influence on physiology of several tree species

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Important Challenges

1. Atmospheric deposition
2. Climate change to drought

Introduction

1. Atmospheric Deposition

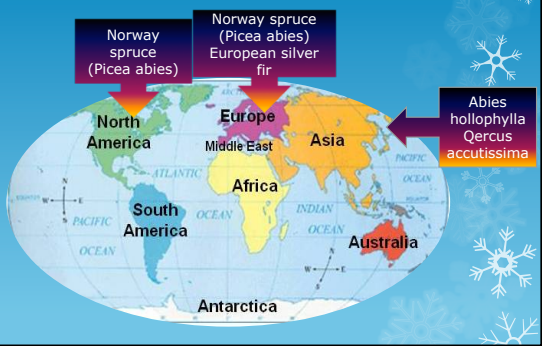
- airborne particles and gases are deposited on the earth's surface (Potter, 2000)

Atmospheric Nitrogen increase

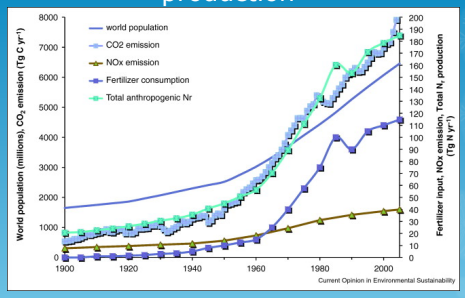
- Nitrogen (N) and sulfur (S) form acid rain
- US nitrogen deposition – 3.74 to 4.54 Teragrams N per year
- Europe nitrogen deposition - 8.42 to 11.15 Teragrams N per year

(Holland et al., 2005)

Forest decline occurrences related to air pollution

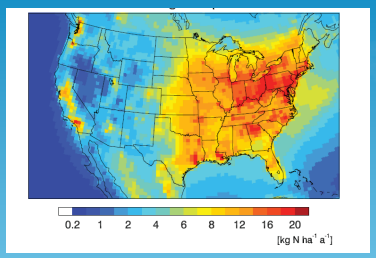


Anthropogenic reactive nitrogen production



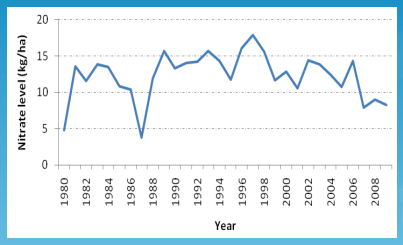
Global trends in human population, CO_2 emissions in Tg C and total anthropogenic reactive nitrogen production (in Tg N) throughout the 20th century (Erisman *et al.*, 2011)

Total nitrogen deposition in U.S.



Simulated annual total nitrogen deposition fluxes over the U.S. values are averages for 2006-2008 (Zhang et al., 2012)

Nitrogen deposition in Tennessee



Nitrate (NO_3) level in annual precipitation from 1980 to 2009 in Great Smoky Mountain – Elkmont

Effects of nitrogen deposition

- Chronic inputs of N deposition can cause leaching of base cations from the soil (McLaughlin et al., 1998), tree mortality (McNulty et al., 2005)
- increase aluminum toxicity to roots (Shortle and Smith, 1988),
- decrease fine root biomass (Nadehoffer, 2000),
- reduce tree cold tolerance (Sheppard, 1994), and
- increase freezing injury in spruce needles (Schaberg et al., 2002).

Responses of eastern hardwood forests to excess nitrogen (N) deposition

- increases in plant tissue N - (Thomas *et al.*, 2010)
- soil N cycling -
- nitrate (NO3-) leaching - (Bailey *et al.* 2005)
- decreases in soil carbon:nitrogen (C:N) ratio -(Driscoll et al. 2003).
- shifts in community composition, including declines in species richness and abundance -(Gilliam 2006)

Responses of eastern hardwood forests to excess nitrogen (N) deposition

- Benefit from nitrogen deposition (marked increase tree growth)

– All hardwood tree species with arbuscular mycorrhizal associations

- Six tree species with ectomycorrhizal associations

Responses of eastern hardwood forests to excess nitrogen (N) deposition

- Benefit from nitrogen deposition (marked increase tree growth)

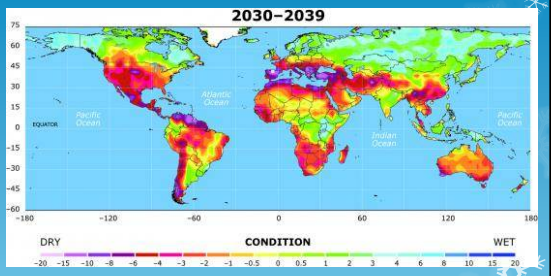
– All hardwood tree species with arbuscular mycorrhizal associations

- Six tree species with ectomycorrhizal associations

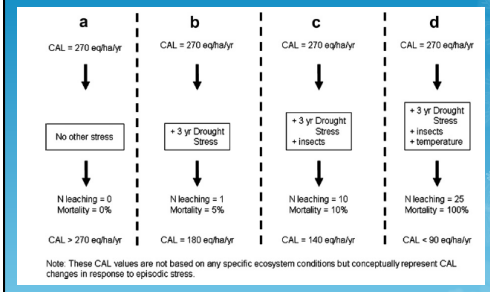
- Detriment from nitrogen deposition (decrease growth and death)

-twelve species including conifers, birch and oaks with ectomycorrhizal association.

2. Climate change and drought



Multiple stresses ??



(McNulty and Boggs, 2010)

Justification

Provide useful guidelines for

- **best fertilizer management**
- **assist in the selection of areas and species**
- **general prediction of future species composition**
- **help maintain or increase timber production**
- **provide habitat for wildlife and recreation**

Objectives

- **To determine acclimation or physiological changes of drought tolerant species to nitrogen addition**
- **To compare the response of selected conifer and deciduous trees to nitrogen addition**
- **To establish the interaction of shade and drought to plants' response with different nitrogen addition**

Hypotheses

- **High drought tolerance species will acclimate more to nitrogen deposition**
- **Deciduous trees response better to more nitrogen than conifers**
- **Shaded trees are less affected by drought compared to unshaded trees**

Planting materials

Species	Drought tolerance	Nitrogen uptake	Shade tolerance
Acer saccharinum L. silver maple	low	slow	Yes
Robinia pseudoacavia L. black locust	high	fast	No
Quercus falcata Michx. Var. falcata southern red oak	high	slow	Intermediate
Quercus michauxii Nutt. swamp chestnut oak	low	fast	No
Quercus velutina Lam. black oak	high	slow	Intermediate
Liquidambar styraciflua L sweetgum	low	fast	No
Platanus occidentalis L. sycamore	high	fast	No
Pinus echinata Mill. shortleaf pine	high	fast	-
Pinus strobus L. eastern white pine	low	slow	-

- Preparation –scarification, stratification

Planting

- Experiment location
  South Greenhouse University of Tennessee

Proposed methods

- **Experimental design –complete randomized block split plot design**

- **6 treatments**

1. **0.2 g/m2 Nitrogen open/unshaded**
2. **2.0 g/m2 Nitrogen open/unshaded**
3. **20.0 g/m2 Nitrogen open/unshaded**
4. **0.2 g/m2 Nitrogen shaded**
5. **2.0 g/m2 Nitrogen shaded**
6. **20.0 g/m2 Nitrogen shaded**

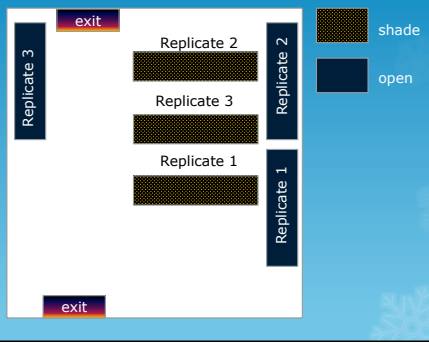
Water stress will be induced at the end of the experiment

- **12 plants / replicate / species**

Location in the greenhouse




Location in the greenhouse



Parameters

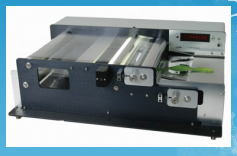
Proposed method for Objective 1 : To determine acclimation or physiological changes of drought tolerance species to nitrogen addition

Photosynthesis rate
Transpiration rate

infrared gas analyser, IRGA (LI-6400 Portable Photosynthesis System, LI-COR, U.S.A.).

Proposed method for Objective 2 :To compare the response of selected conifer and deciduous trees to nitrogen addition

Growth :
Leaf area
Total root and shoot length
Biomass root and shoot
Chlorophyll content



Leaf area meter

spectrophotometer

Proposed method for Objective 3 : To establish the interaction of shade and drought to plants' response with different nitrogen addition

Water potential
Photosynthesis rate
injury

Measurements are before and after water stress

Statistical analysis

- Analysis of variance – compare means of measurement
- Regression – relationship of nitrogen, water stress and photosynthetic and transpiration rates

References

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Images resources

- http://itp.learnetic.com/index.php/resources/enthalpy_solution_structure_water_ionic_compound_dissolving_t_page_18.html
- http://www.canstockphoto.com/drop-animated-5828164.html
- http://www.ucdenver.edu/academics/InternationalPrograms/CIBER/WorldRegionResources/Pages/WorldRegionResources.aspx
- http://www1.ncdc.noaa.gov/pub/data/cmb/images/drought/nadm/usnmx-phdi-pg.gif
- http://msnbcmedia4.msn.com/j/MSNBC/Components/Photo/_new/101019_Drought2039.grid-8x2.jpg
-
- http://hydrology1.nmsu.edu/teaching/soil698/pressure-bomb/1000.JPG
- http://www.deagle.com.tw/images-2/biomate3-1.gif
- http://envsupport.licor.com/images/env/product_list_photos/LI-3100C_lg.jpg

Thank you

- **Committee members**

Dr. Jennifer Franklin
Dr. Dave Buckley
Dr. Bill Klingeman
Dr. Sharon Jean-Philippe