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Climate Change in Illinois and Baldcypress Swamps

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USGS
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Climate change in Illinois and baldcypress swamps

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U.S. Department of the Interior
U.S. Geological Survey

Climate Change and Swamps

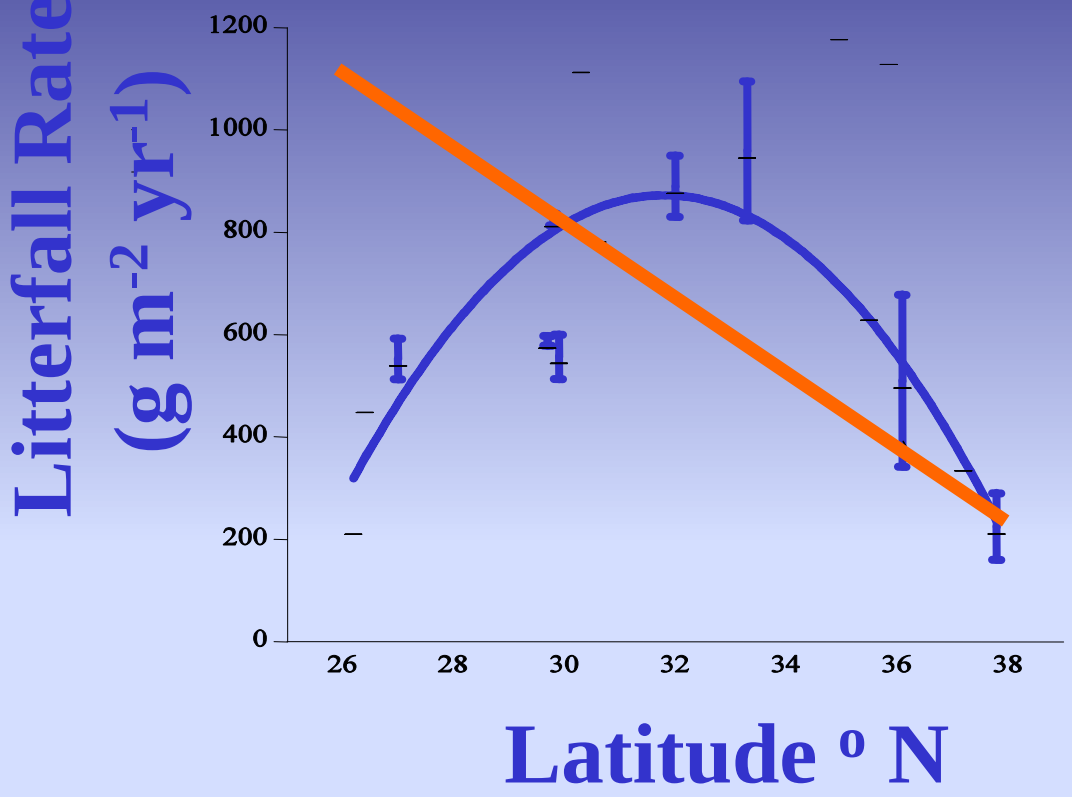
temperature increase

extreme flooding and drought

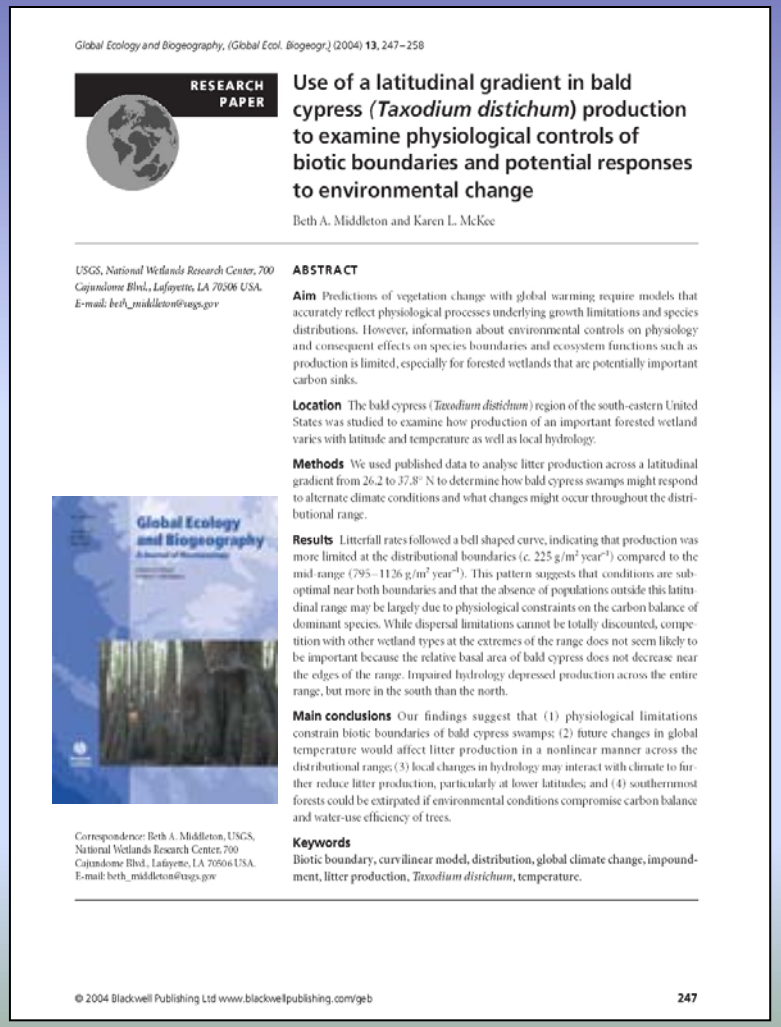
How will the Illinois swamps do?
production
regeneration

PRODUCTION

Litterfall is higher at middle latitude, lower at north and south latitudes.



Global Ecology & Biogeography 13:247-258



Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2004) 13, 247–258

RESEARCH PAPER

Use of a latitudinal gradient in bald cypress (*Taxodium distichum*) production to examine physiological controls of biotic boundaries and potential responses to environmental change

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ABSTRACT

Aim Predictions of vegetation change with global warming require models that accurately reflect physiological processes underlying growth limitations and species distributions. However, information about environmental controls on physiology and consequent effects on species boundaries and ecosystem functions such as production is limited, especially for forested wetlands that are potentially important carbon sinks.

Location The bald cypress (*Taxodium distichum*) region of the south-eastern United States was studied to examine how production of an important forested wetland varies with latitude and temperature as well as local hydrology.

Methods We used published data to analyse litter production across a latitudinal gradient from 26.2 to 37.8° N to determine how bald cypress swamps might respond to alternate climate conditions and what changes might occur throughout the distributional range.

Results Litterfall rates followed a bell shaped curve, indicating that production was more limited at the distributional boundaries (c. 225 g/m² year⁻¹) compared to the mid-range (795–1126 g/m² year⁻¹). This pattern suggests that conditions are sub-optimal near both boundaries and that the absence of populations outside this latitudinal range may be largely due to physiological constraints on the carbon balance of dominant species. While dispersal limitations cannot be totally discounted, competition with other wetland types at the extremes of the range does not seem likely to be important because the relative basal area of bald cypress does not decrease near the edges of the range. Impaired hydrology depressed production across the entire range, but more in the south than the north.

Main conclusions Our findings suggest that (1) physiological limitations constrain biotic boundaries of bald cypress swamps; (2) future changes in global temperature would affect litter production in a nonlinear manner across the distributional range; (3) local changes in hydrology may interact with climate to further reduce litter production, particularly at lower latitudes; and (4) southernmost forests could be extirpated if environmental conditions compromise carbon balance and water-use efficiency of trees.

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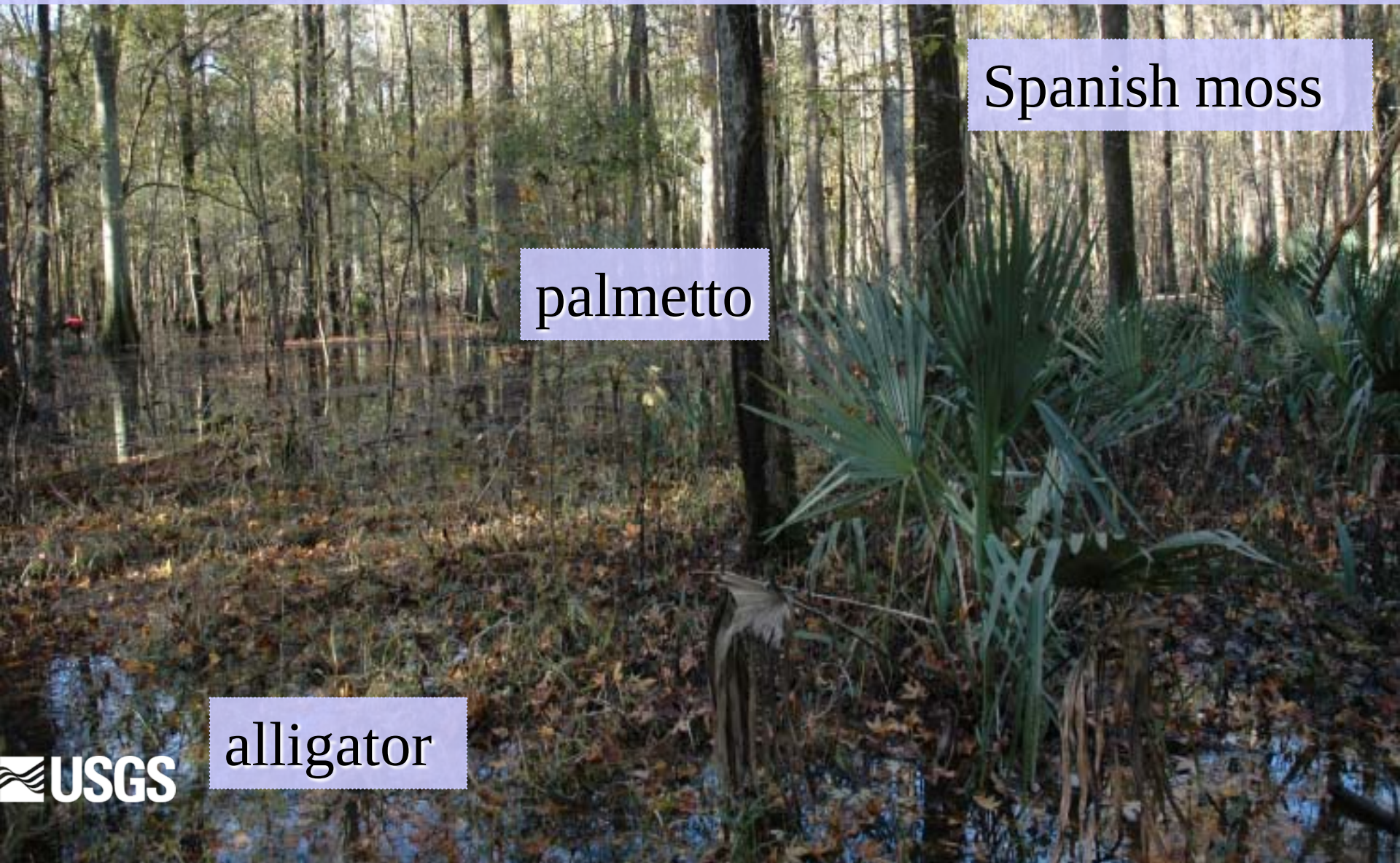
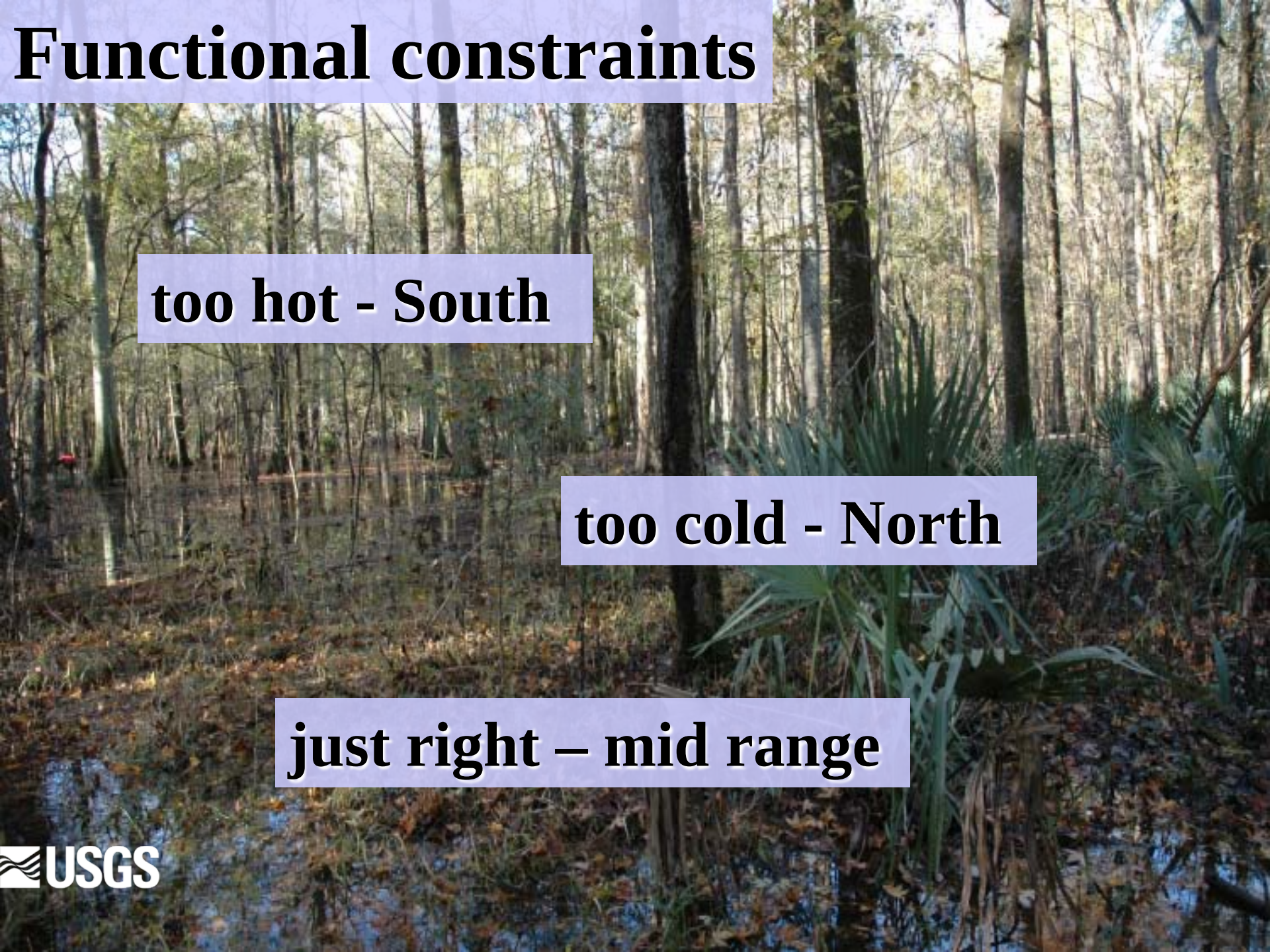
Keywords
Biotic boundary, curvilinear model, distribution, global climate change, impoundment, litter production, *Taxodium distichum*, temperature.

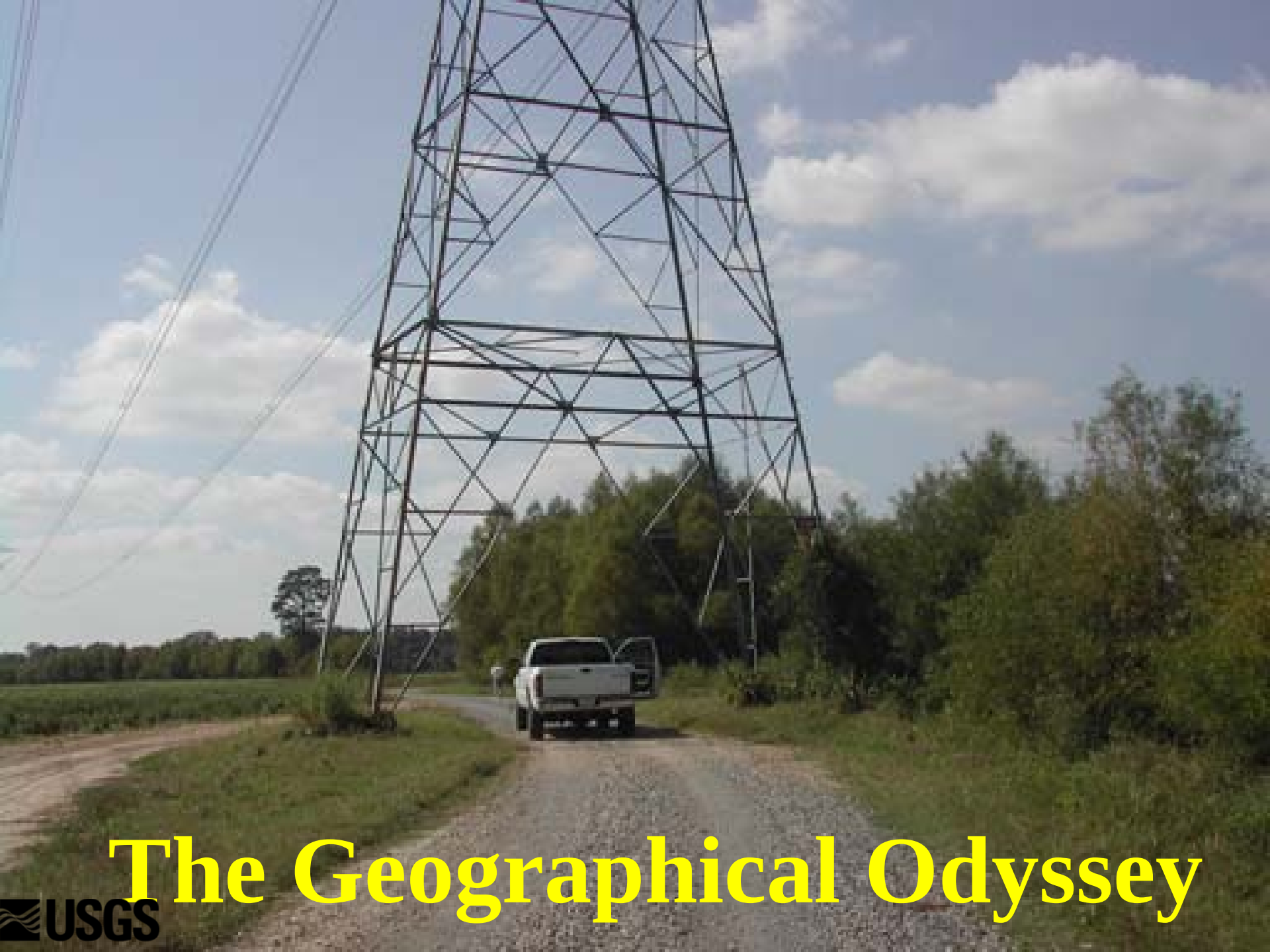
USGS

Wetland function shifts with latitude.
south/north biodiversity

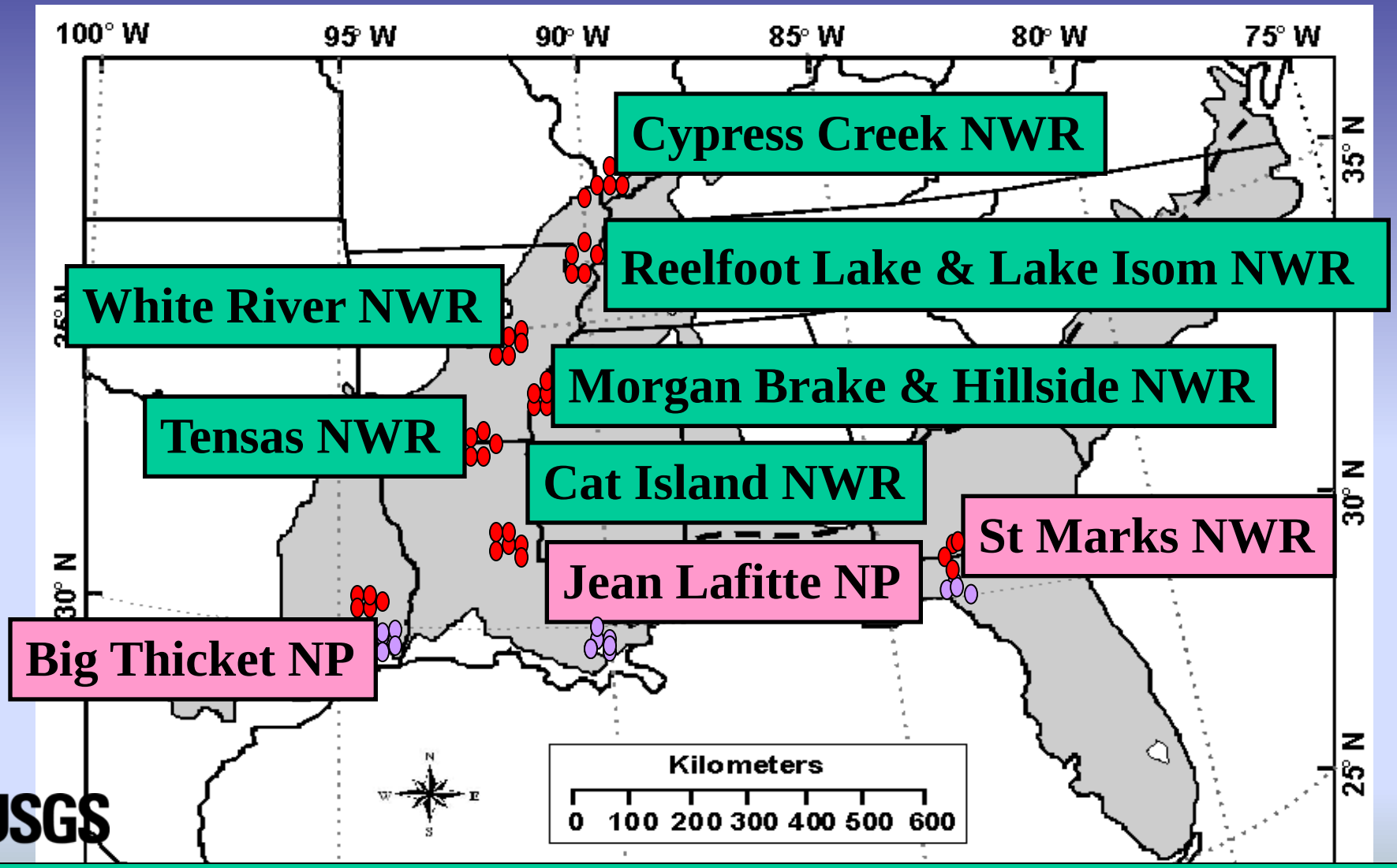


Functional constraints




The Geographical Odyssey
USGS

Production and regeneration studies, latitude and longitude.



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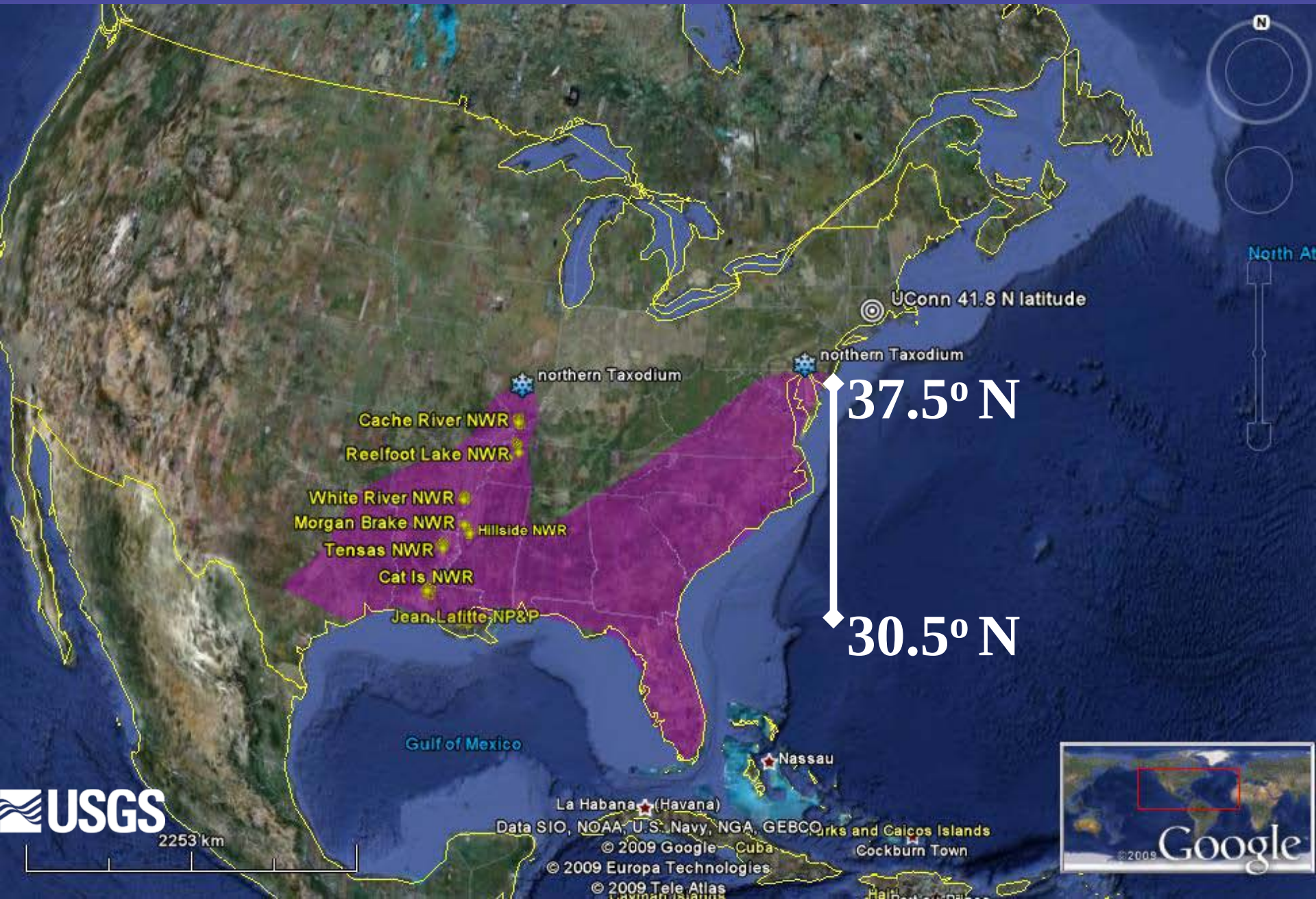
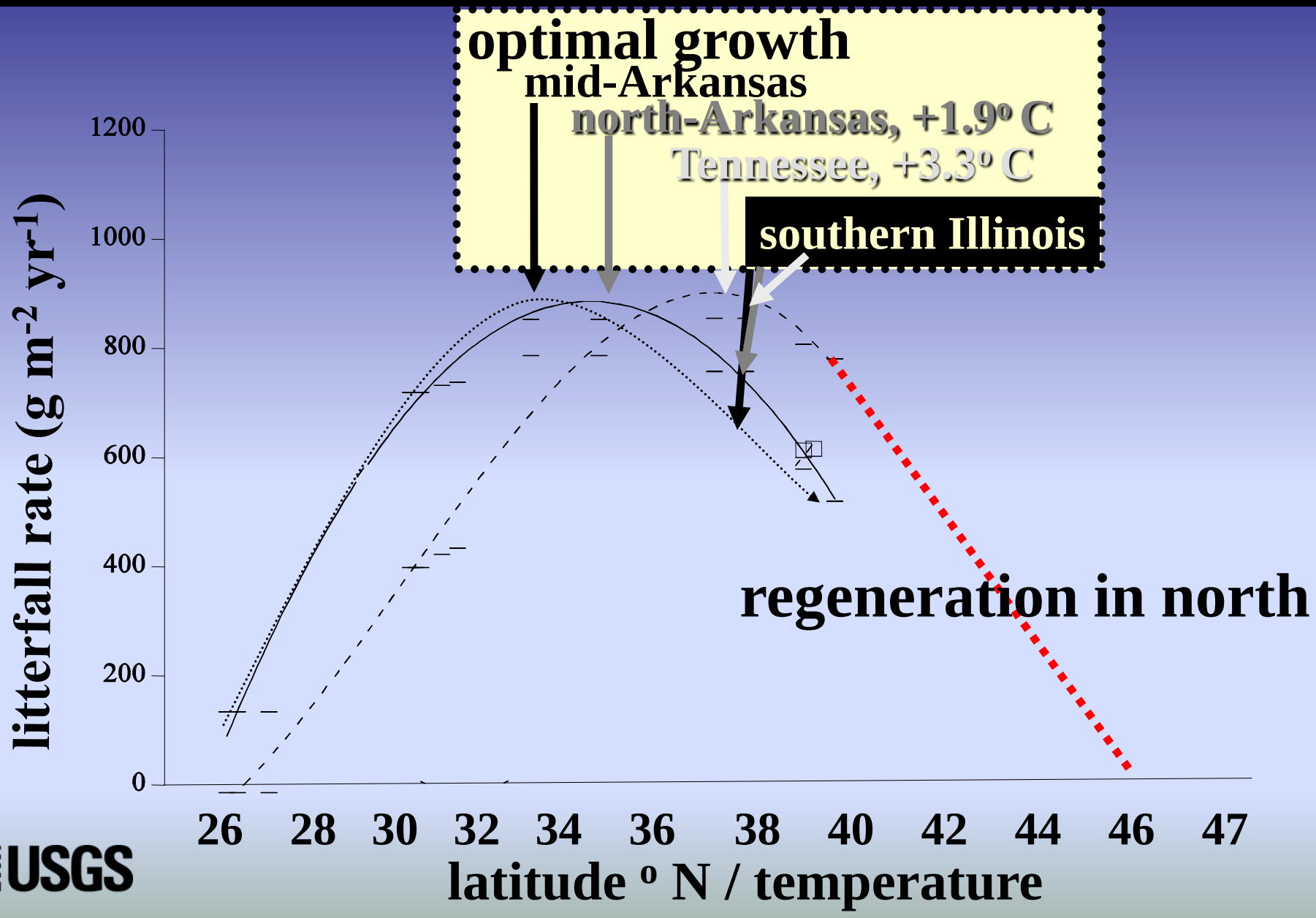
North American Baldcypress Swamp Network

Latitude substitutes space-for-time; 7 latitudes, 5 reps



Climate warming: production maximum shifts north.

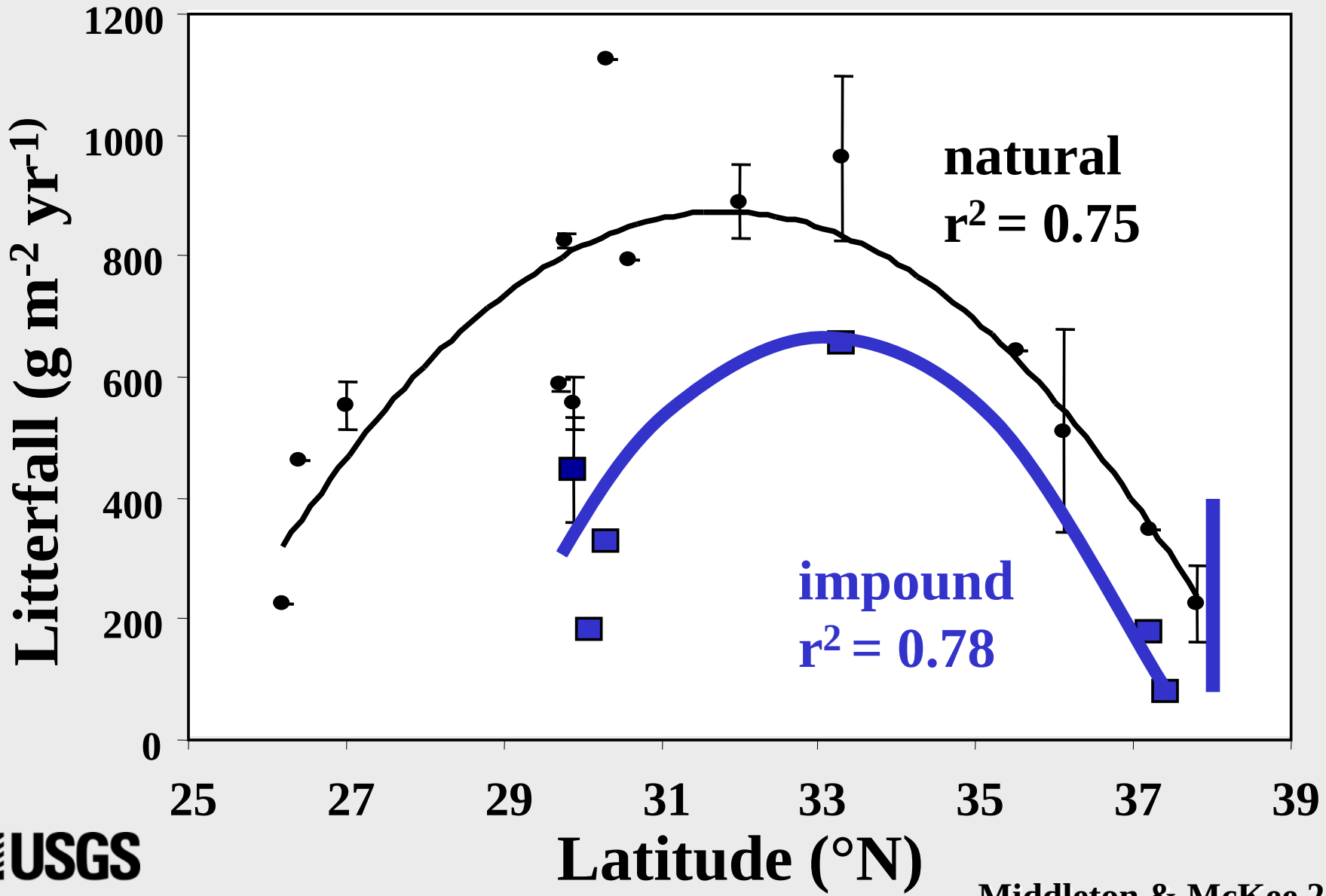


USGS

latitude/temperature: $y = -19 x^2 - 26 x + 284$

Middleton & McKee 2004

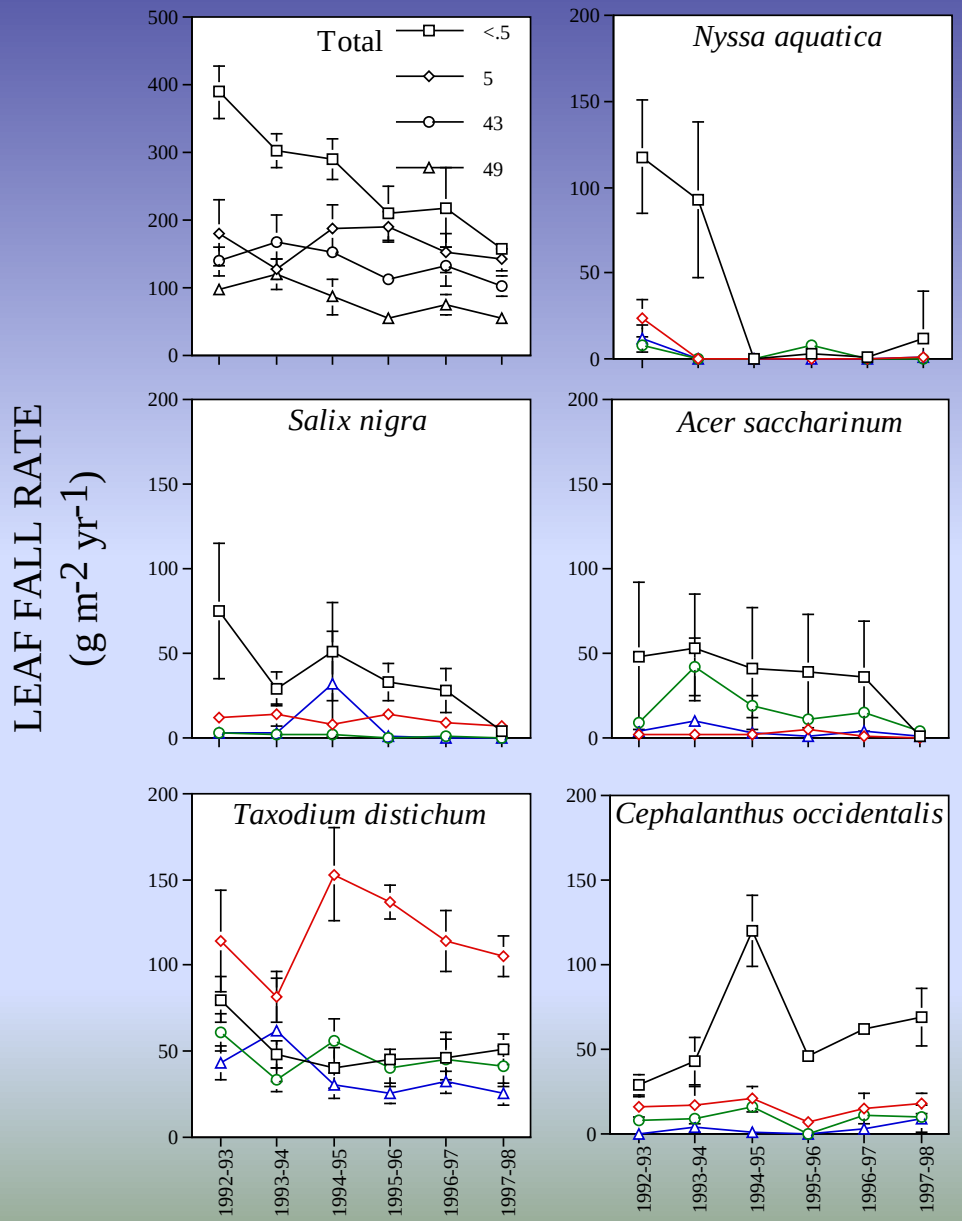
Impoundment & Restoration: Impounded swamps have low levels of production, especially in South.



USGS

Middleton & McKee 2005

Buttonland Swamp Impoundment: production ↓ 1992-98.



USGS

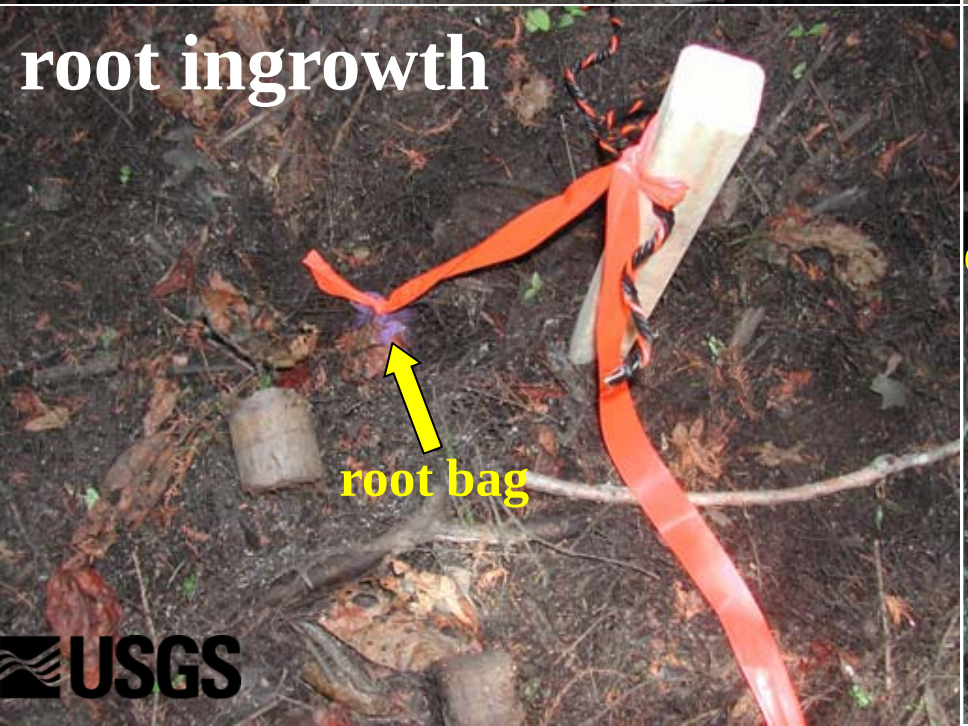
Middleton & McKee 2004

Production monitored

leaf litter

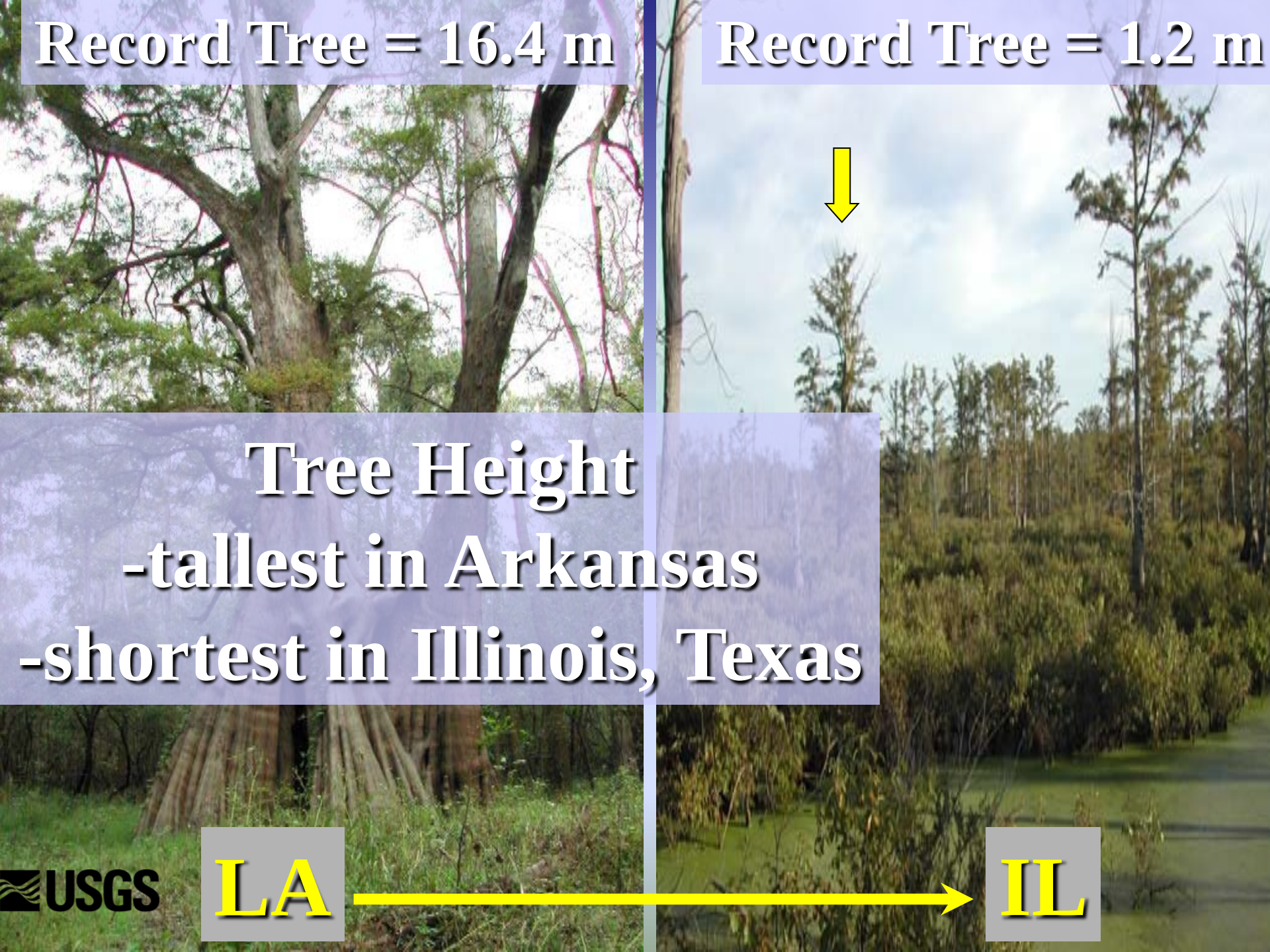
cone size

root ingrowth

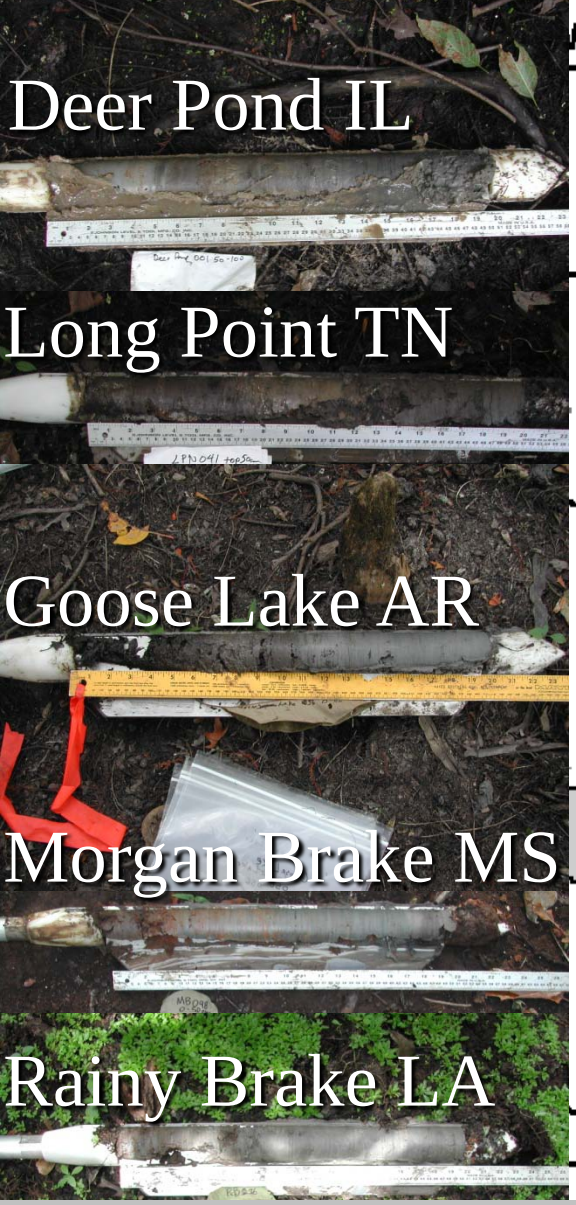


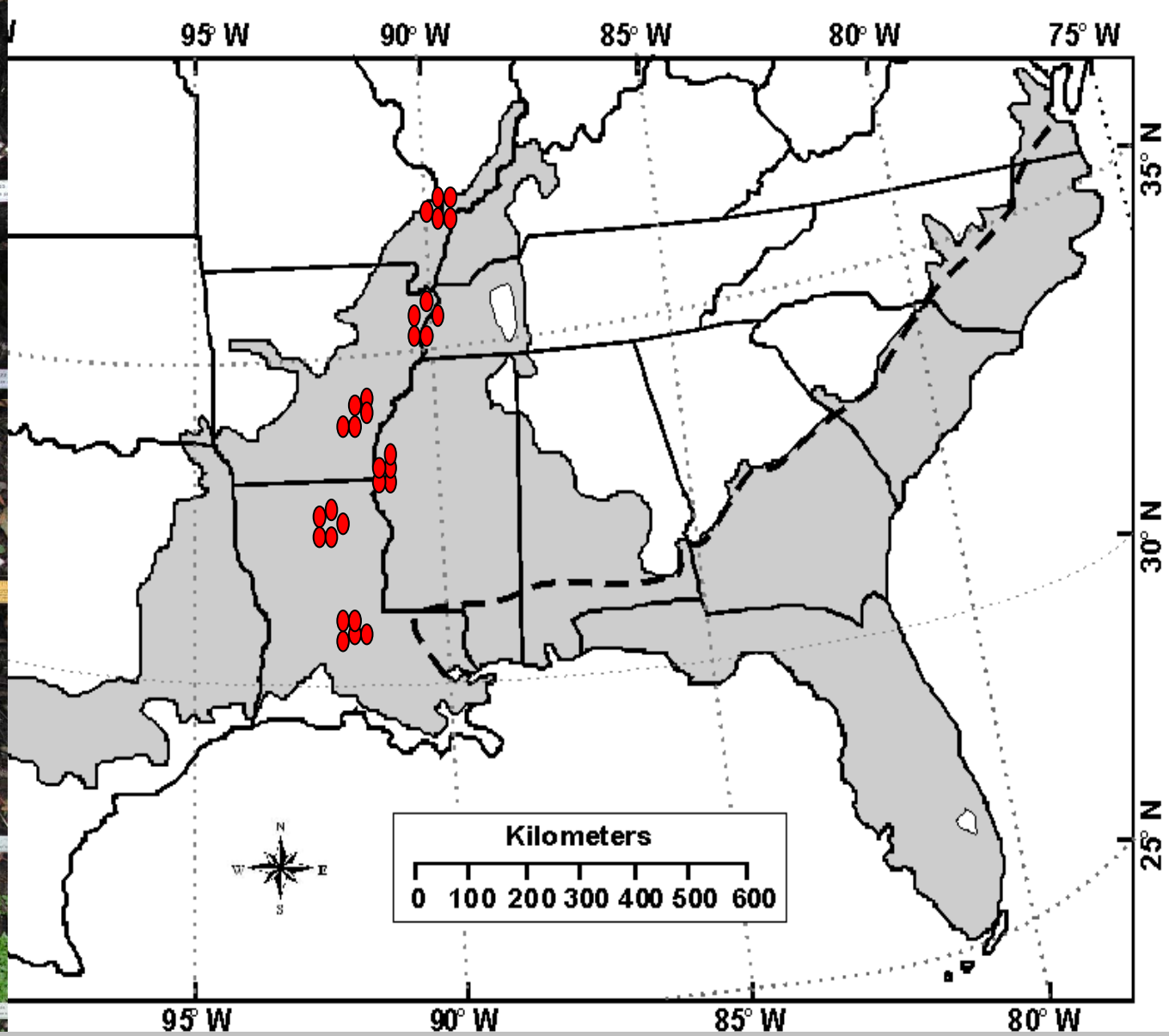
USGS

annual tree growth


Record Tree = 16.4 m
Record Tree = 1.2 m
Tree Height
-tallest in Arkansas
-shortest in Illinois, Texas
USGS
LA
IL

Soil Carbon – The Russian Peat Corer

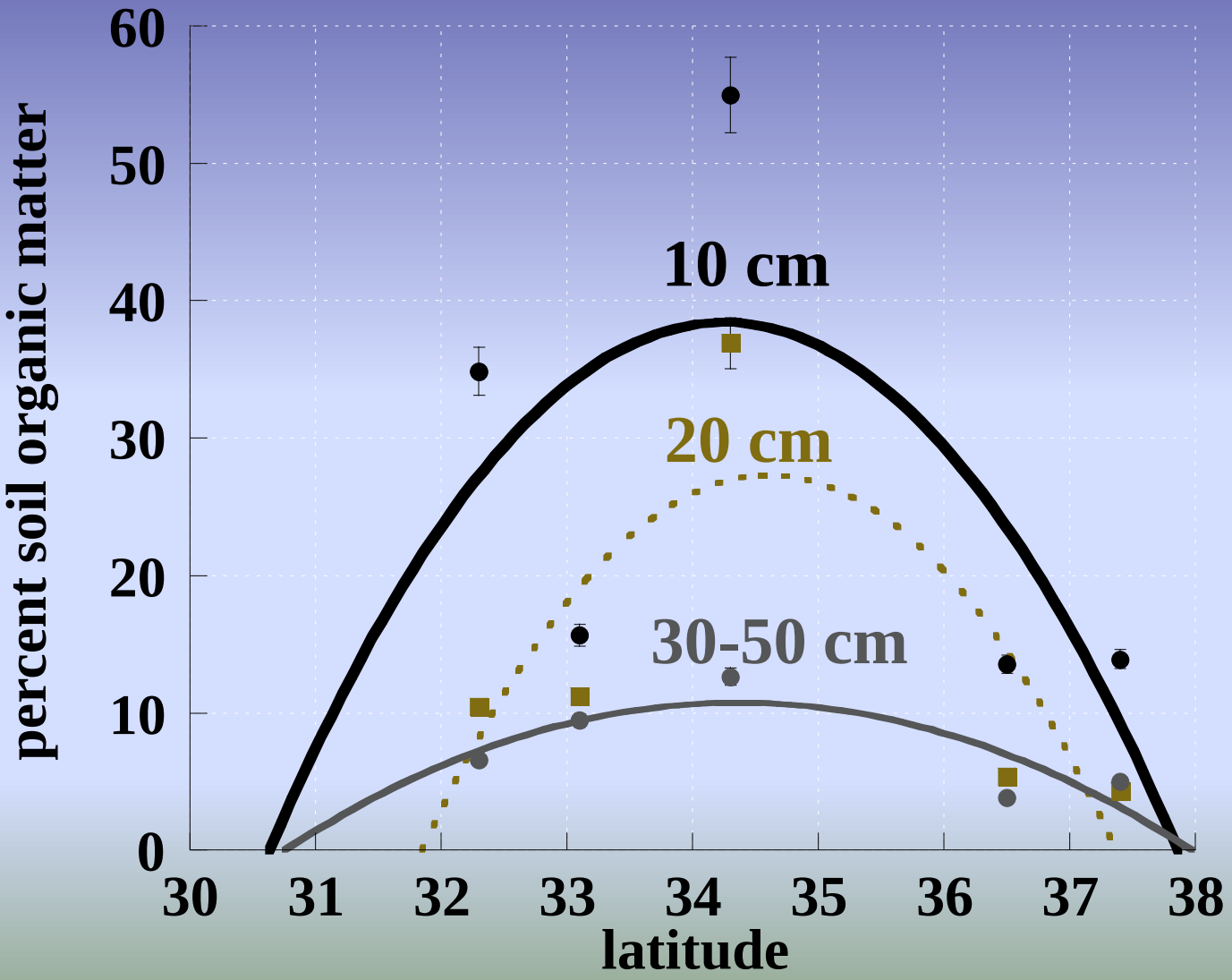




Hypothesis: Carbon highest in mid-range?

USGS

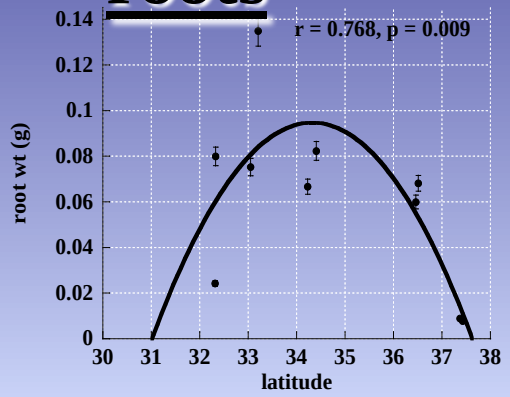
Soil organic matter highest in midrange (AR). Will organic matter increase in Illinois?



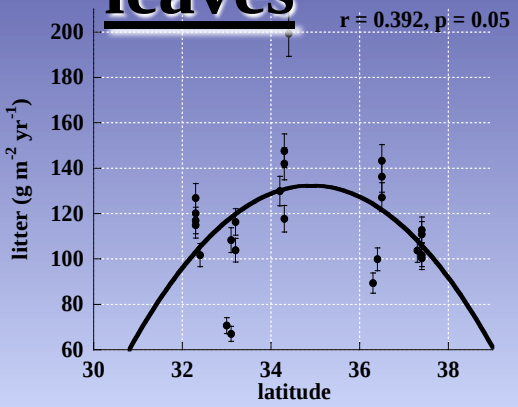
USGS

Leaf, root and soil organic matter highest in mid-range.

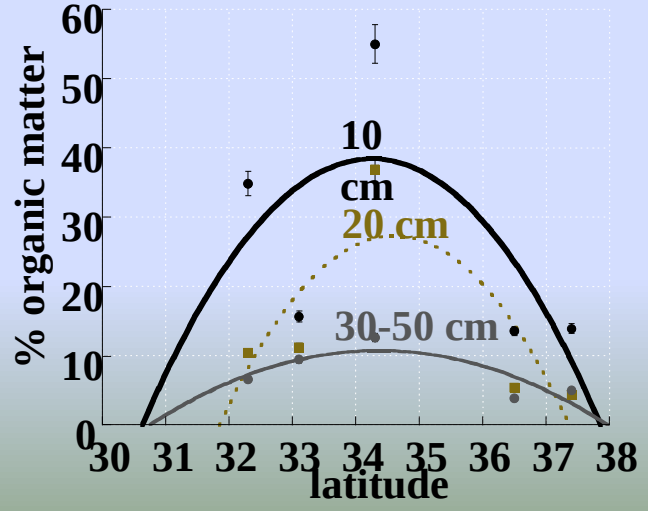
roots



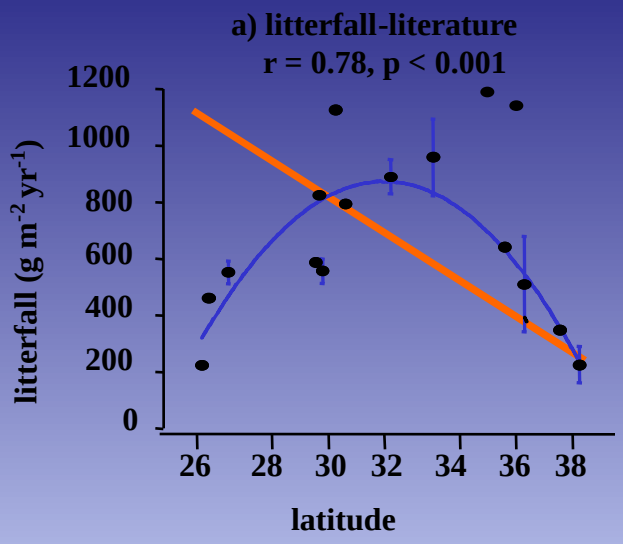
leaves

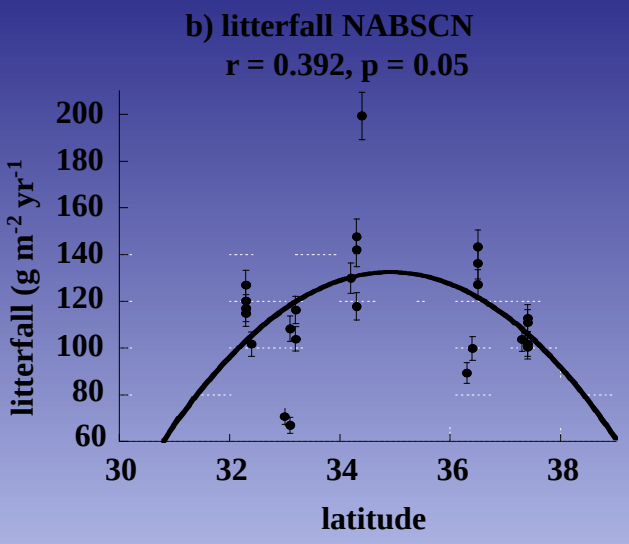


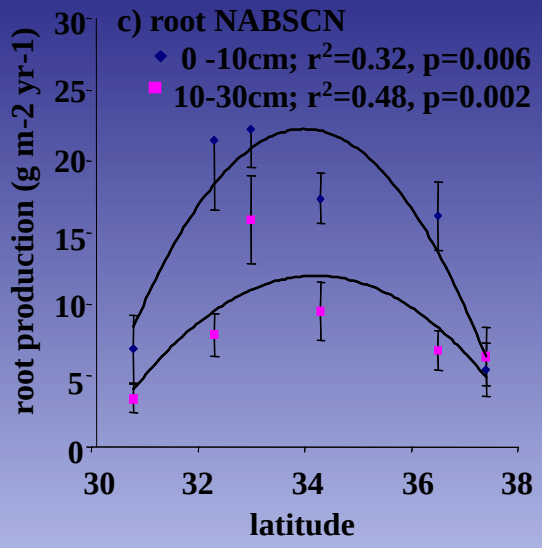
soil organic matter?

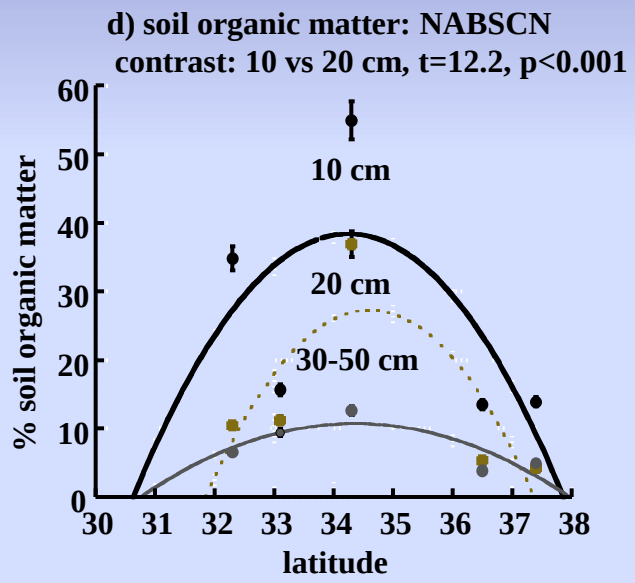


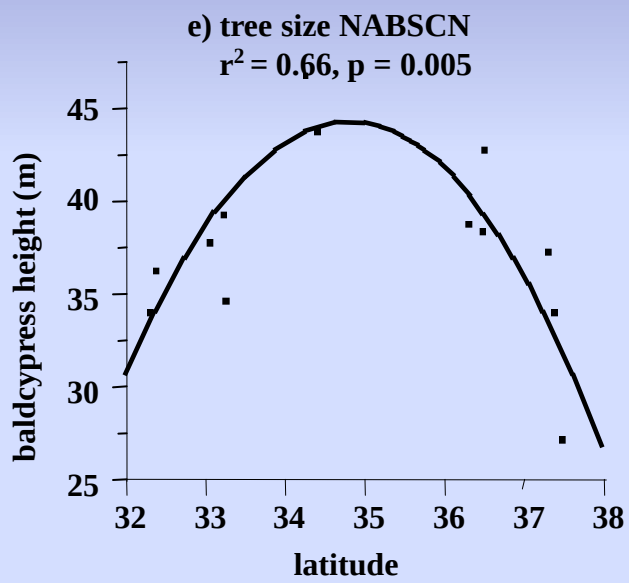
USGS

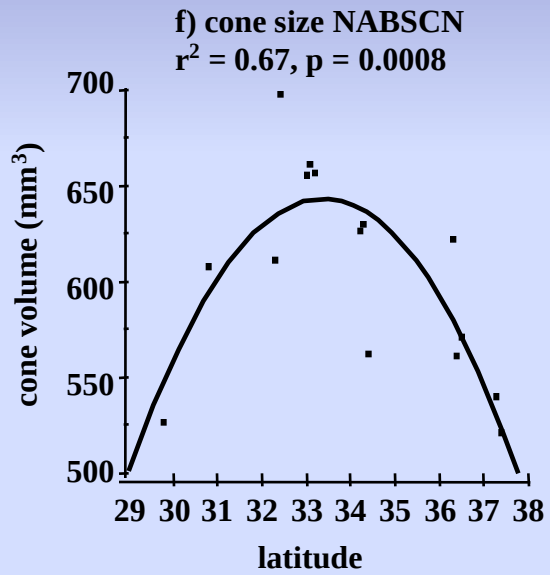












Production will increase in Illinois swamps.

USGS

Elevation, production, decomposition, organic matter monitored

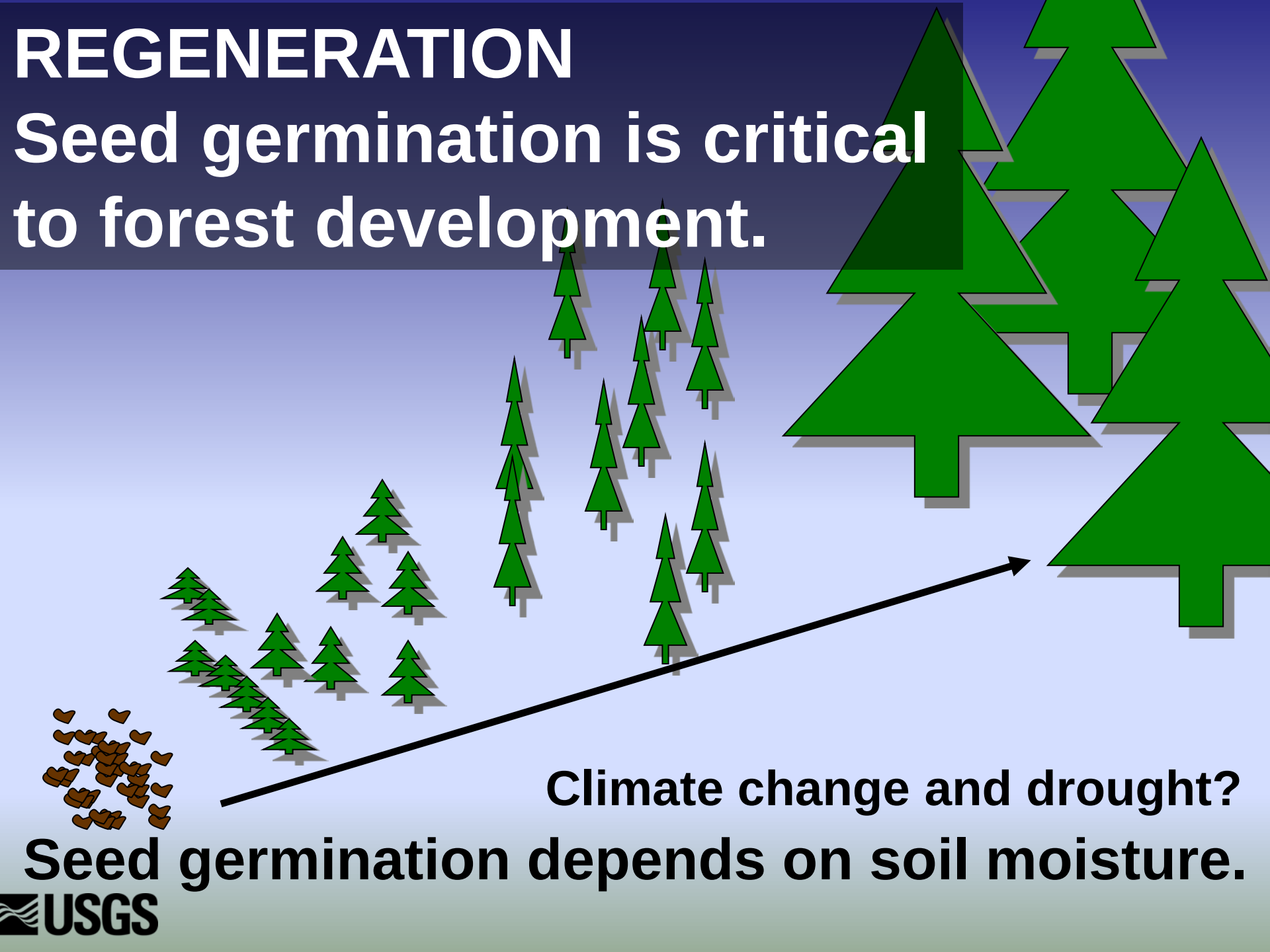
Snake Hole

USGS

SET elevation increase north decrease south

REGENERATION

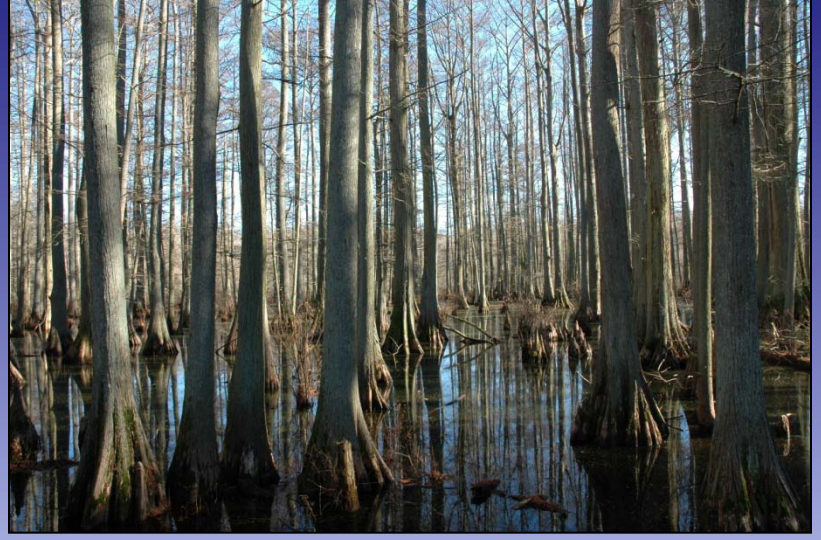
Seed germination is critical to forest development.



Climate change and drought?

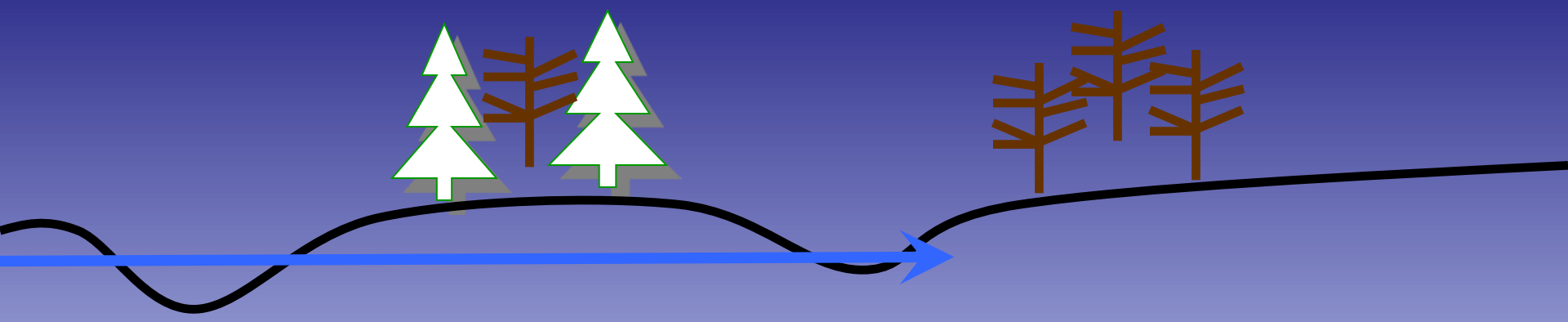
Seed germination depends on soil moisture.

USGS

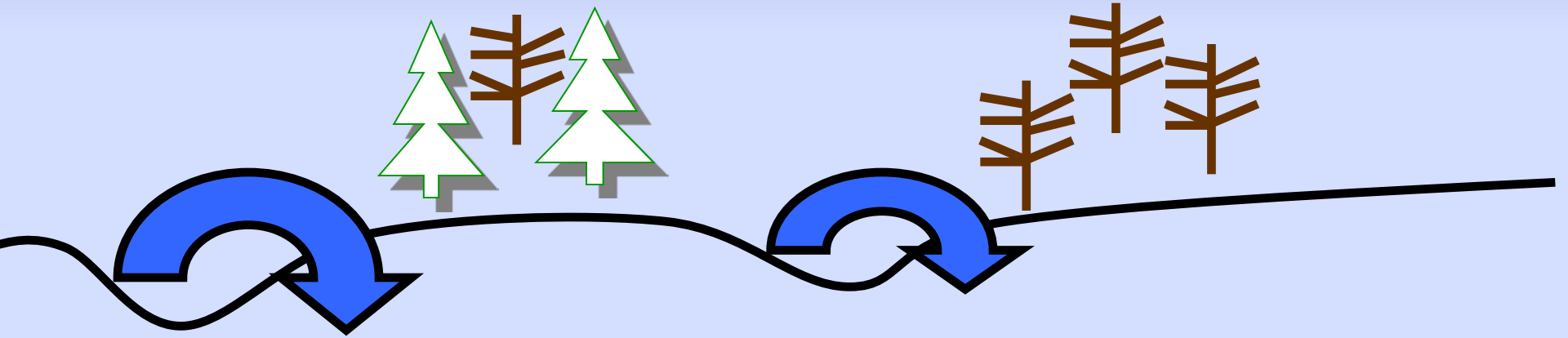


Climate change will alter drawdown/flooding.
Biodiversity patterns will shift.

USGS



seeds disperse across floodplain



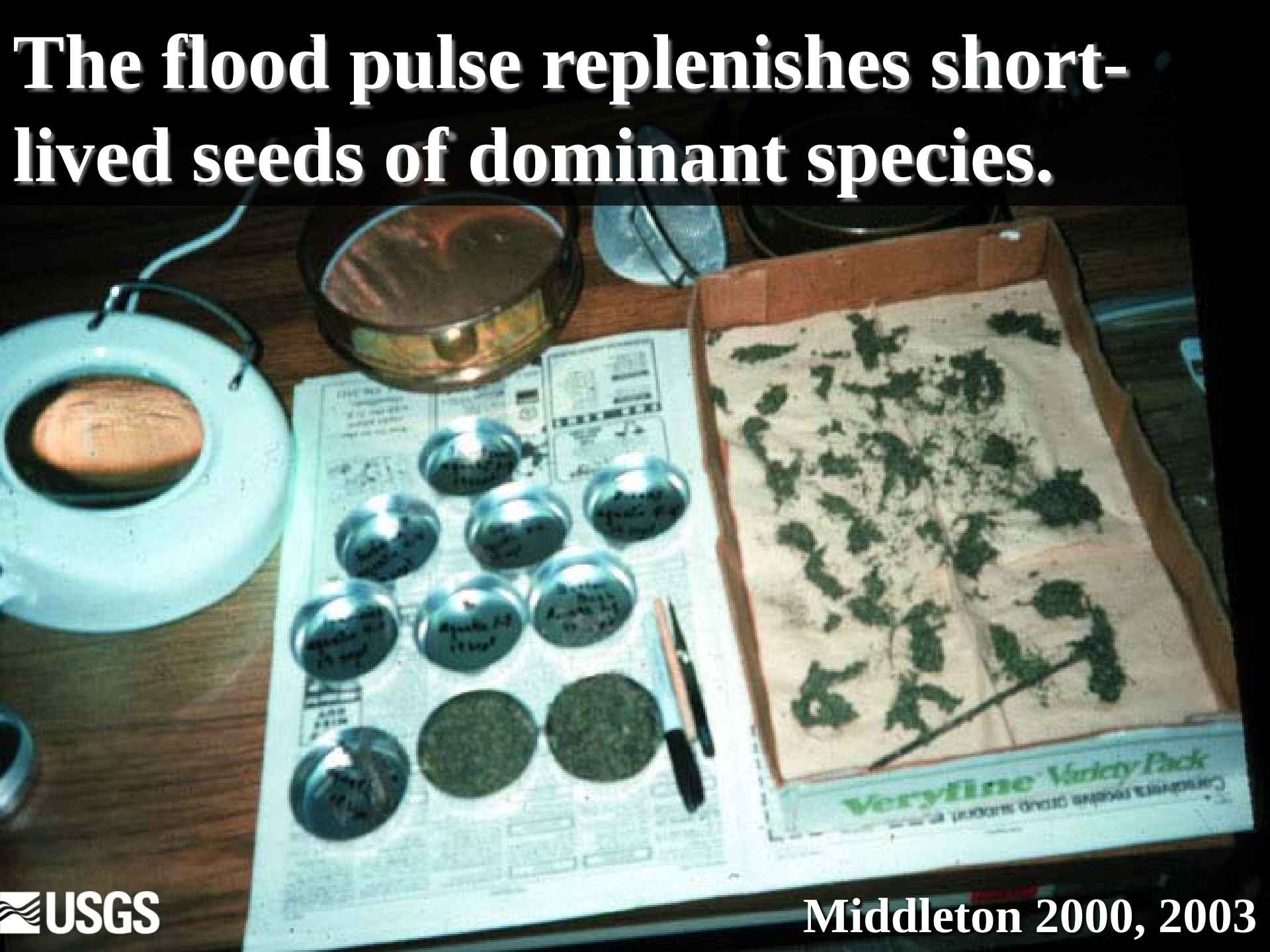
seeds migrate downstream in channel

USGS

Middleton 1999. Book: Wetland restoration
Middleton 2000 *Plant Ecology* 146:169-184

Aquatic species will migrate downstream, southward.

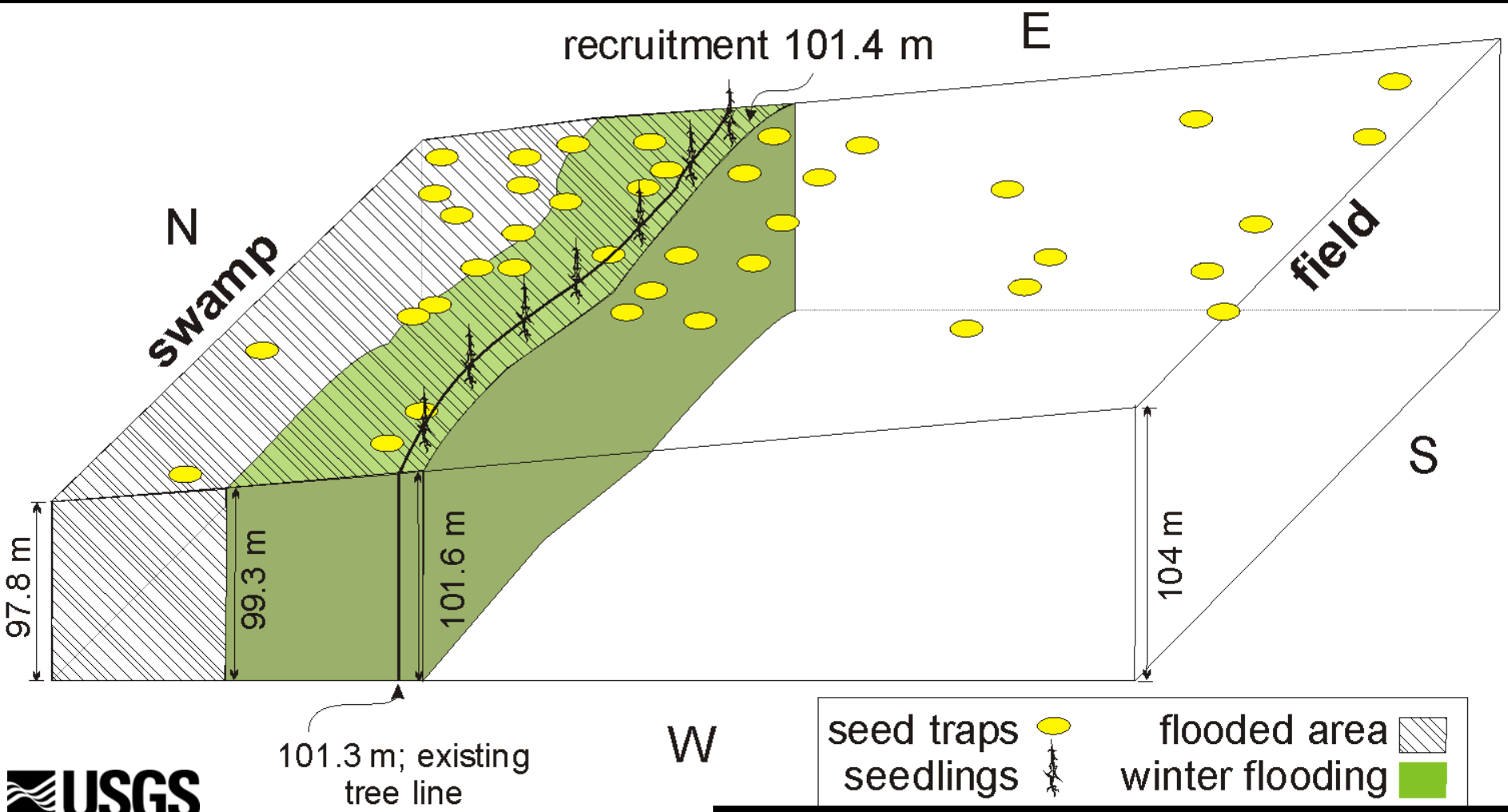
The flood pulse replenishes short-lived seeds of dominant species.



USGS

Middleton 2000, 2003

Aquatic seeds disperse to edge of swamp. Flooding extremes will affect recruitment.



USGS

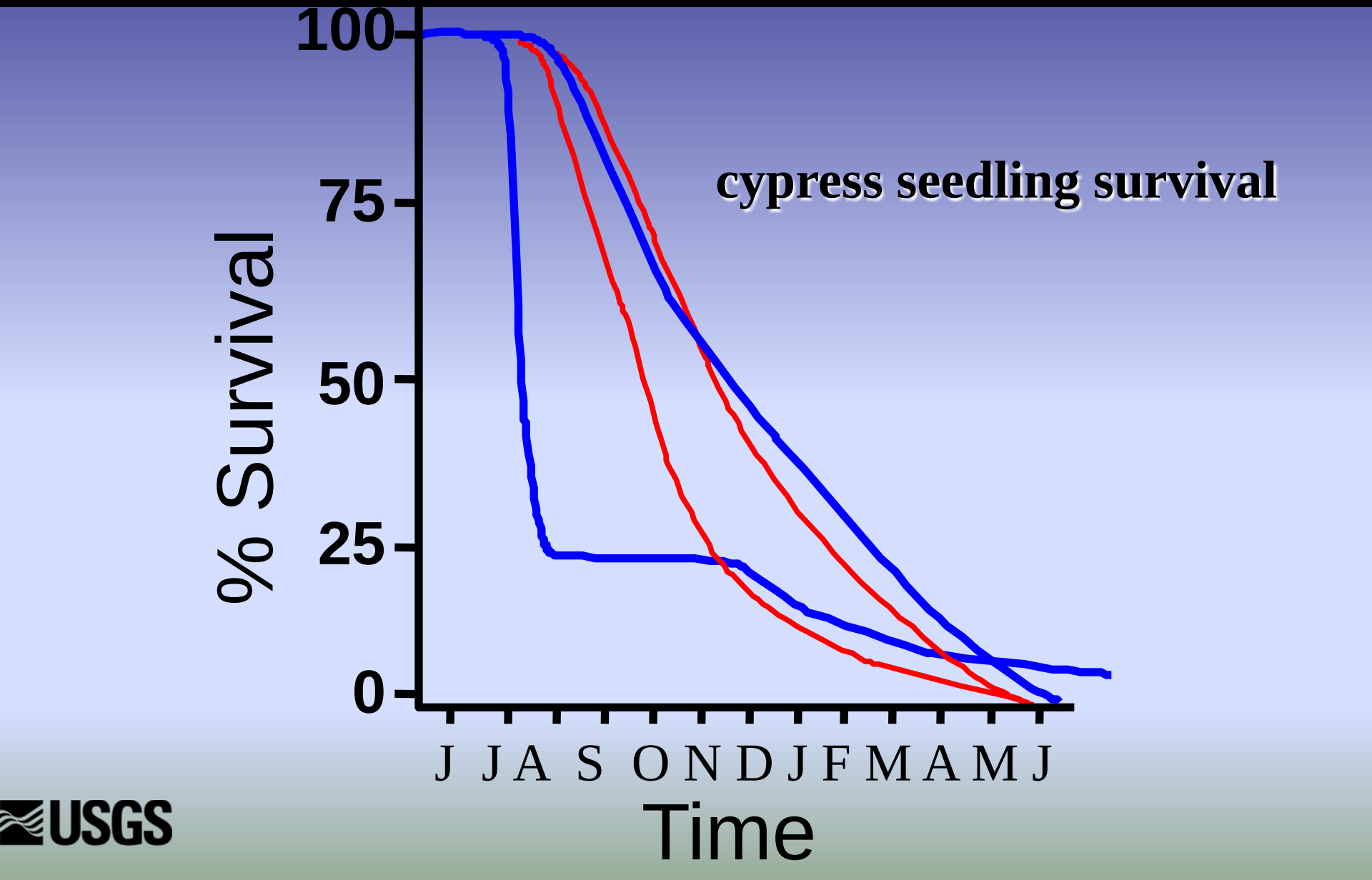
Buttonland Swamp, Middleton 2000

Tree seedling recruitment & floodpulsing

USGS

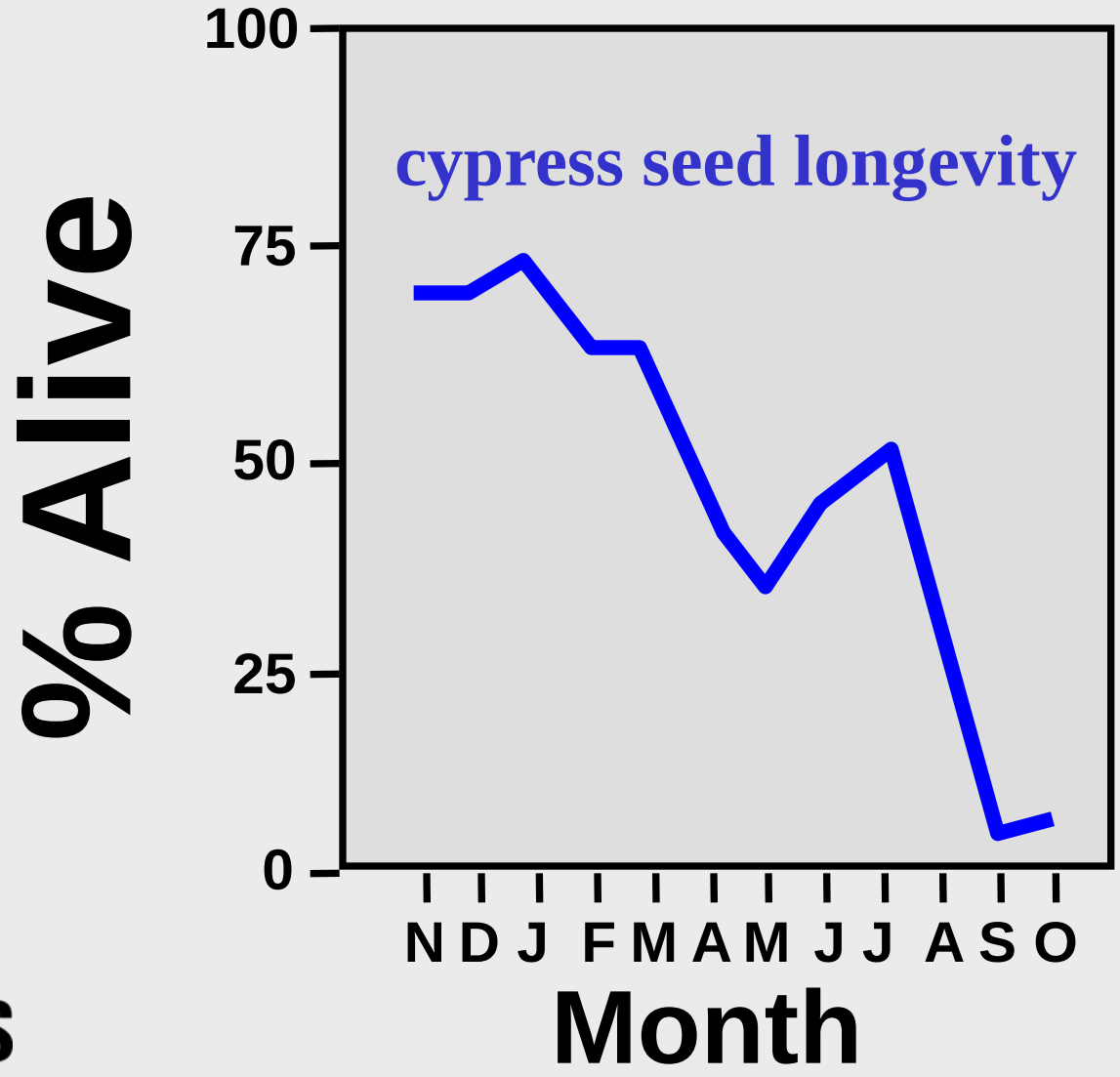
Fessel/Hoyer/Middleton

Cypress seedlings are killed during summer flood in impoundments, but survive at higher elevations..



USGS

Cypress seeds live for less than 1 year in the swamp, & depend on flood pulsing to restore live seeds to the soil.



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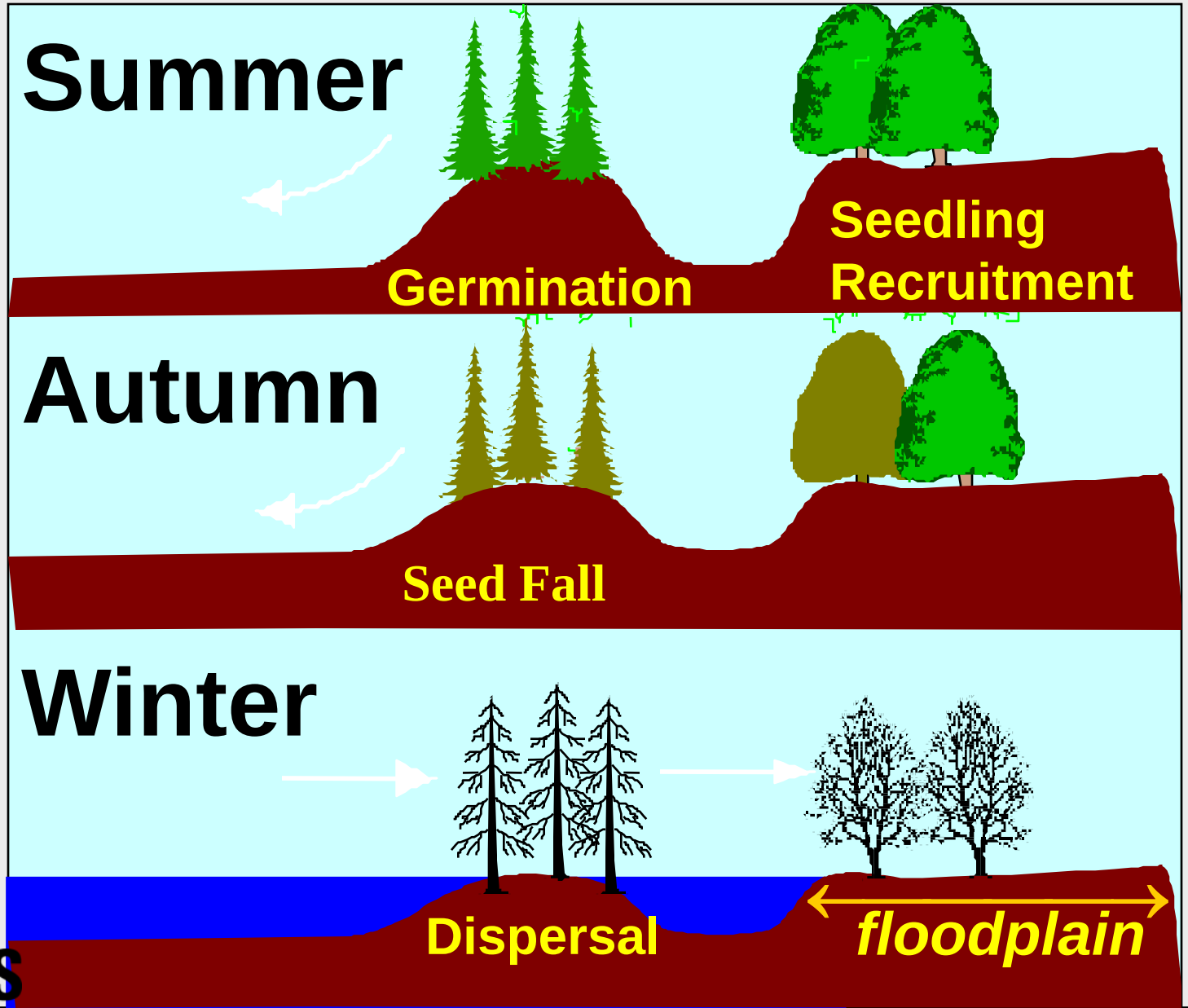
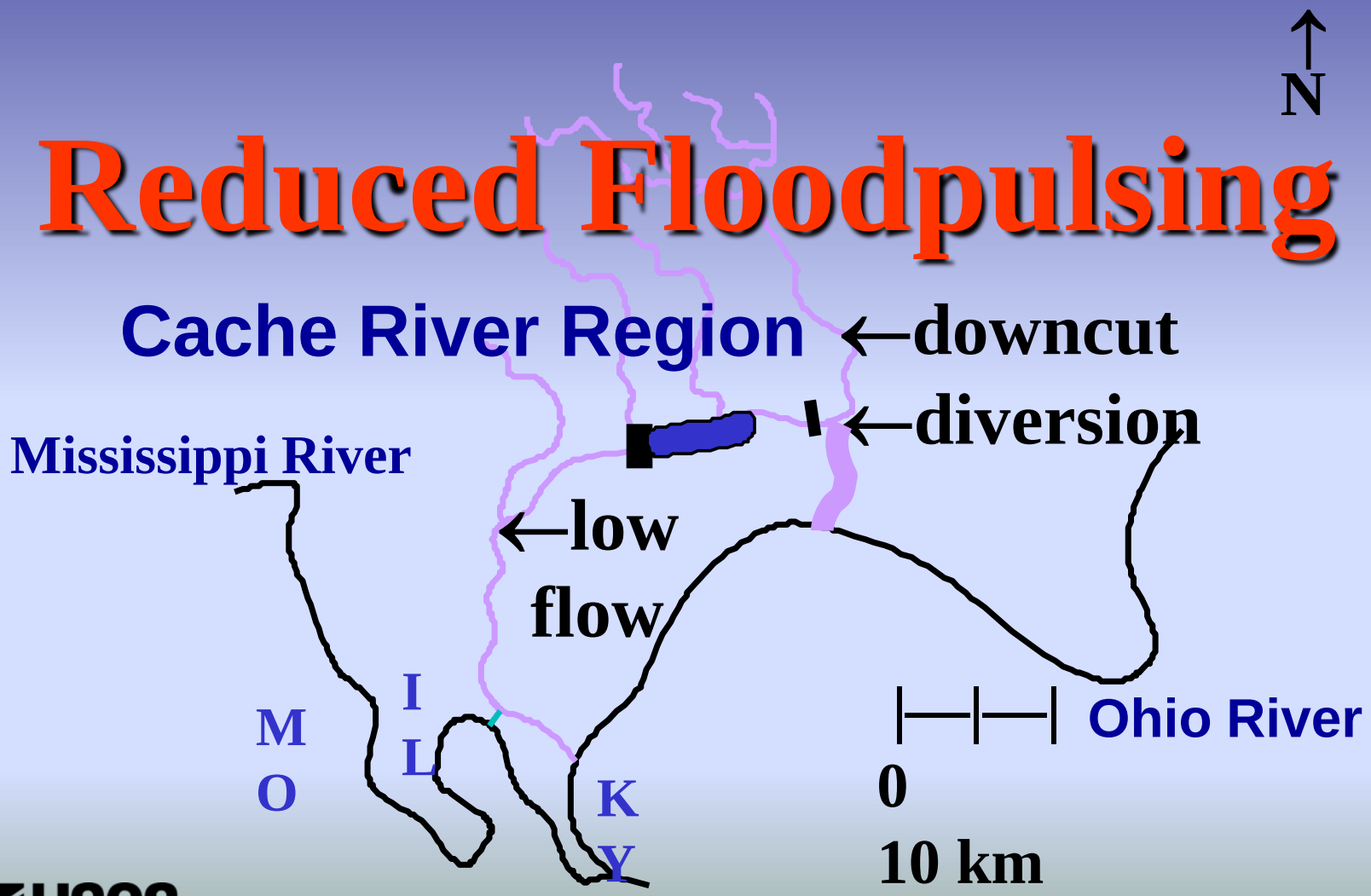
Flood pulsing maintains the maximum amount of tree production & regeneration.



USGS

Cache has been hydrologically altered, and this setting impacts restoration.

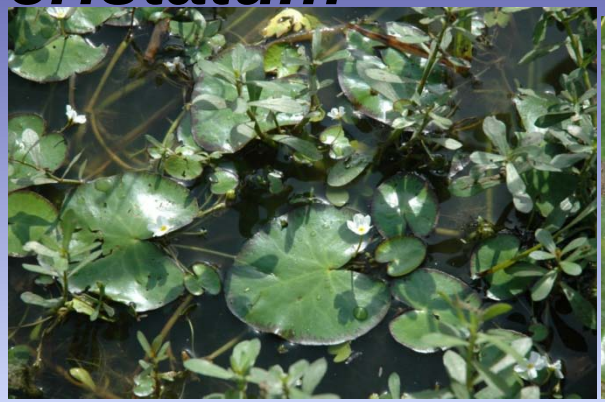


USGS

Seeds disperse in flood water.

Seed banks store seeds?

Nymphoides cristatum



Nymphoides indicum

Publications from 1980's Research

Middleton et al 1991Aq Botany 40:239-59
Middleton et al 1992 Wetlands 12:37-44
Middleton 1992 J Tropical Ecology 8:181-19
van der Valk et al. 1993 Vegetatio 109:81-90
Middleton 1999 WEM 6:189-202

2009 Vegetation Status Report

Middleton 2009 usgs.gov/sir/2009/5193

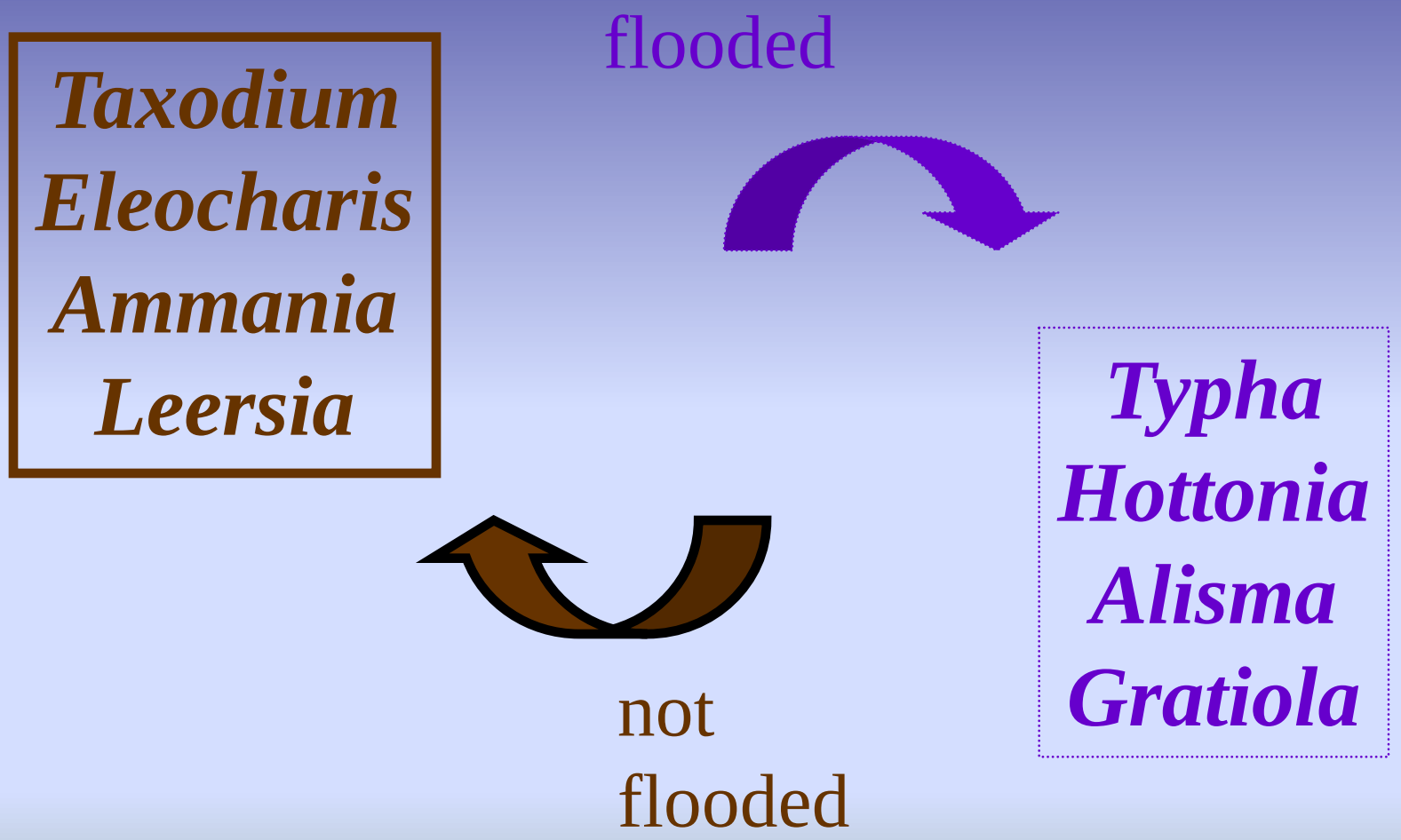
temporary pond

woodland kadam


baldcypress - *Taxodium*
seed bank
USGS


flooded
freely drained
USGS

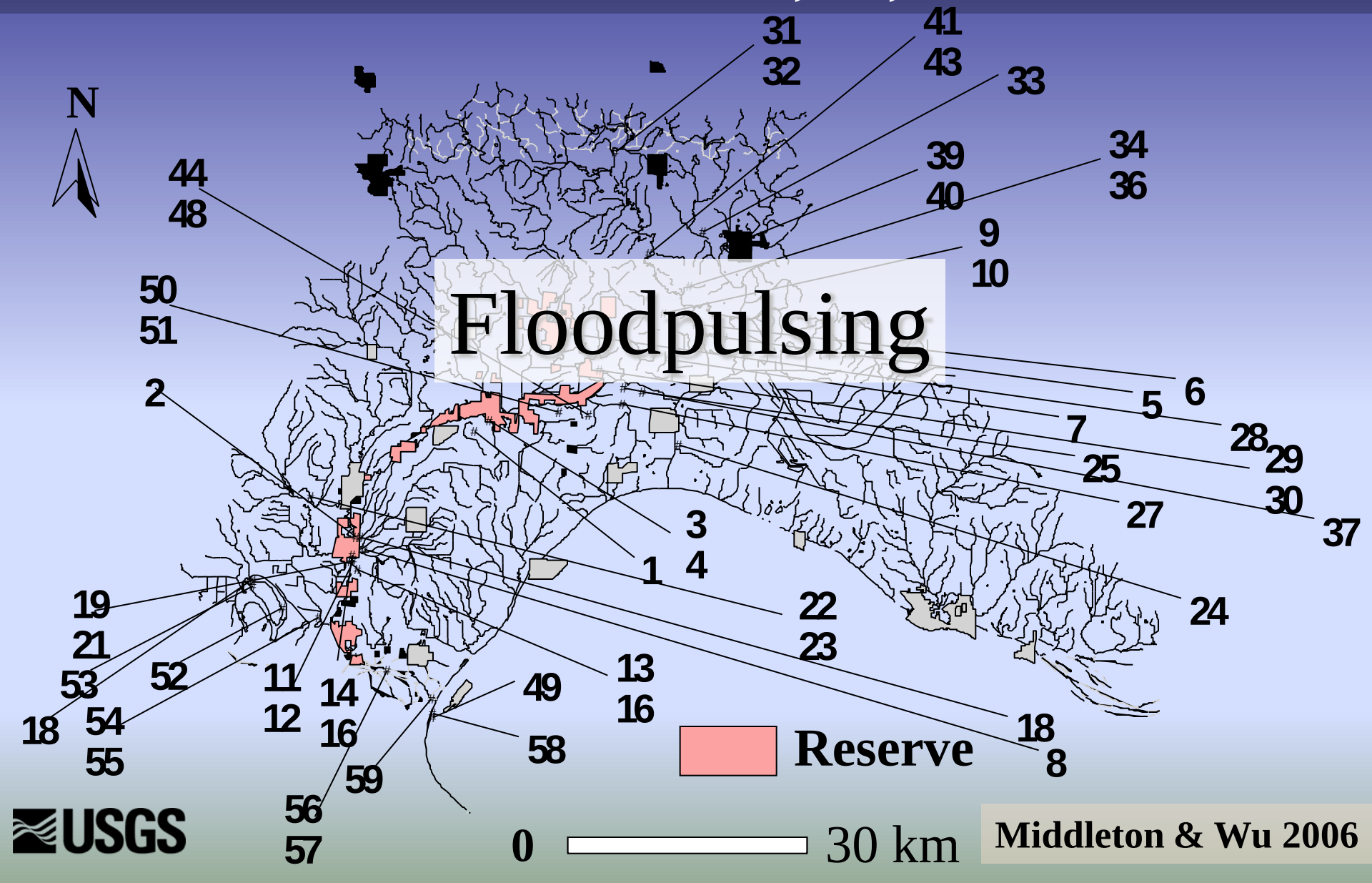
Species composition will change with water regime.



USGS

Middleton 2009, Plant Ecology 202:257-274

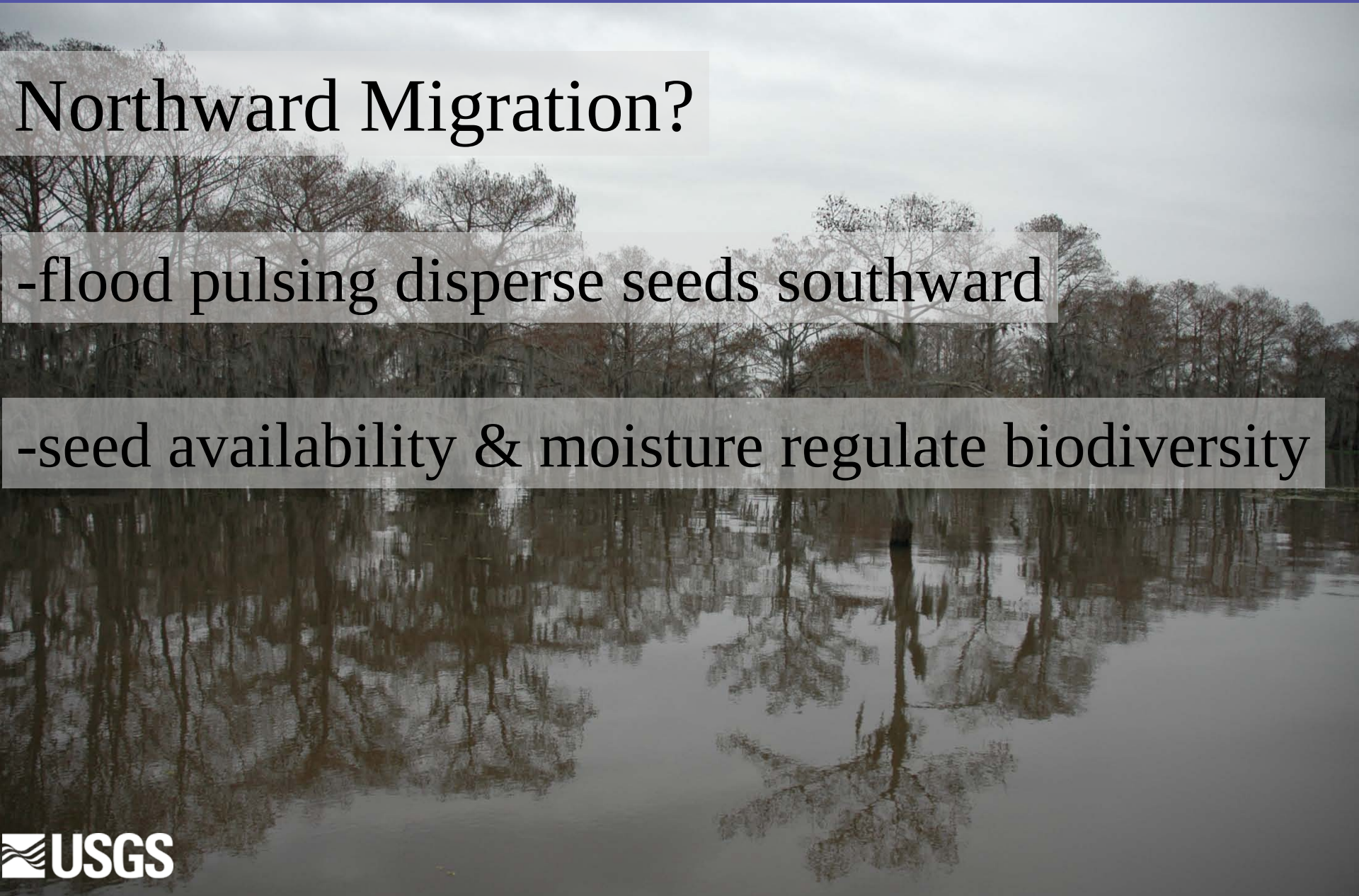
Seed banks collected in farmed and intact swamps in the Cache River Watershed, IL, USA.



Genetic diversity of *Taxodium distichum* same across range.

Kusumi et al. American Journal of Botany (in press)

Climate change & swamp biodiversity



Northward Migration?

-flood pulsing disperse seeds southward

-seed availability & moisture regulate biodiversity

USGS

One thing brings the world together…

Climate Change

Wanted: ideas!

The plan for climate change?

Wetlands are important to wildlife.

Barheaded

Anser indicus

Greylag

Anser anser

USGS

Photo by Gertrud Denzau

Wetlands are important to people.

habitat

recreation

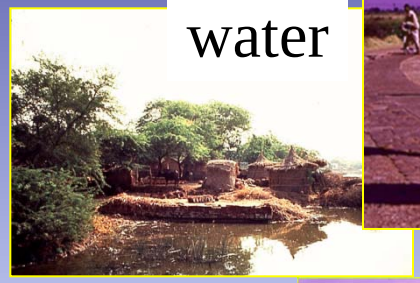
tourism

hunting

Developed

gathering

water



agriculture

grazing

Developing

Climate change problems require interdisciplinary thinkers.

USGS

Interdisciplinary thinking….

-multidisciplinary teams e.g., ecologists, ethicists, physicists, climate scientists, sociologists (NSF 2009)

-interdisciplinary training

-synthetic studies of old data (Sidlauskas & Ganapathy 2010)

USGS

Interagency thinking….

-land use, climate conflict

-interagency dialogue difficult

-Cache River Joint Venture

USGS

Re-establish Flood Pulse Lower Cache

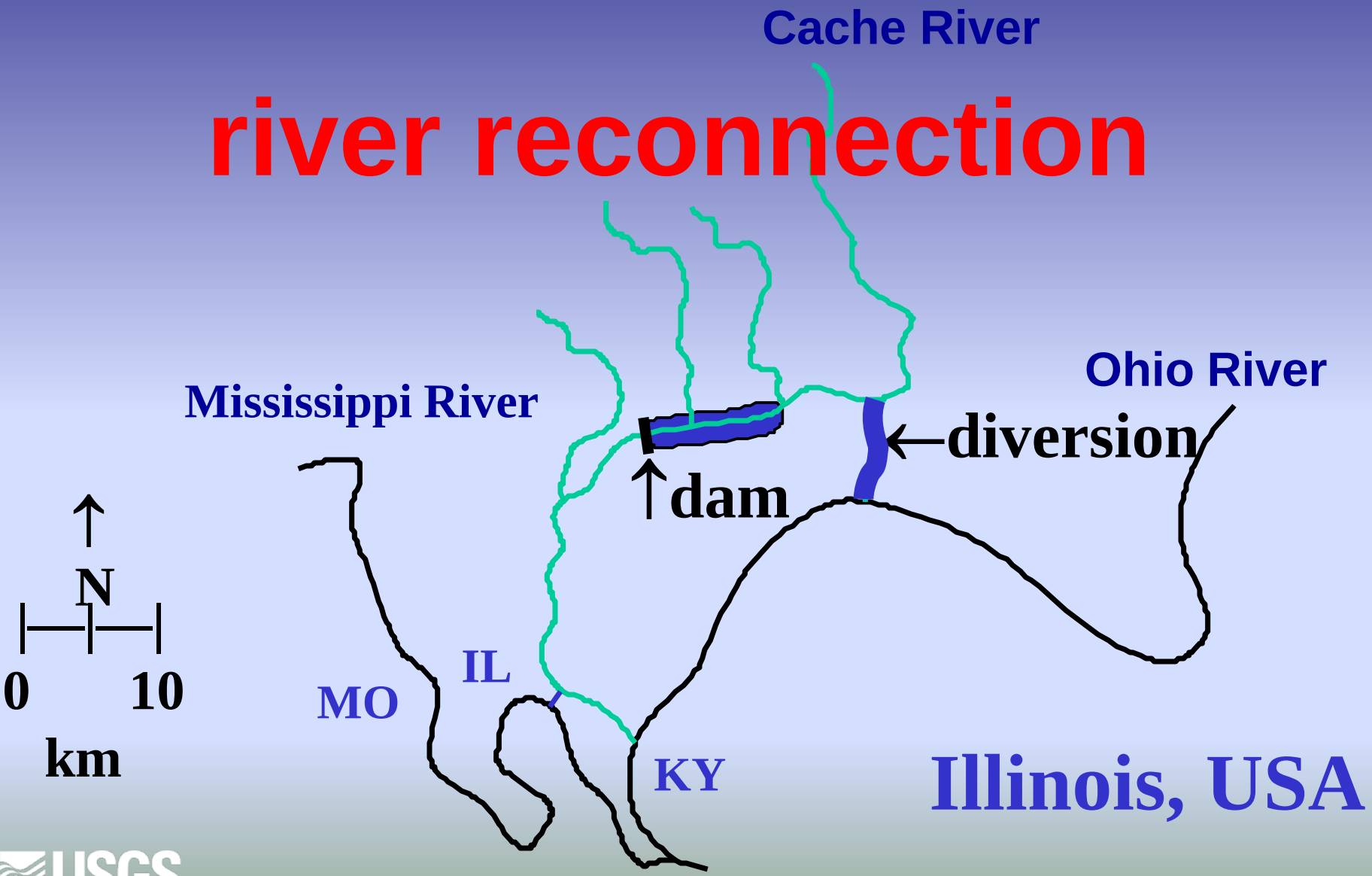
- connect migration routes
- maintain temporary moist refugia
- restore flood pulsing along corridor
- more resilience of ecosystem (Baron et al. 2009)

Management for Climate Change

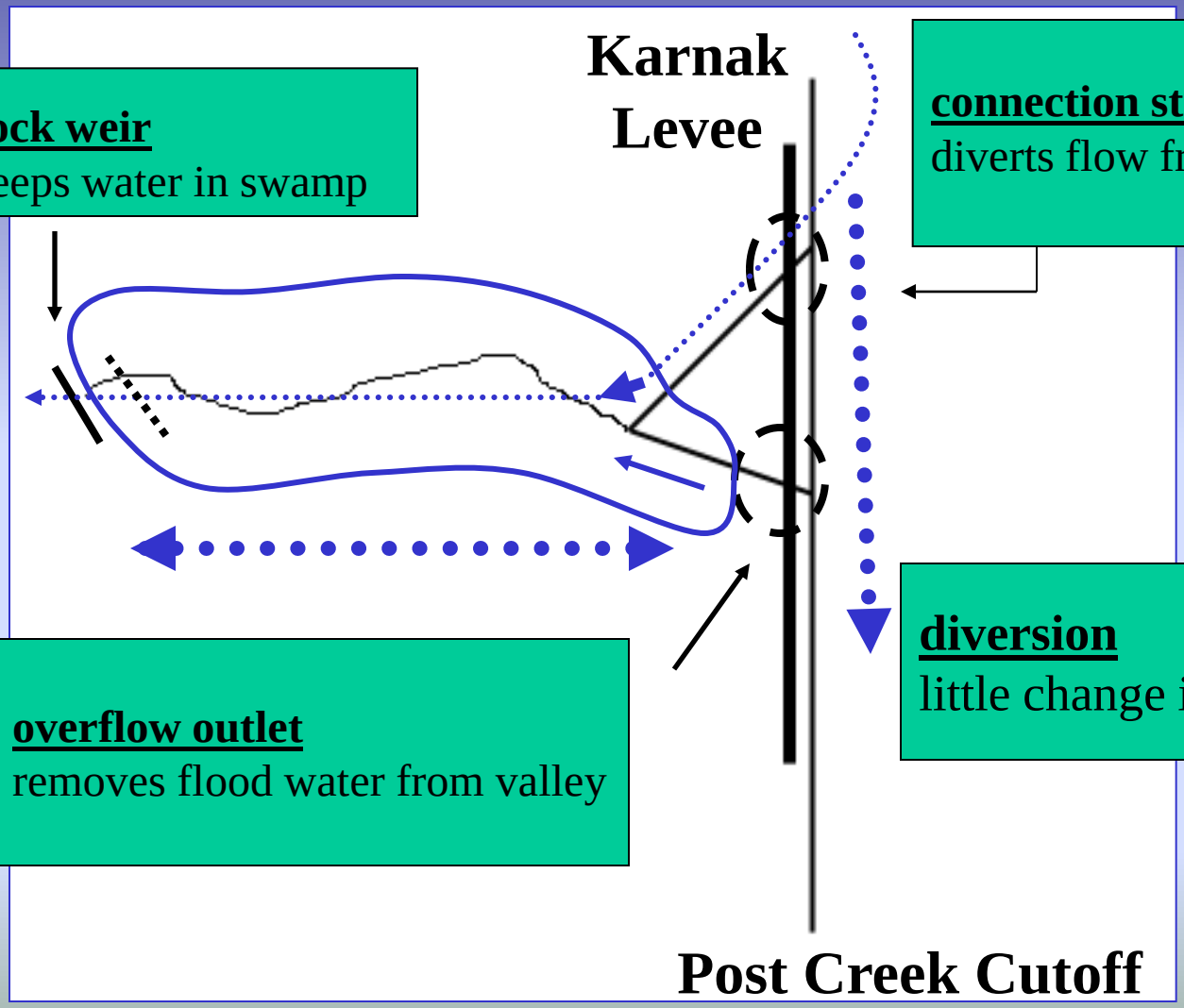
-reconnect fish, seed dispersal, floodplain process, human economy

USGS

Reconnecting rivers can help maintain biodiversity during climate induced drought.



Reconnection of Migration Pathways
Cache River RAMSAR



rock weir
keeps water in swamp

connection structure
diverts flow from upper to lower river

diversion
little change in diverted water

overflow outlet
removes flood water from valley

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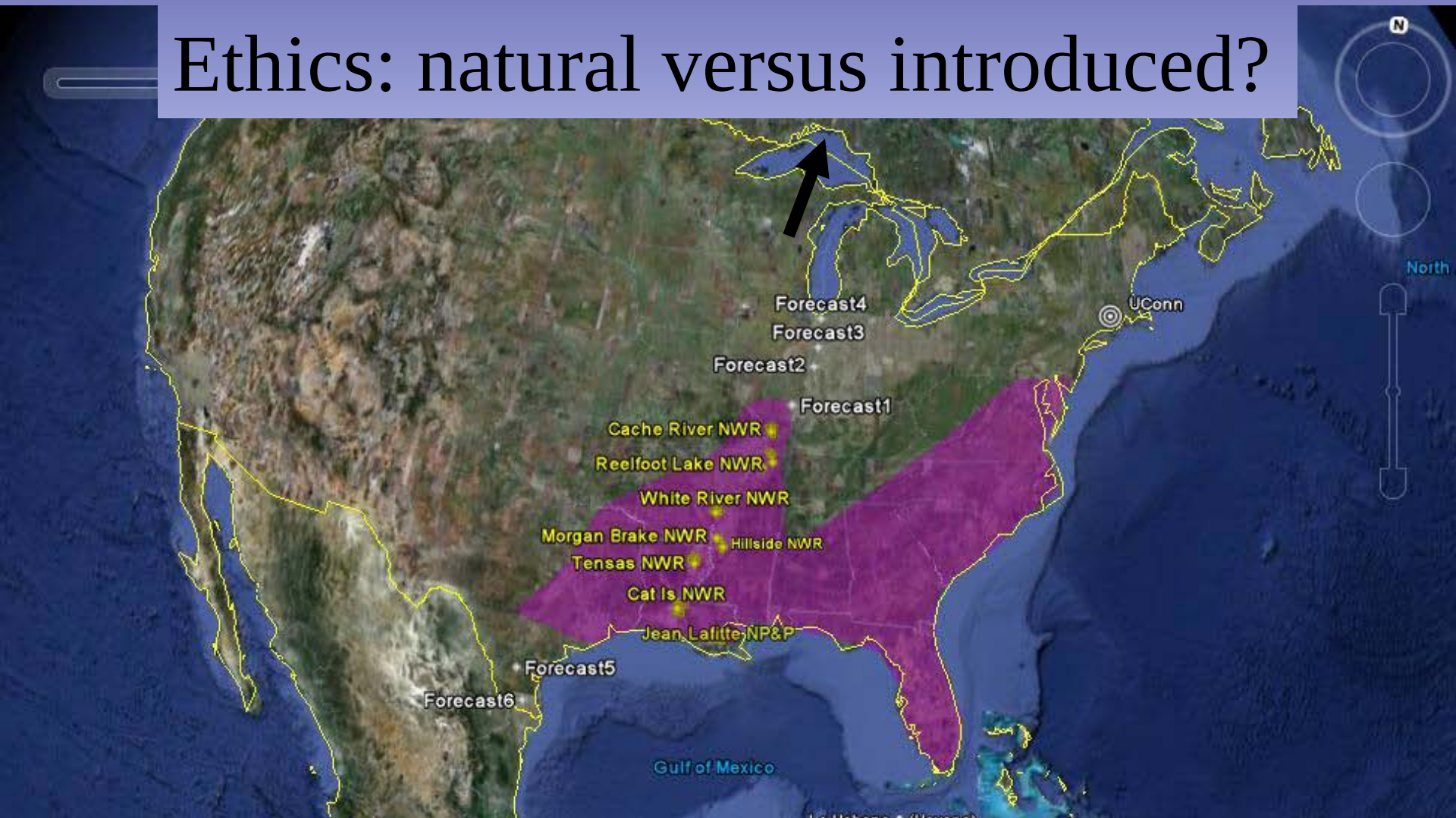
We could move southern species northward, i.e., assisted migration.

Ethics: natural versus introduced?



Thanks

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IL Water Resources Center

The US Crew

Evelyn Anemaet

Inyoung Jang

Justin Stelly

The India Crew 1983-1987
Keoladeo Naturalists Society

USGS