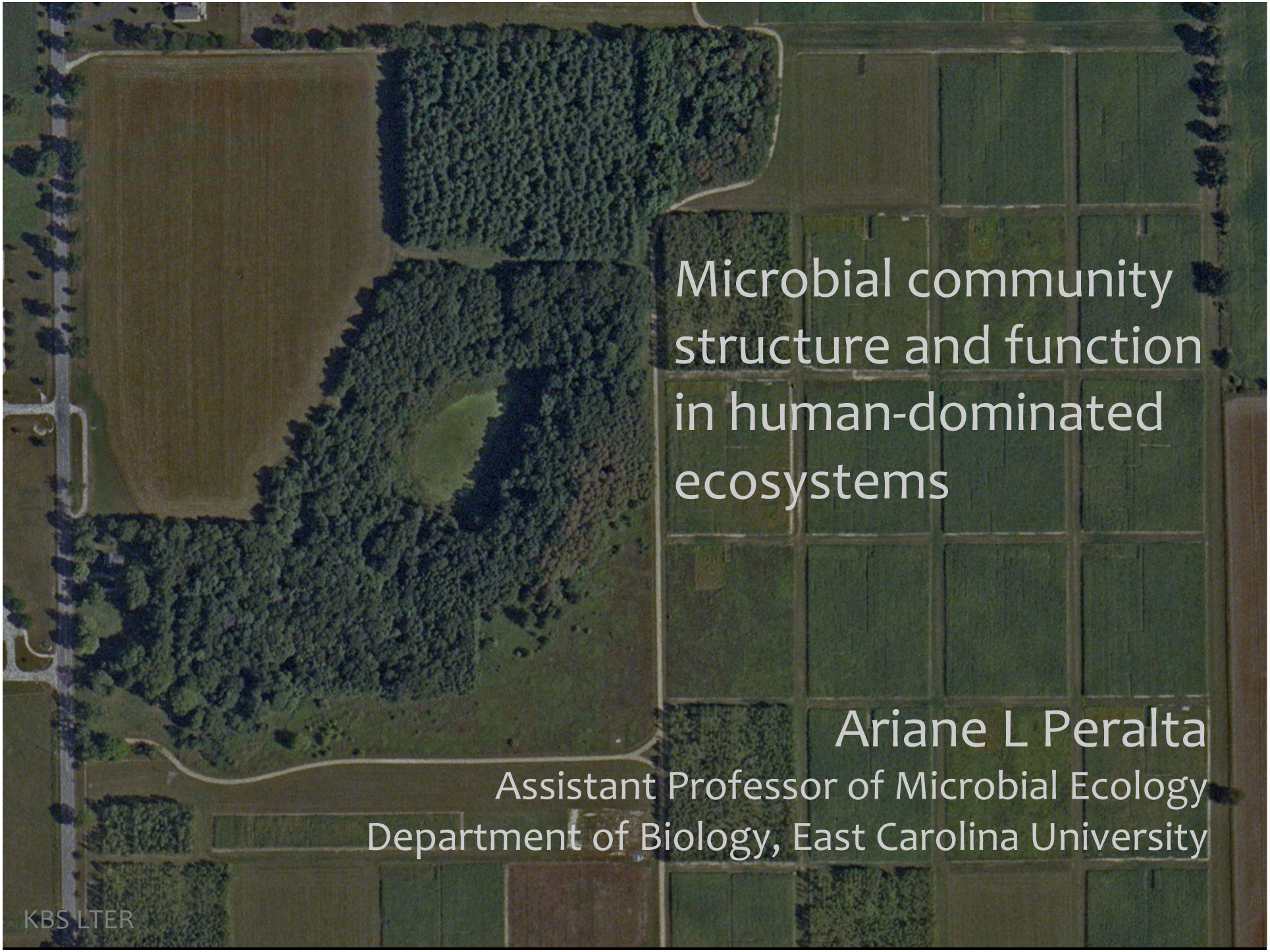
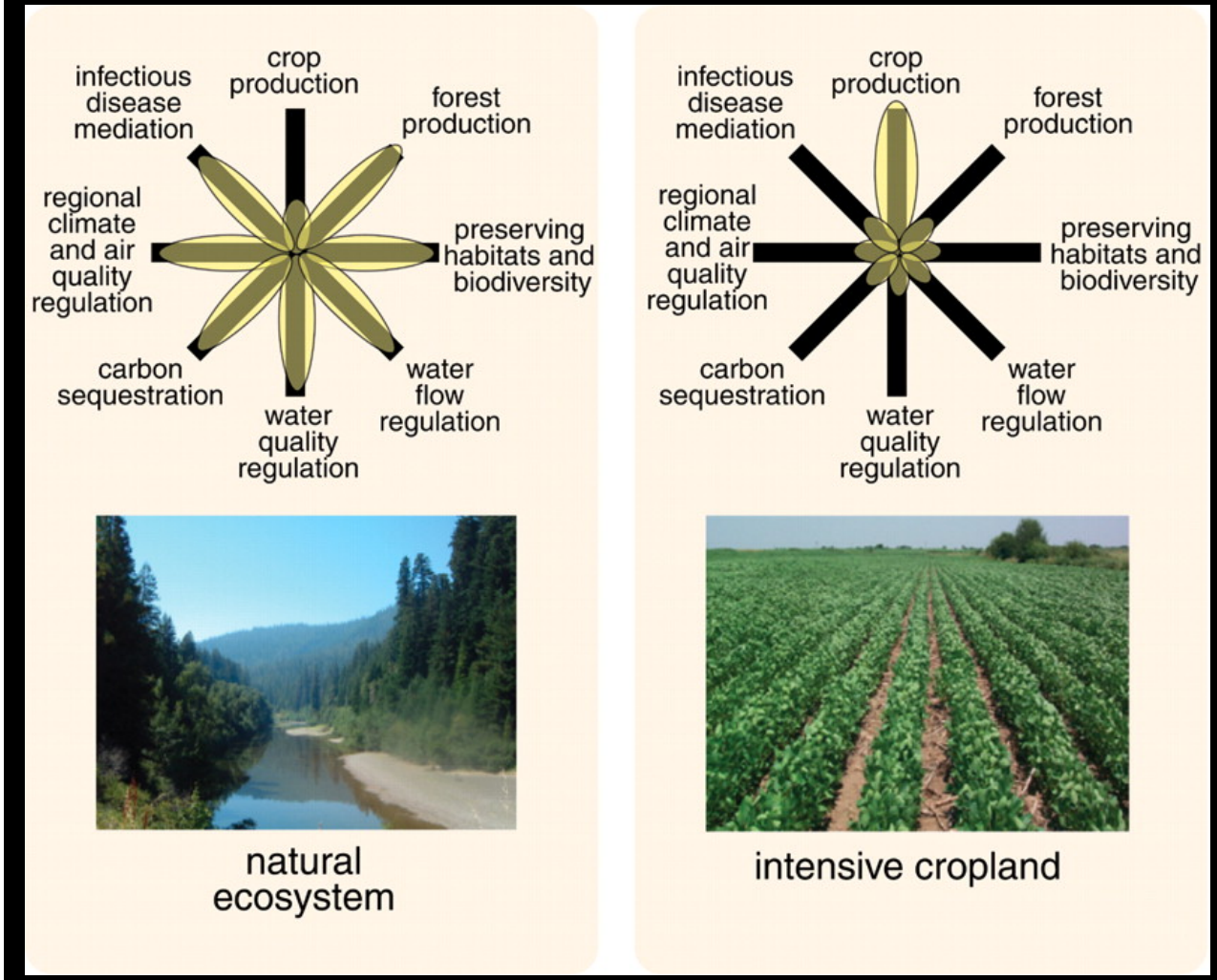


Microbial community structure and function in human-dominated ecosystems

Ariane L Peralta
Assistant Professor of Microbial Ecology
Department of Biology, East Carolina University

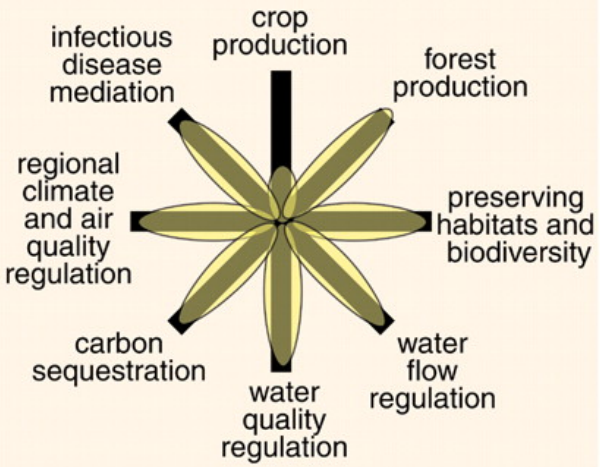
Land use change imposes tradeoffs among ecosystem services

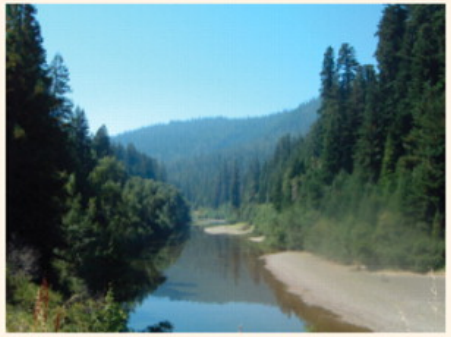


Land use dilemma

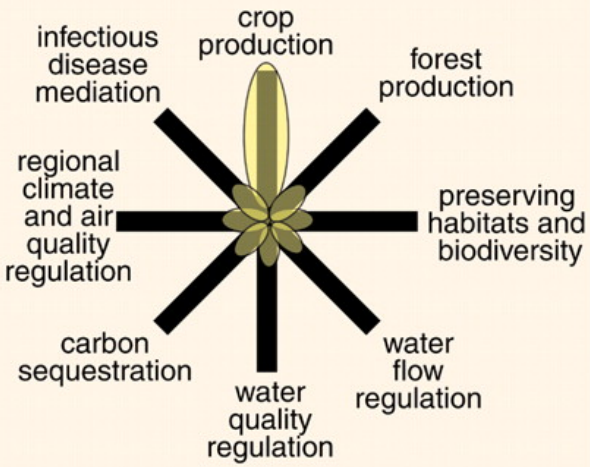
Foley et al., 2005

How can we restore ecosystem services in human-dominated ecosystems?

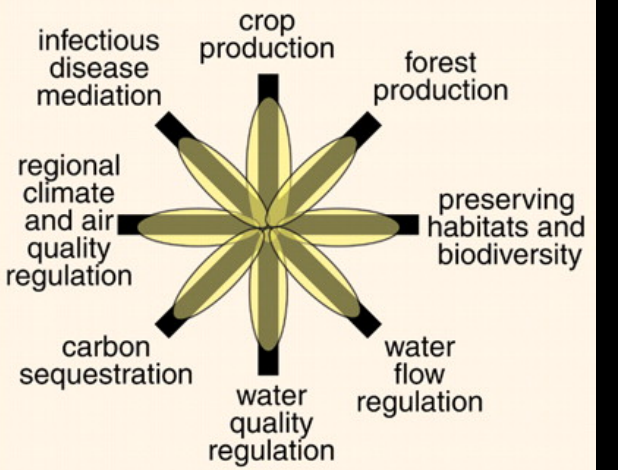




natural ecosystem



intensive cropland



cropland with restored ecosystem services

Foley et al., 2005

Does restoration of services work?

Challenges to restoring ecosystem services

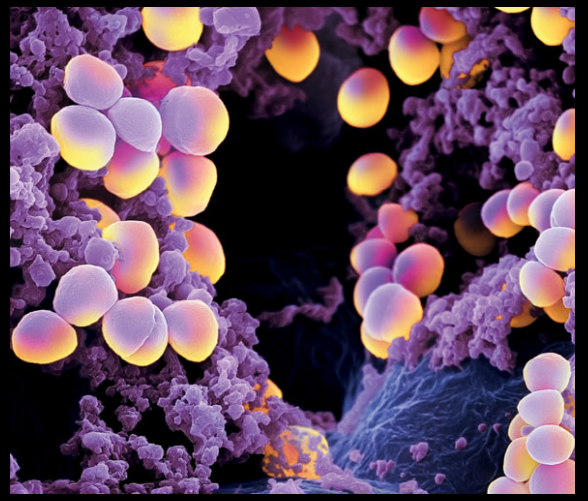
- Legacy effects: long-term persistence of chemical, physical or biological factors developed under prior land use
- Ecosystems slow or resistant to recover

Physical

Chemical

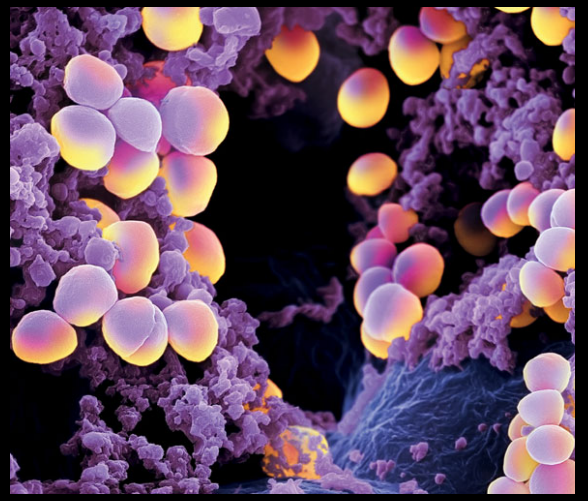
Biological

How do microbes respond to land use legacies?



How do microbes respond to land use legacies?

If you build it….



they will come…

- not dispersal limited
- fast growers
- rapid evolution

How do microbes respond to land use legacies?

If you build it….

they will come…

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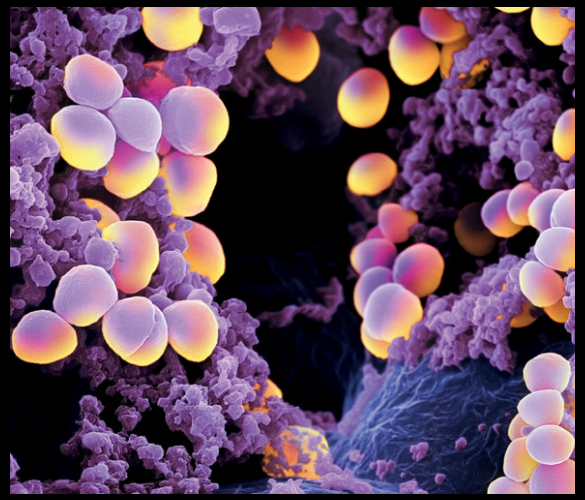


land use legacies persist…

- microhabitats destroyed
- slow growers
- microbial seed bank

Long-term impacts of land use on microbes

Wetland restoration

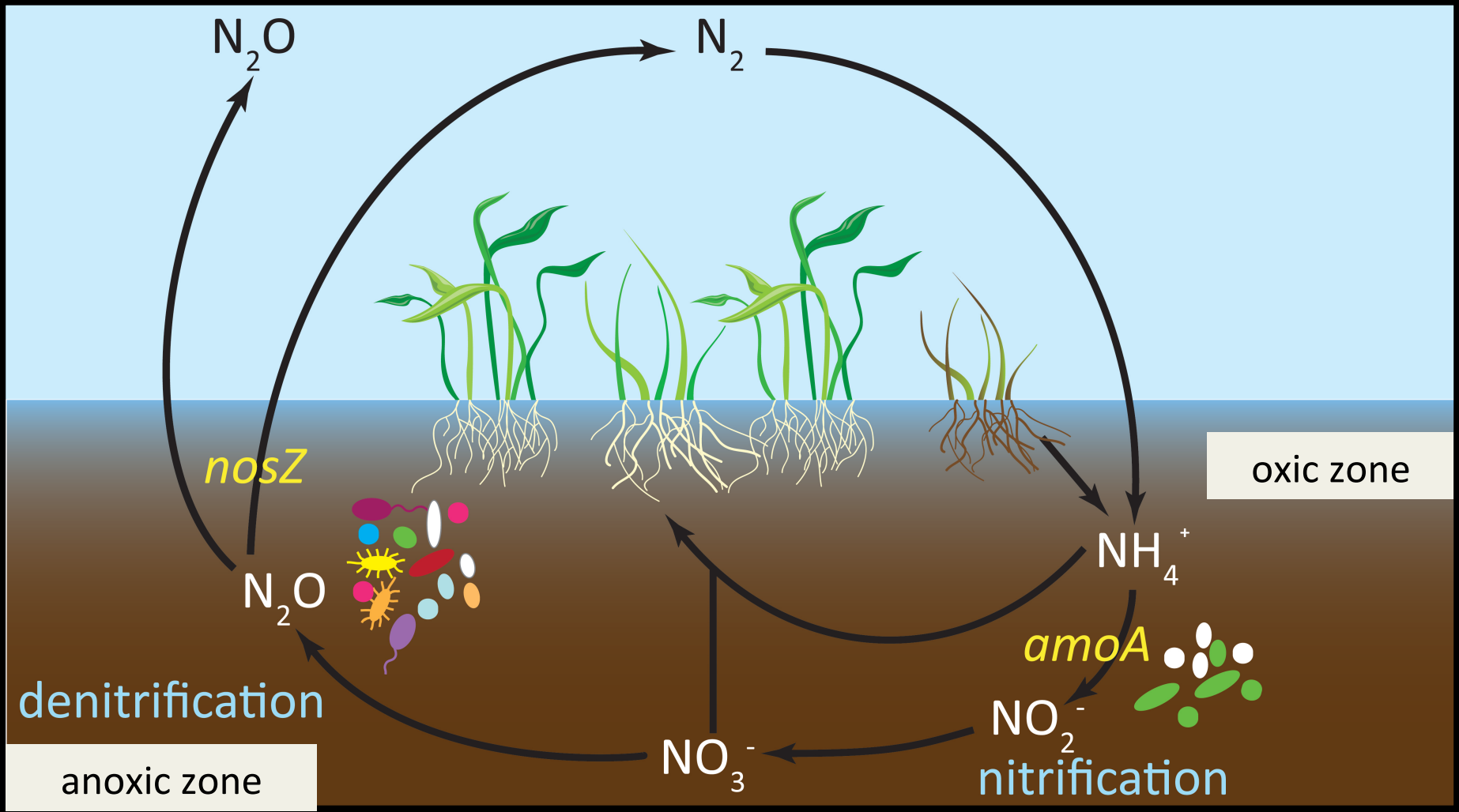
Agricultural diversification

Examine relationships: environment – microbes – functions

Wetland ecosystem services

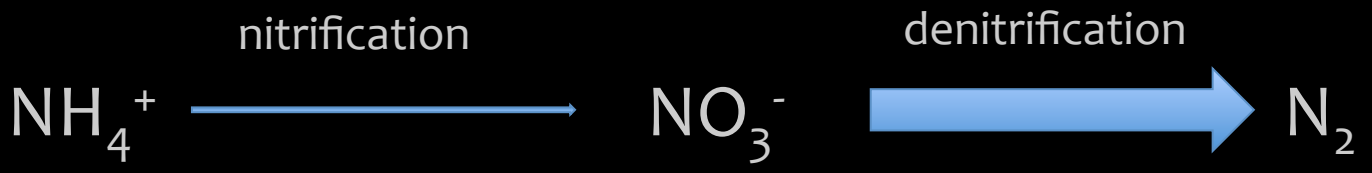
- Habitat
- Flood control
- Nutrient cycling
  - Enhanced water quality
  - Carbon sequestration

Tracking microbial response to hydrology

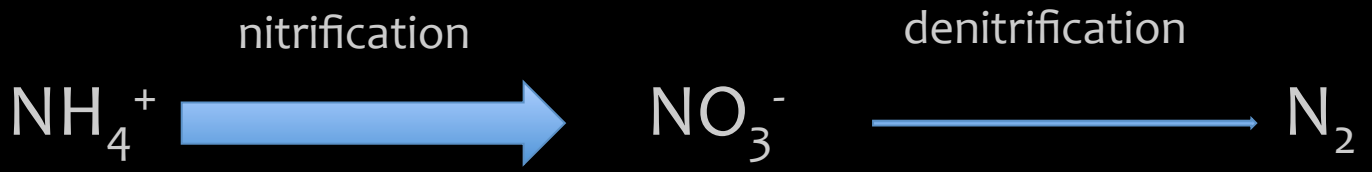


Microbial response to fluctuating hydrology

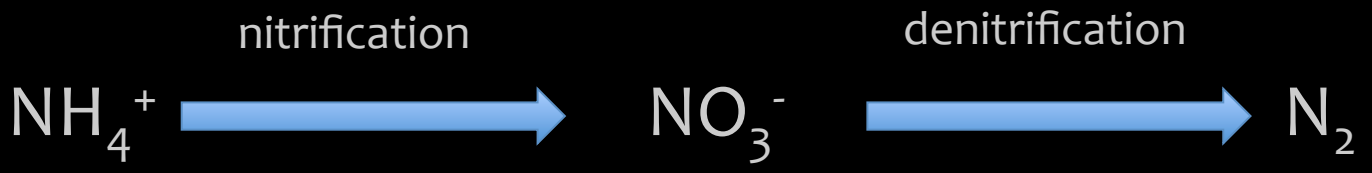
Saturated (anoxic) conditions



Dry (oxic) conditions



Wet-Dry conditions

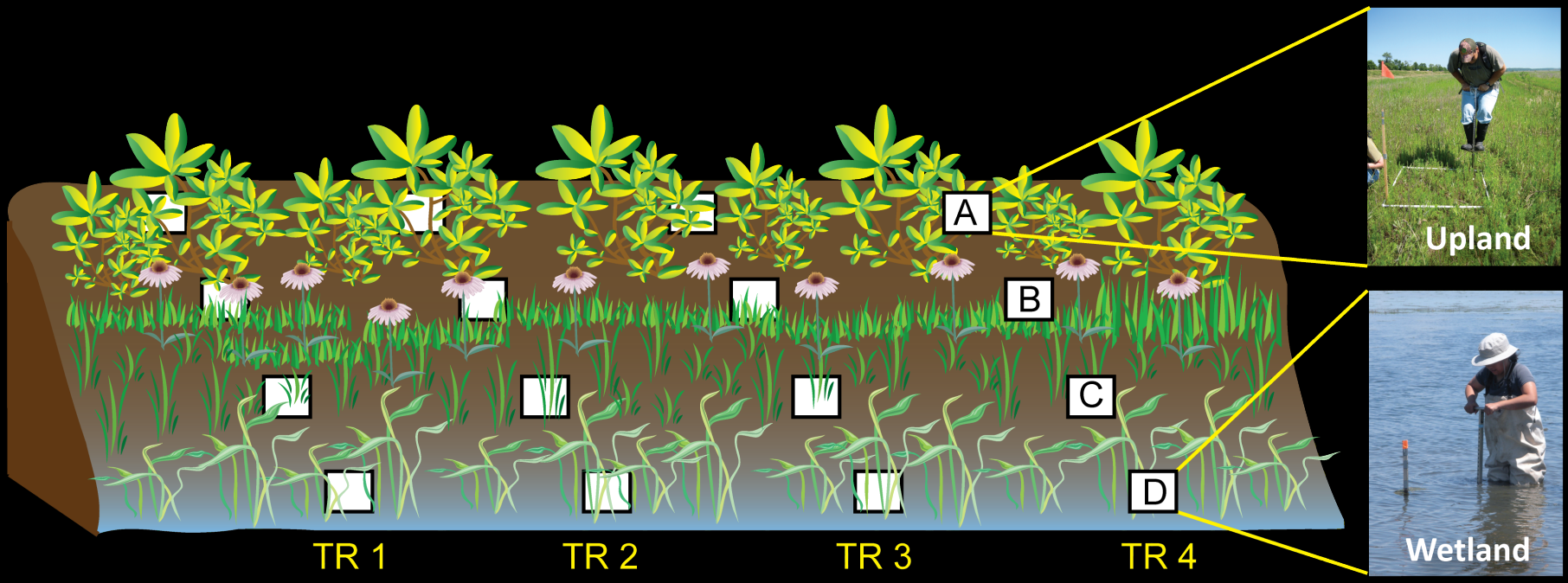


Does land use history constrain microbial community structure and function?

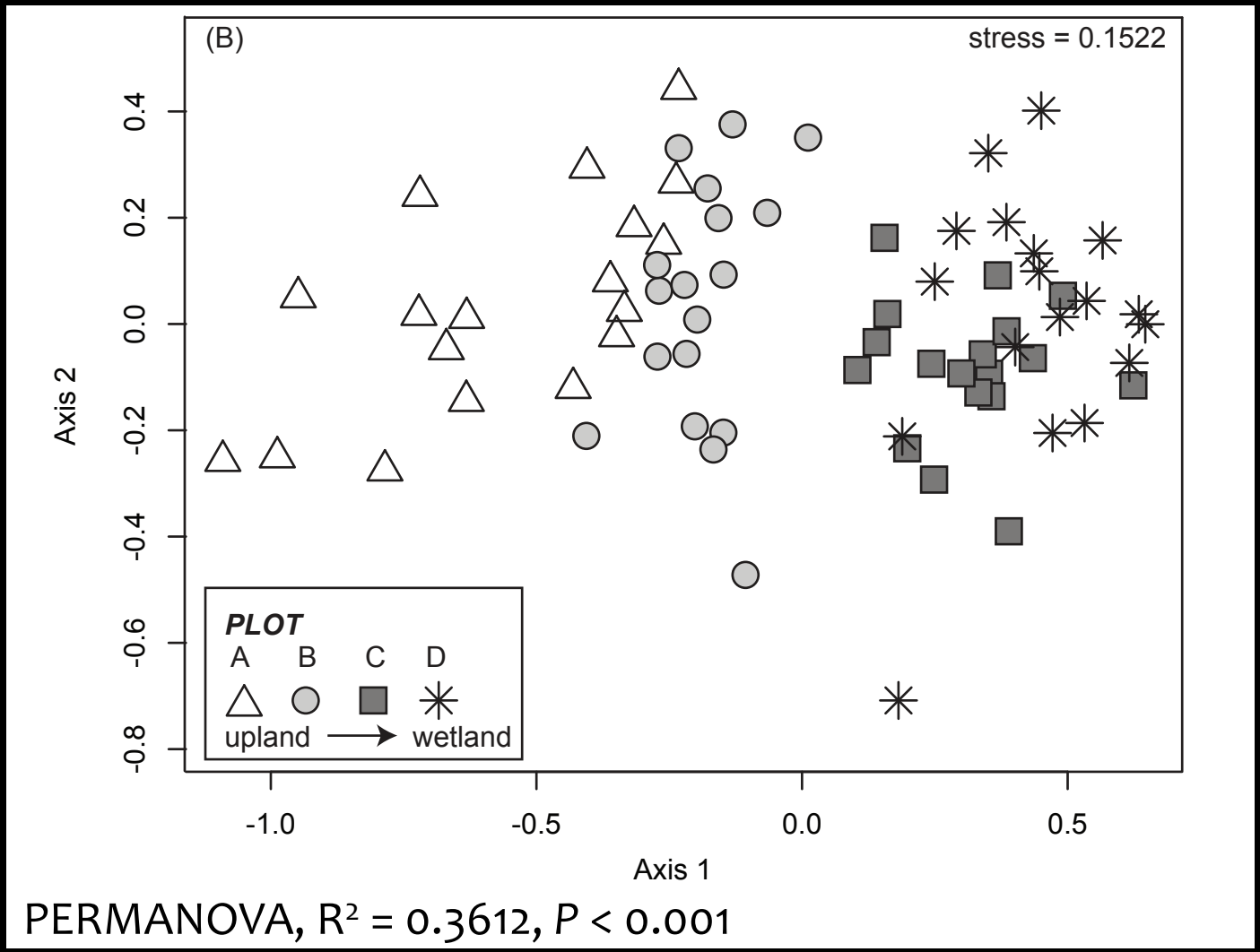
Hypothesis

Microorganisms from contrasting hydrologic histories respond differently to drying and flooding

Field Sampling



Hydrology influences microbial communities



PERMANOVA, $R^2 = 0.3612$, $P < 0.001$

Peralta, Ludmer, Matthews, & Kent, Ecol Eng, *In revision*

Experimental design

HISTORY

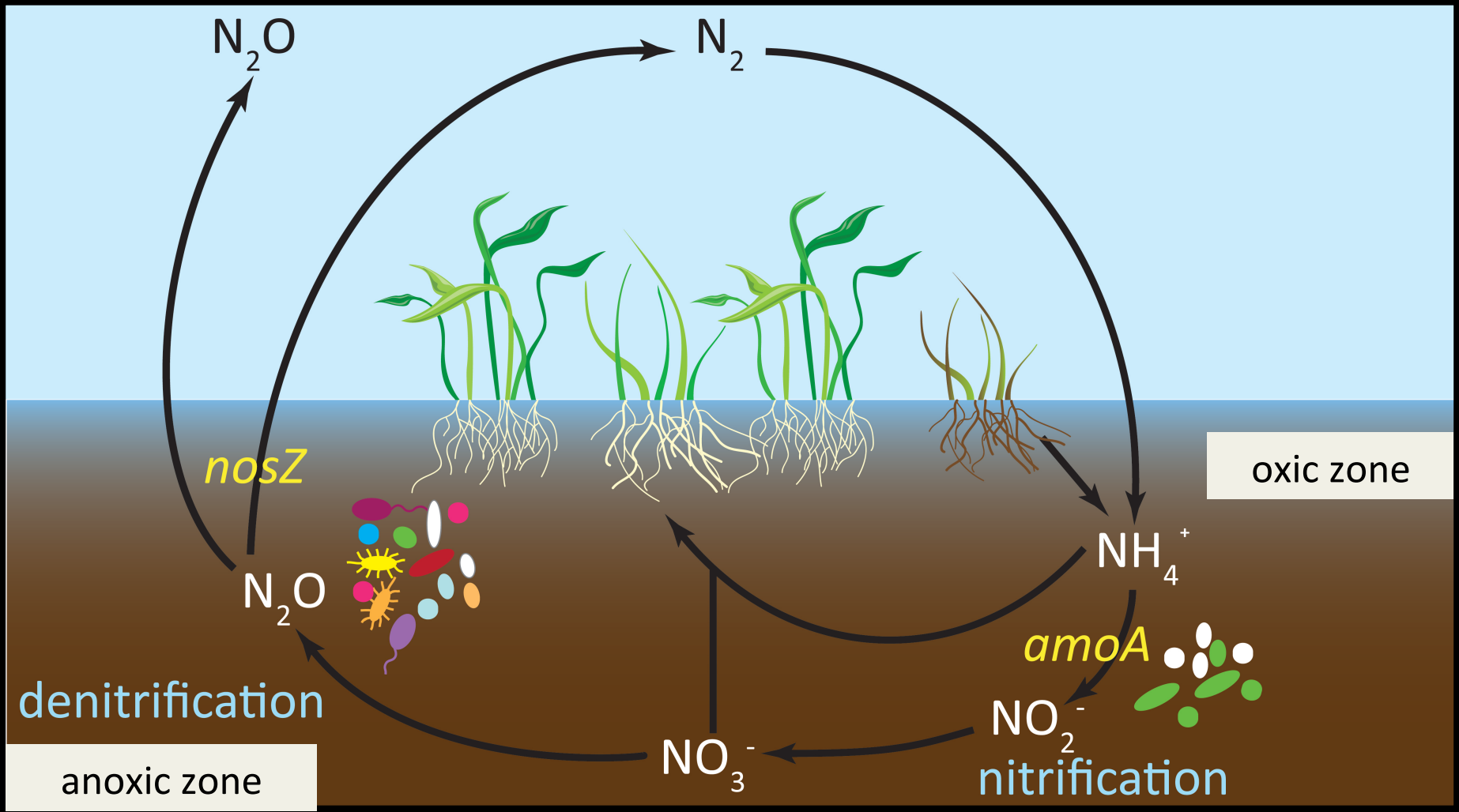
upland/wetland

×

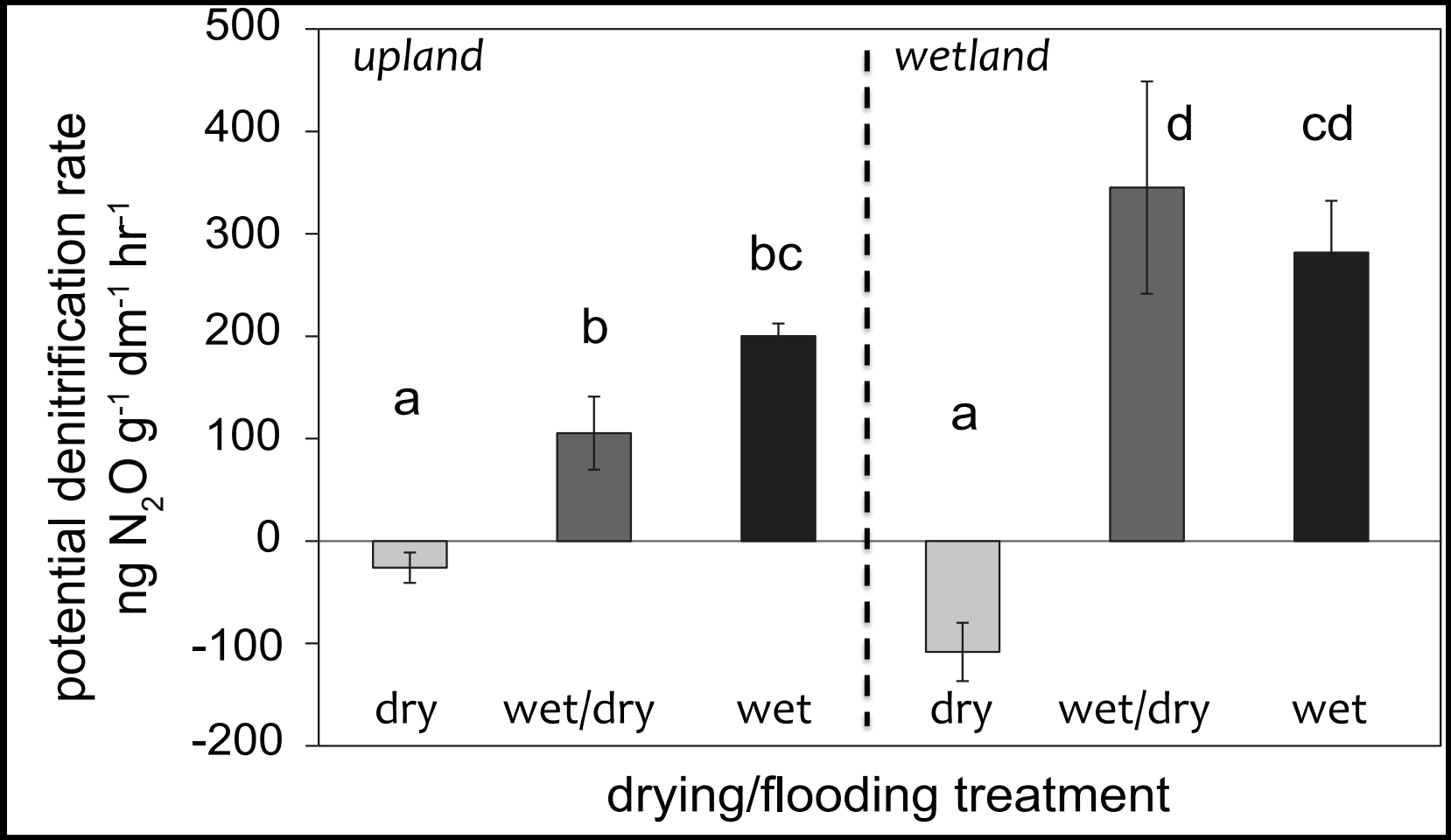
MOISTURE TREATMENT

dry/wet-dry/wet

Tracking microbial response to hydrology



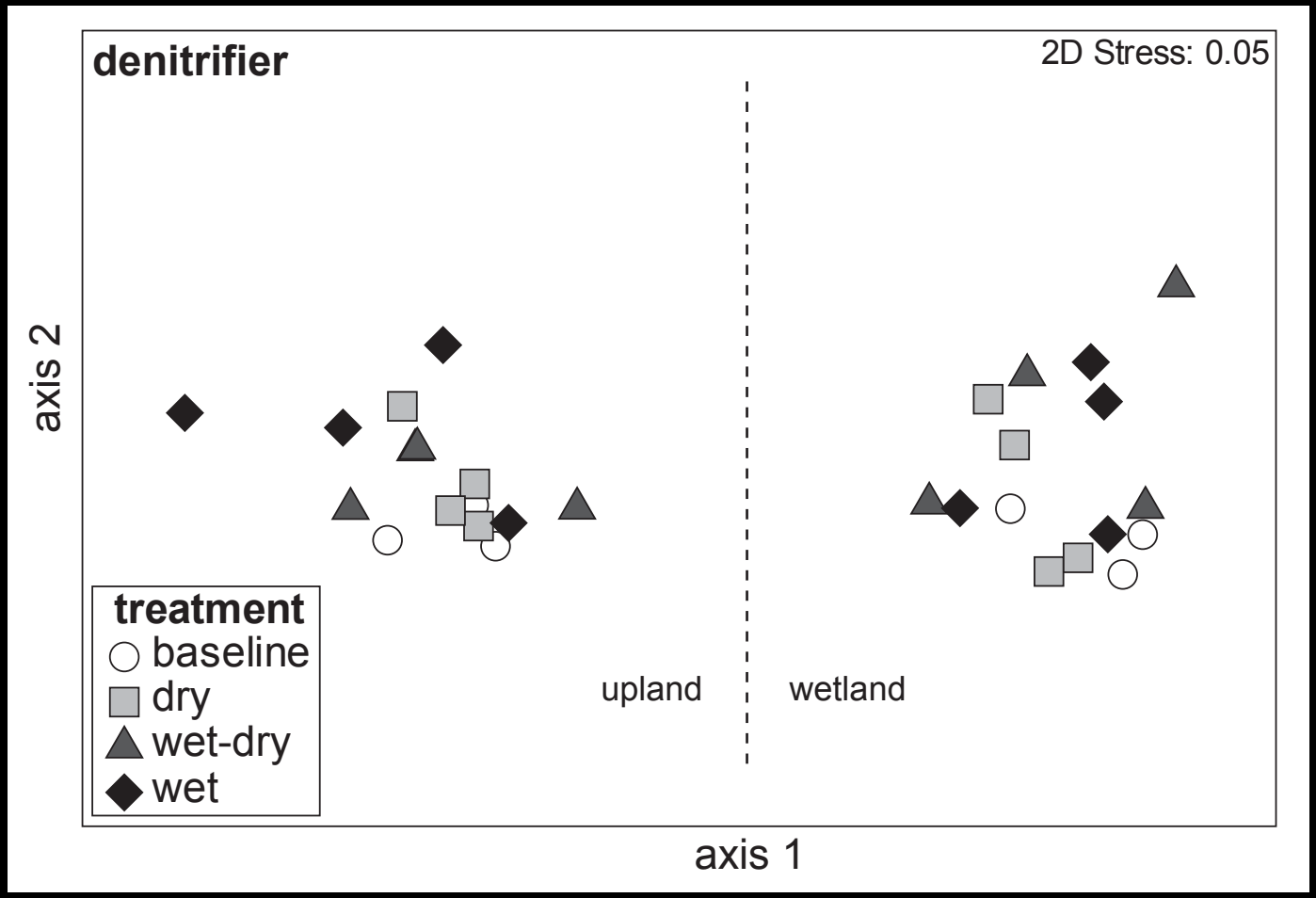
Denitrification increased with flooding



ANOVA: history x treatment; $F_{(2,17)} = 12.30$, $P < 0.0001$

Peralta, Ludmer, & Kent 2013, *Soil Biol Biochem*

Hydrologic history influences denitrifier communities

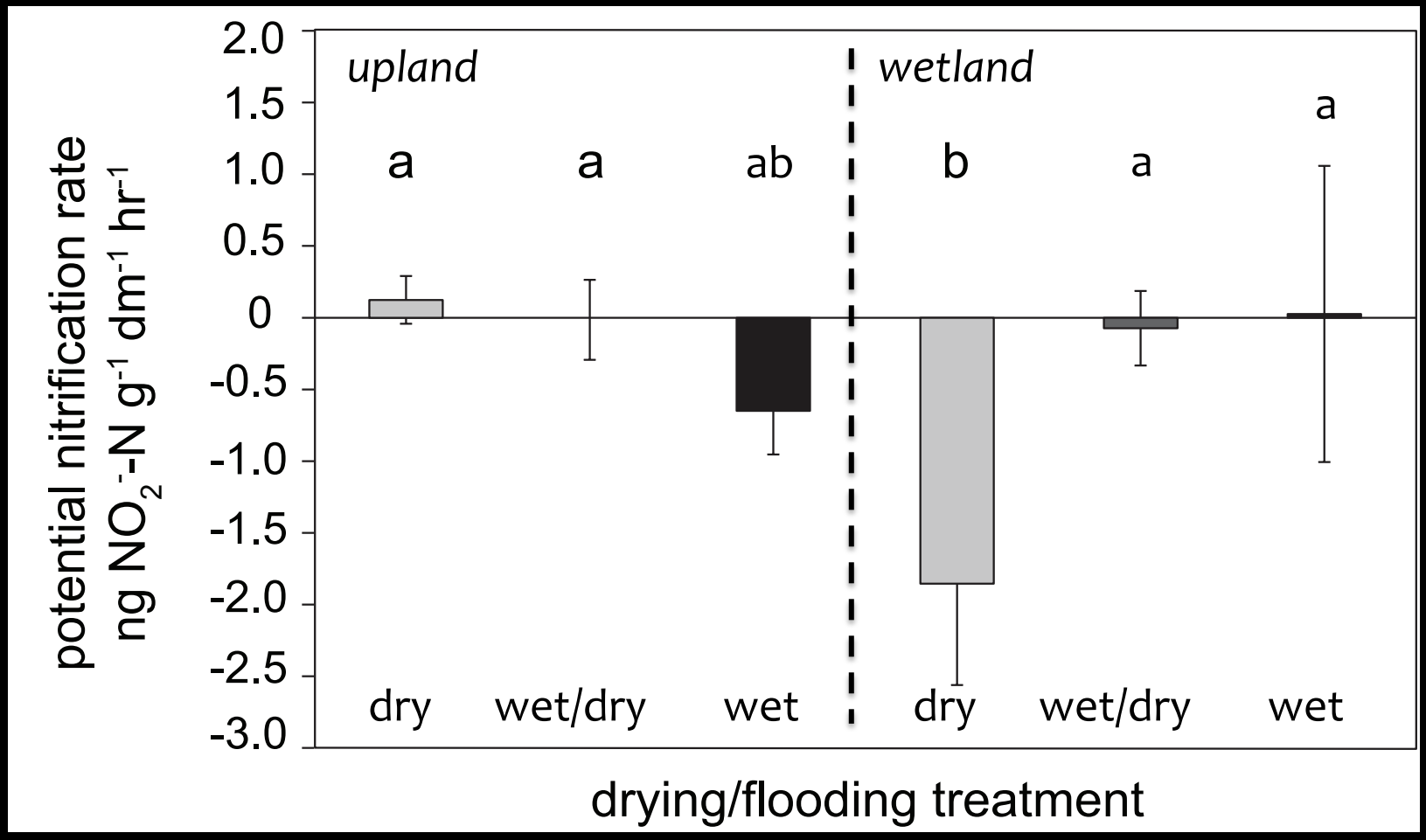


hydrologic history: PERMANOVA, $R^2 = 0.6722$, $P = 0.0010$

drying/flooding treatment: PERMANOVA, $R^2 = 0.0399$, $P = 0.0390$

Peralta, Ludmer, & Kent 2013, *Soil Biol Biochem*

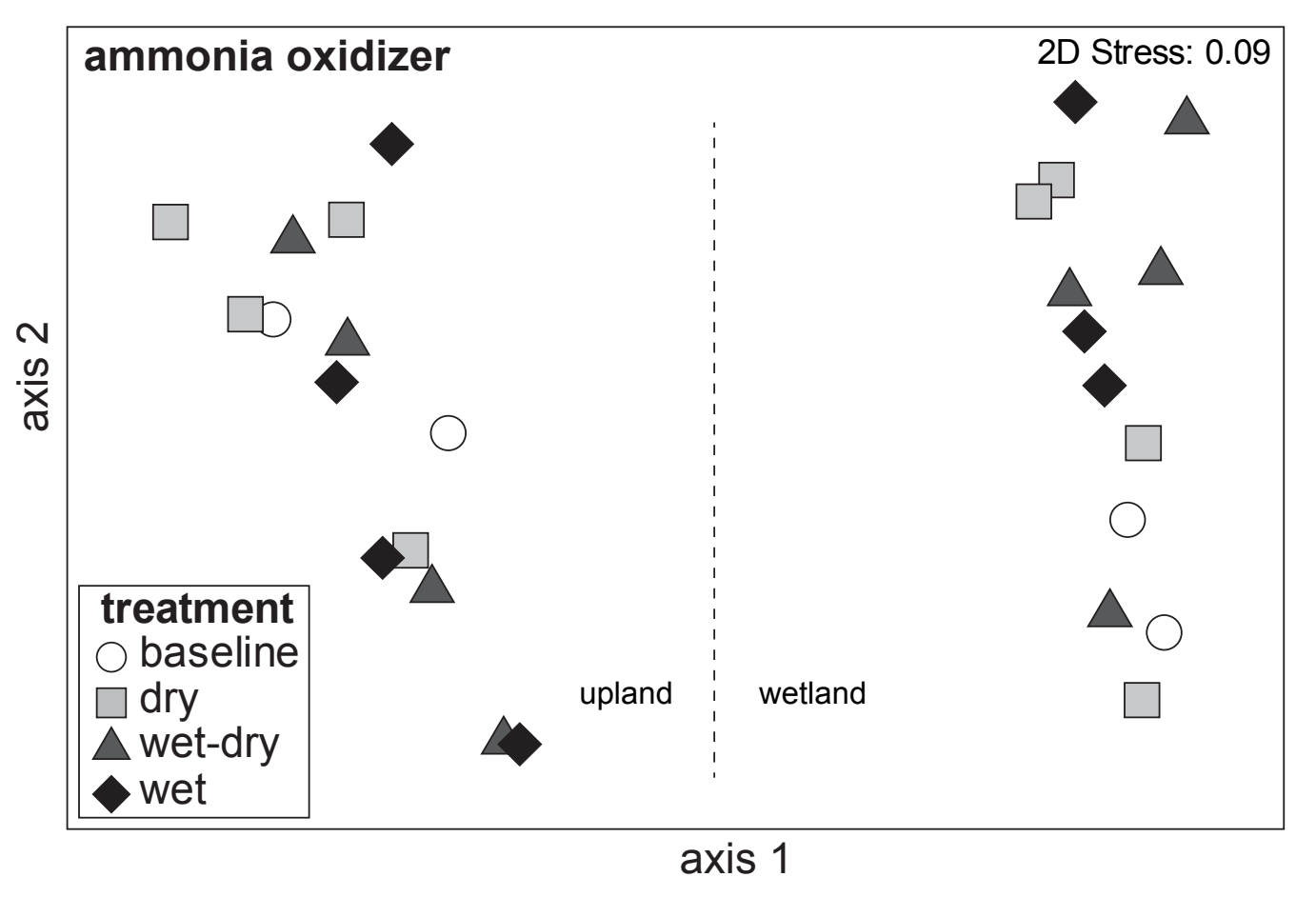
Drying reduces nitrification



ANOVA: history x treatment; $F_{(2,17)} = 20.78$, $P = 0.0005$

Peralta, Ludmer, & Kent 2013, *Soil Biol Biochem*

Hydrologic history influences ammonia oxidizer communities



hydrologic history: PERMANOVA, $R^2 = 0.3816$, $P = 0.0010$

drying/flooding treatment: PERMANOVA, $R^2 = 0.0315$, $P = 0.5385$

Peralta, Ludmer, & Kent 2013, *Soil Biol Biochem*

Summary

RESULTS

- Community composition differs due to history
- Denitrification rate ⇧ under wet conditions
- Nitrification rate less sensitive to moisture treatment

Summary

RESULTS

- Community composition differs due to history
- Denitrification rate ⇧ under wet conditions
- Nitrification rate less sensitive to moisture treatment

IMPLICATIONS

- Nitrate levels may build under dry conditions
- Not all microorganisms respond to environmental change similarly (e.g., varied shifts in N cycling)

Agricultural Legacy Effects

- Long-term persistence of chemical, physical or biological factors developed under agriculture
- Strong: ecosystems are slow/resistant to 'recover'
- Weak: ecosystems are quick to 'recover'

Physical

Chemical

Biological

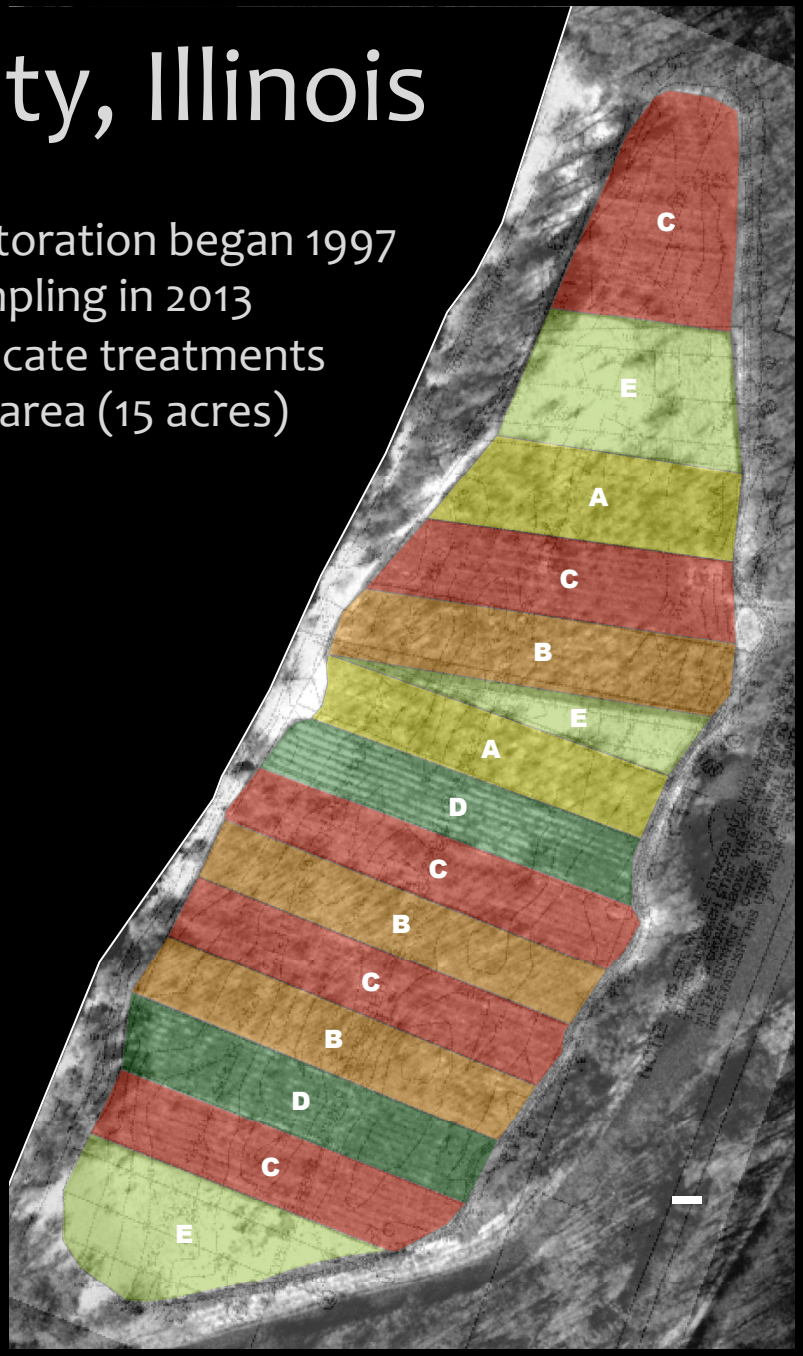
Questions

- Does management strategy impact plant and microbial community composition?
- Does cost of restoration impact outcomes?
- Can management override land use legacies?

Field Site: Henry County, Illinois

IDOT restoration began 1997
Field sampling in 2013

- 3 replicate treatments
- 30 ha area (15 acres)



Experimental Design

Restoration goal:

To create 15 acres of jurisdictional wetland

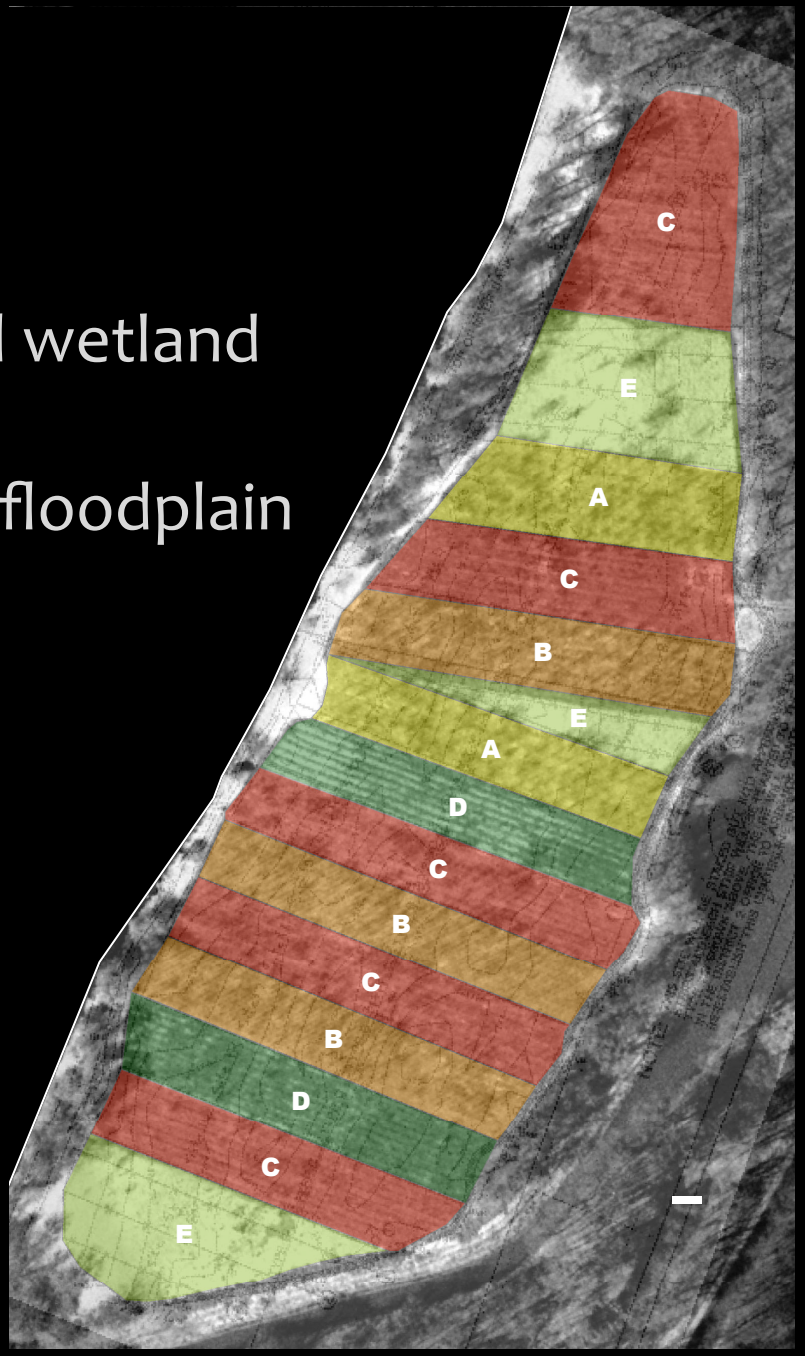
Bonus:

To assess alternative methods of floodplain forest restoration

Restoration Treatments:

- A – balled and burlapped
- B – 5 ft bare root
- C – seedlings
- D – acorns
- E – seedbank (control)
- R – reference wetland

*Site is completely dependent on Rock River for hydrologic input



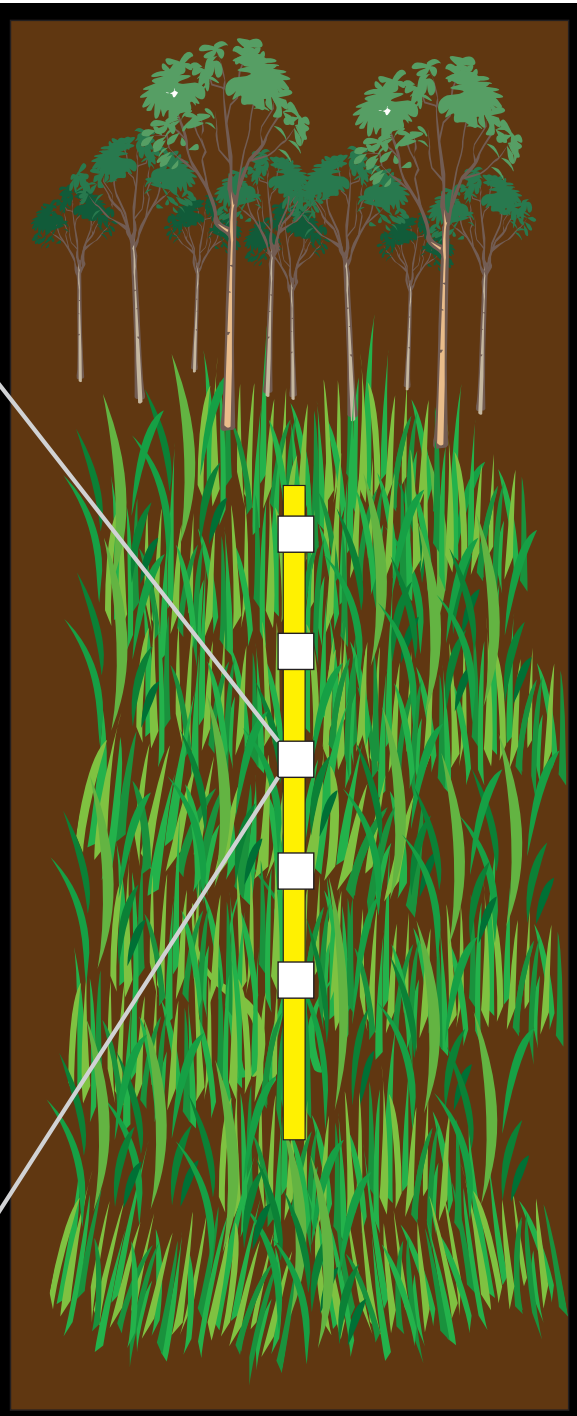
Field Sampling

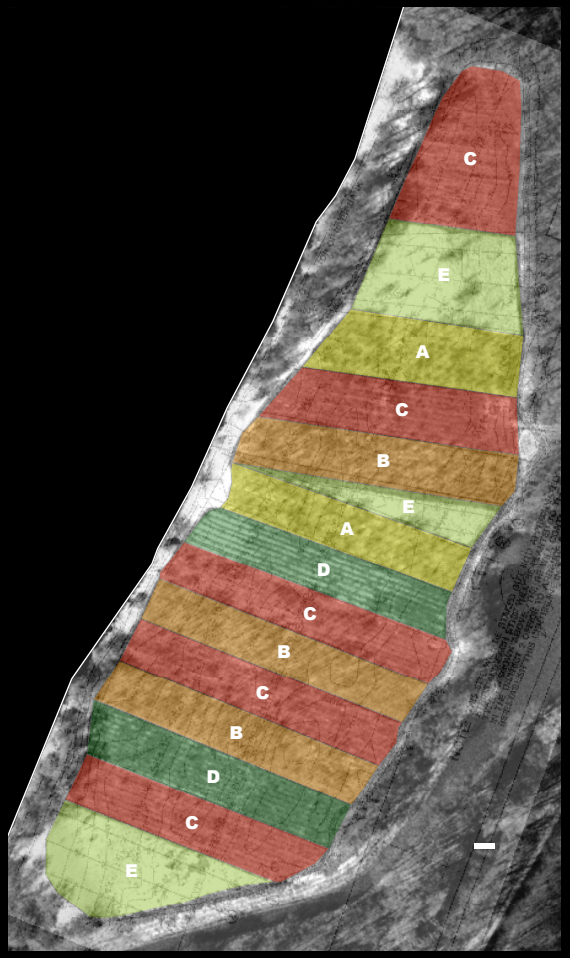
Microbial Community Composition
(16S rRNA sequencing)

Plant Community Composition

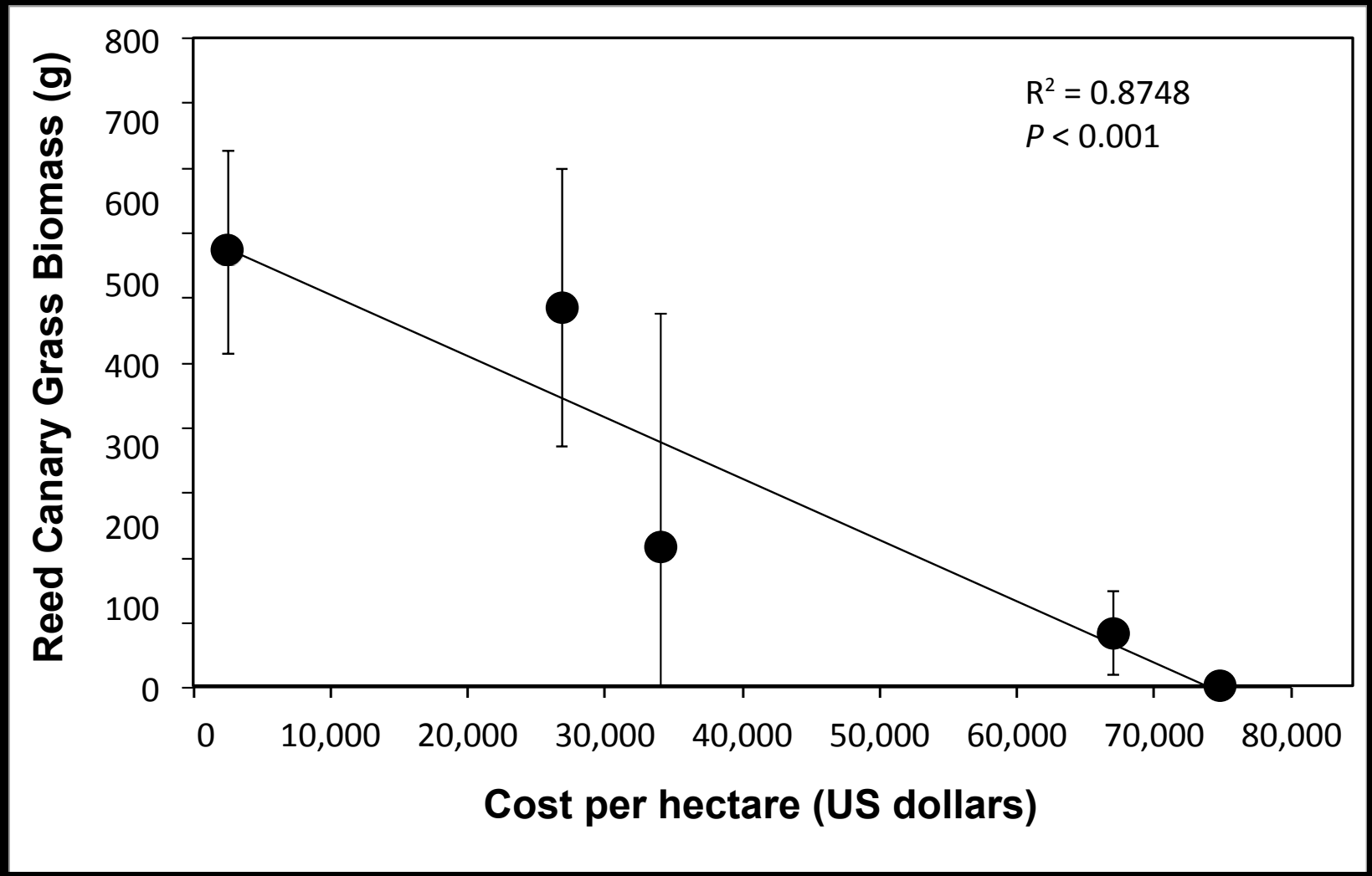
Soil Factors

pH
soil moisture
presence of standing water
soil organic matter (TN, TOC, C/N ratio), ammonia, nitrate
soil temperature



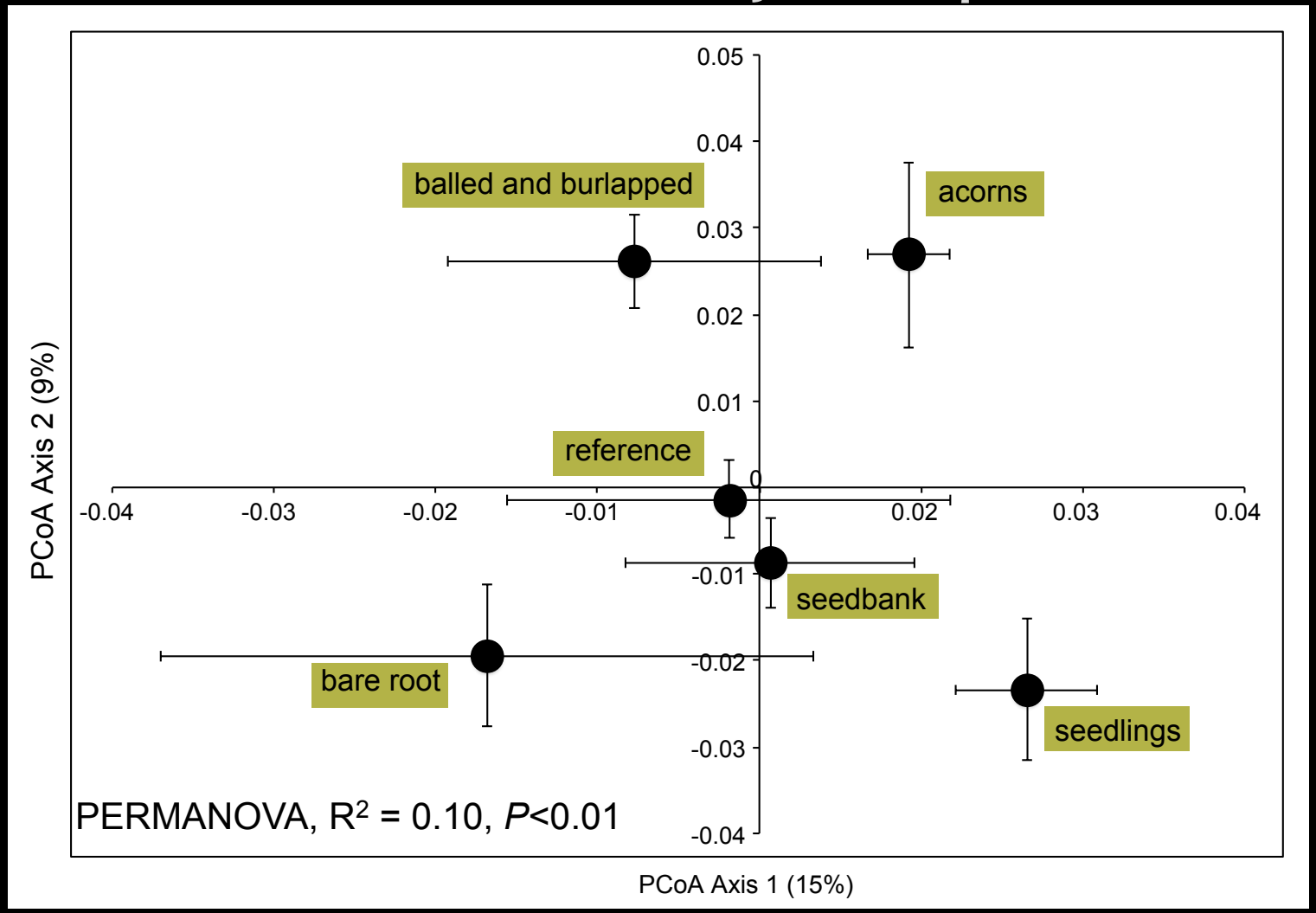


Does cost influence restoration outcome?



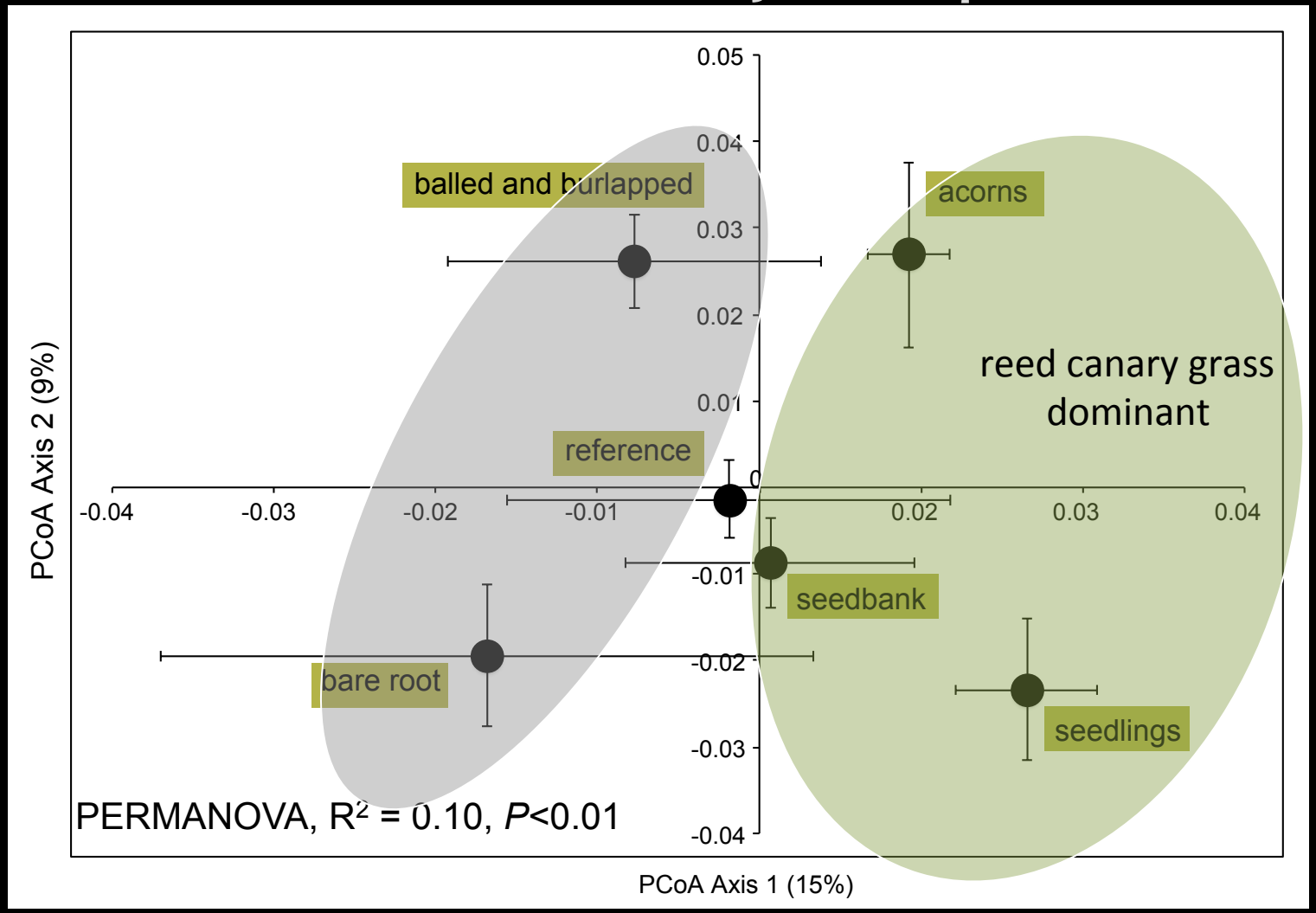
Matthews & Peralta, In preparation

Does management strategy impact microbial community composition?



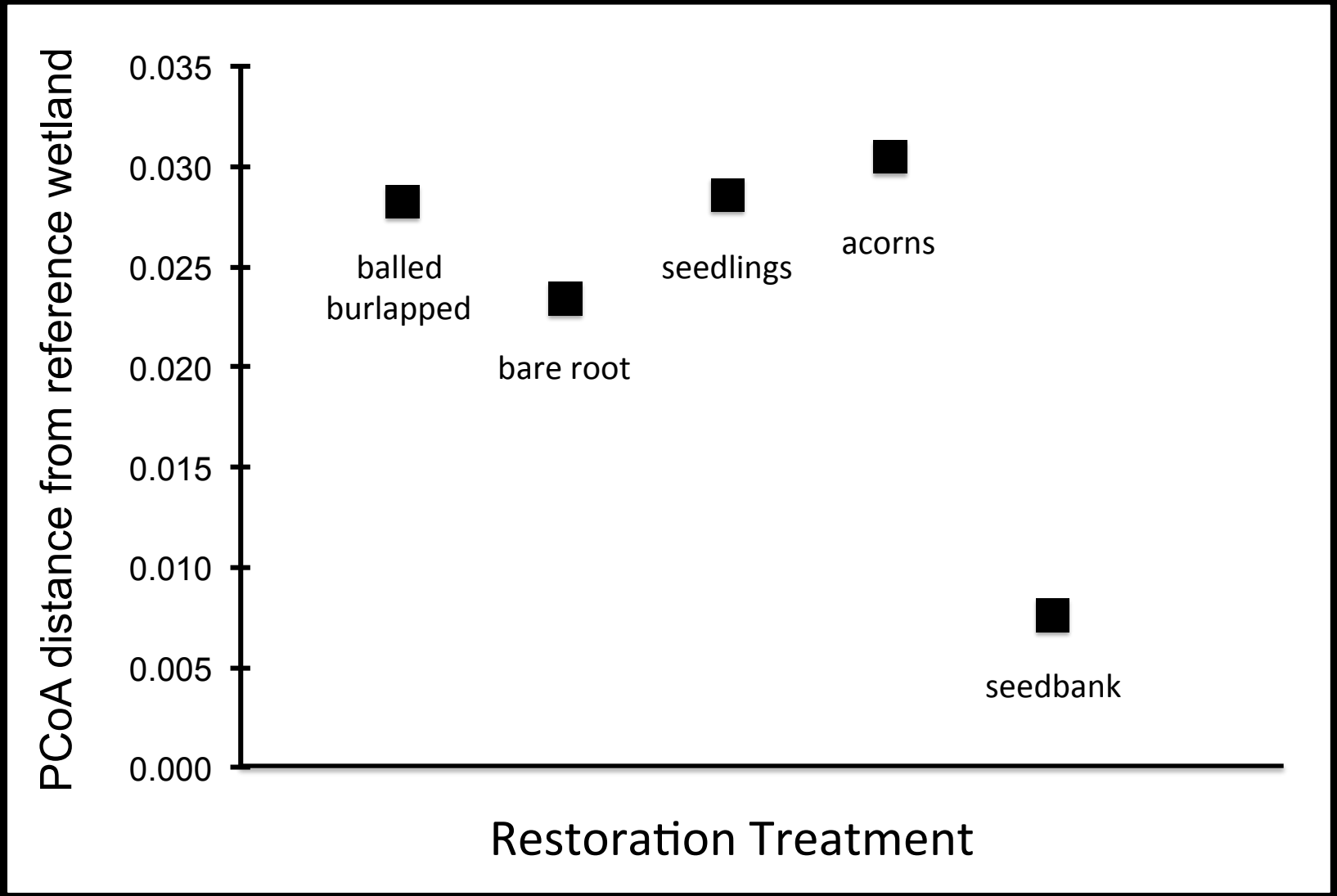
Peralta & Matthews, In preparation

Does management strategy impact microbial community composition?



Peralta & Matthews, In preparation

Agricultural legacy effects in microbial communities



Can management override land use legacies?

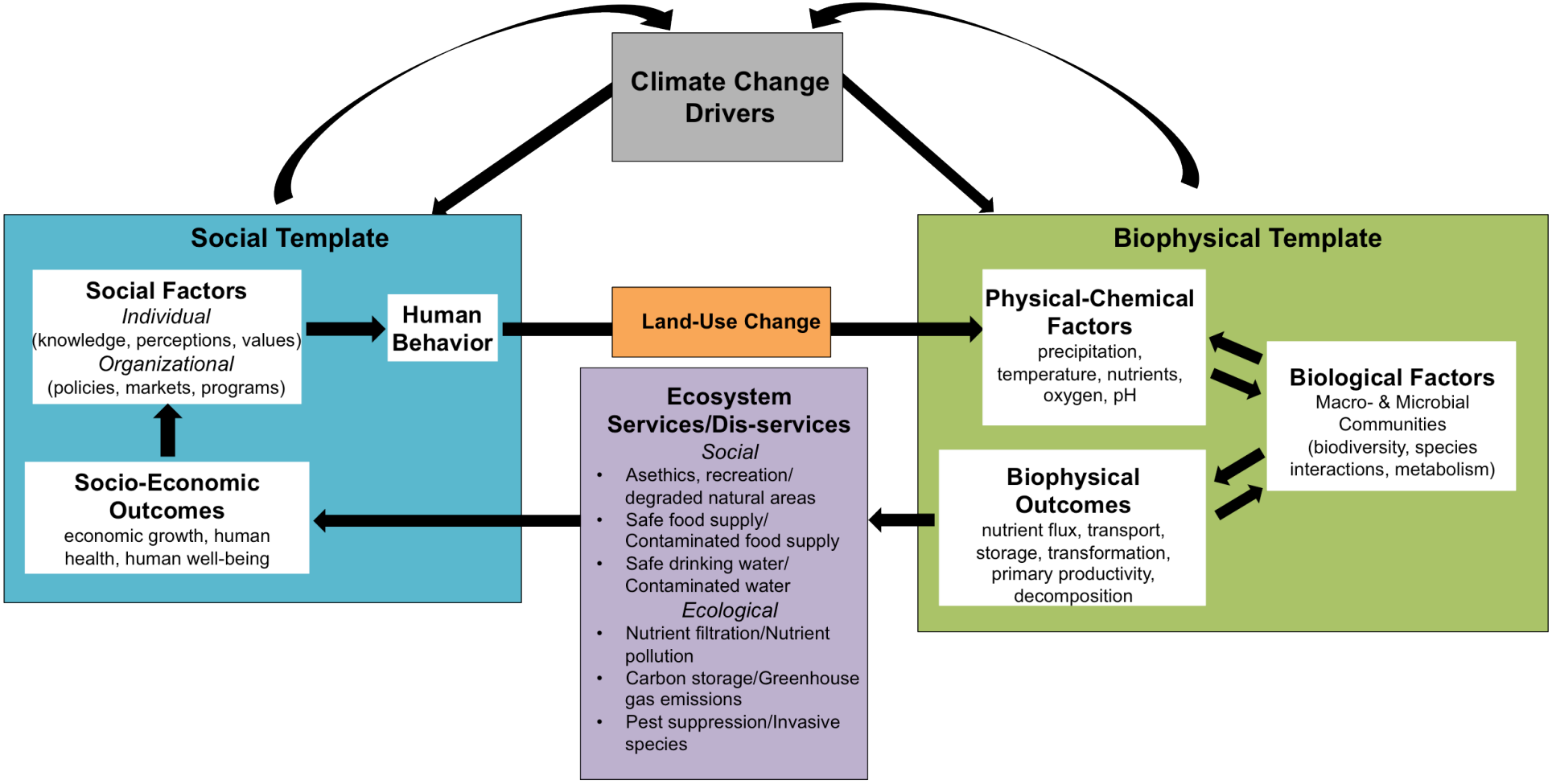
Consequences for restoring ecosystem function:

- Biodiversity
- Erosion control
- Carbon sequestration
- Water quality improvement

+

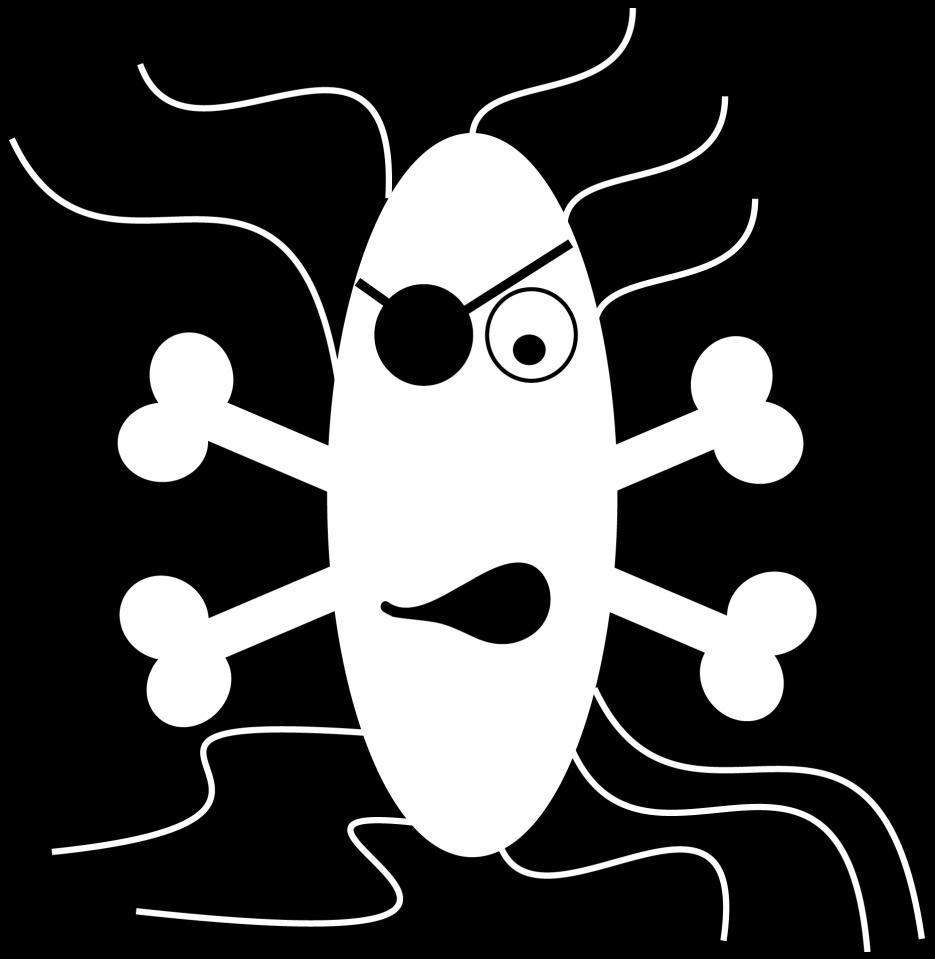
=

‘micromanaging’ microbes



Modified from Peralta, Stuart, Kent, & Lennon, Frontiers in Ecol & Env, *In press*

Microbial Ecology at East Carolina University



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