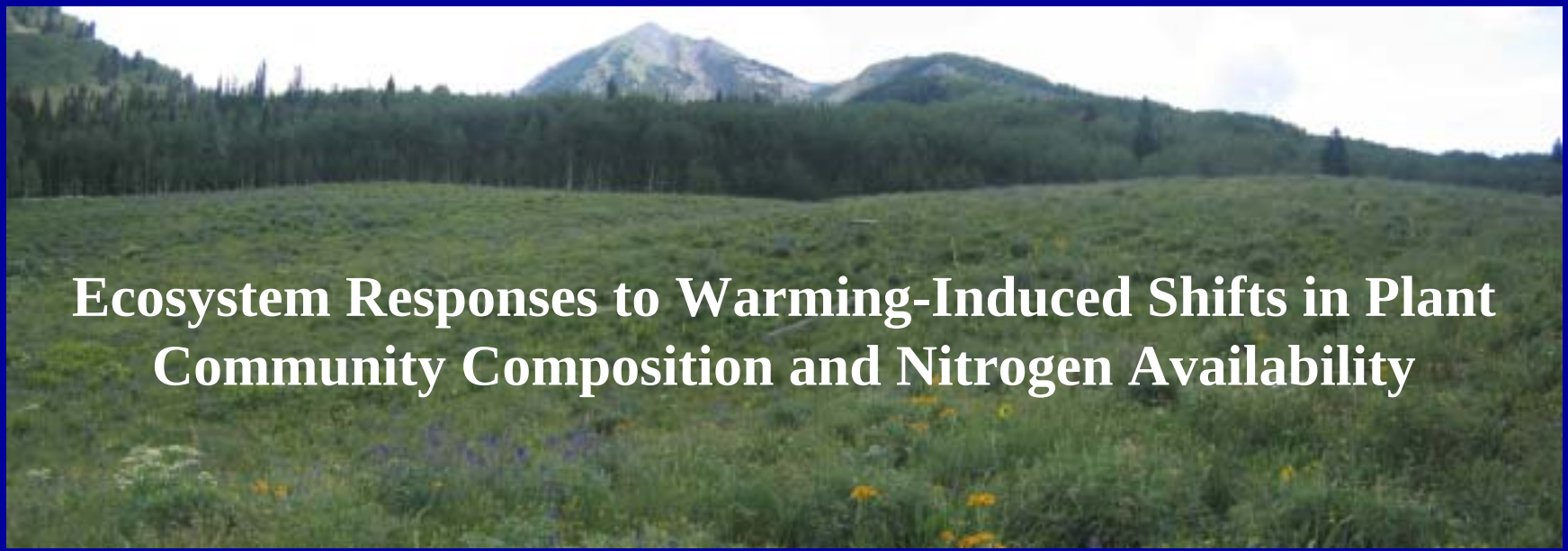
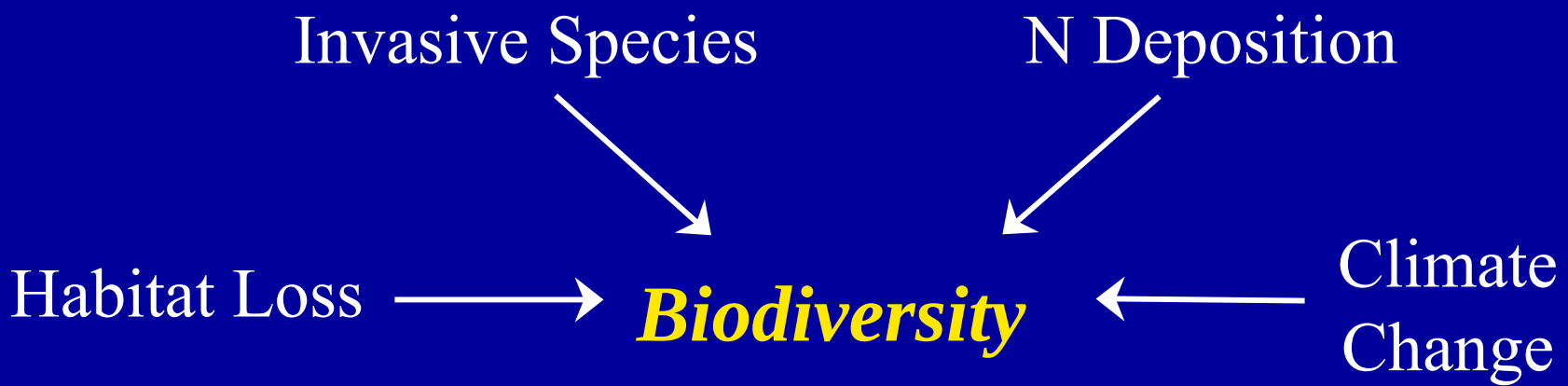


Ecosystem Responses to Warming-Induced Shifts in Plant Community Composition and Nitrogen Availability

Molly Smith and John Harte

University of California, Berkeley
Environmental Science, Policy and Management


Invasive Species
N Deposition
Habitat Loss
Biodiversity
Climate Change

Invasive Species

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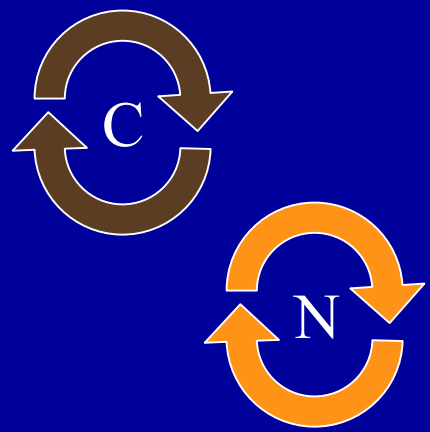
?

Ecosystem Processes

Productivity

Carbon Cycling

Nitrogen Cycling



Plant Diversity ← Climate Change

↓ ?

Ecosystem Processes

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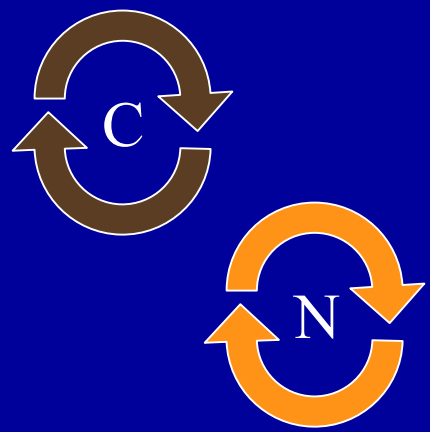


Talk Outline

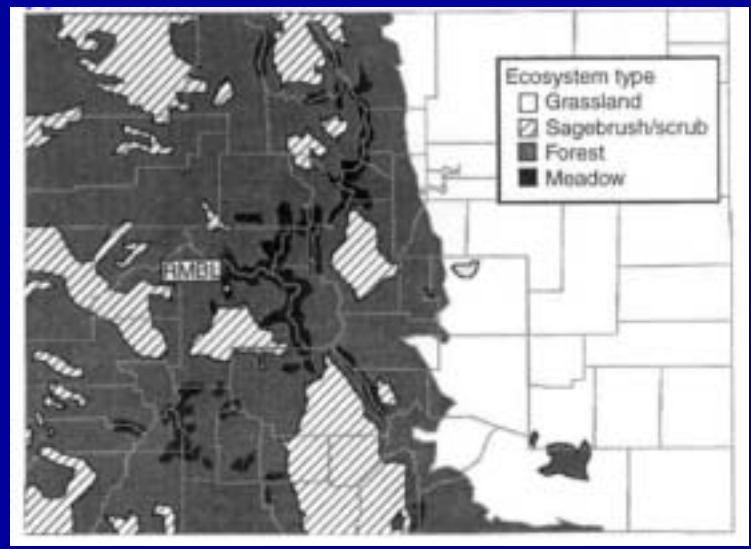
1. Description of site and experimental warming results
2. My research questions and hypotheses
3. Removal experiment description
4. Preliminary results

Site Description

Rocky Mountain Biological Laboratory (RMBL)

- Ungrazed, perennial meadow (~100 herbaceous forb, grass and shrub spp.)
- Ecotone between Great Basin shrubland and Rocky Mt. subalpine meadow

- Elevation = 2,920m (9,500 ft)
- Annual Precip. = 750mm, 80% as snow
- Mean summer temperature = 10°C
- Growing season = mid May-early Sept.



Colorado Vegetation Map

Warming Experiment

- Began in 1990
- Increases heat flux by 22 W/m^2
- Microclimate Responses to heating:

  Increase in soil T by ~2˚C
  Decrease in soil M by ~14%
  Earlier snowmelt by ~2 weeks

Harte et al. (1995) Ecological Applications.

Heating Has Resulted In…

Heating Has Resulted In…

Shrub Aboveground Biomass (AGB) ↑

Harte and Shaw (1995) Science.

Heating Has Resulted In…

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Shallow-Rooted Forb success ↓

Tap-Rooted Forb AGB (No Δ, or ↑)

De Valpine and Harte (2001) Ecology.

Saavedra et al. (2003) Global Change Biology.

Helianthella quinquinervis

Linum lewisii

Heating Has Resulted In…

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- Shallow-Rooted Forb success ↓
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Net Nitrogen Mineralization ↑

Shaw and Harte (2001) Global Change Biology.

Hypotheses

H1 = **The loss of shallow-rooted forb species will lead to:**

- ↓ Primary Productivity
- ↓ Net N Mineralization Rates
- ↓ Plant Uptake of N
- ↓ Ecosystem Carbon Storage

Hypotheses

H2 = **The addition of nitrogen (N) will lead to:**

- ↑ Primary Productivity
- ↑ Net N Mineralization Rates
- ↑ Plant Uptake of N
- ↑ Ecosystem Carbon Storage

Hypotheses

H3 = **The loss of shallow-rooted forb species will reduce the expected positive responses to N addition:**

- ↑ Primary Productivity
- ↑ Net N Mineralization Rates
- ↑ Plant Uptake of N
- ↑ Ecosystem Carbon Storage

Plant Species Removal + N Addition Experiment

- Began in 2001.
- Followed guidelines developed by the Species Removal Network.
- Adjacent to warming meadow experiment, but not under heaters.

Treatments

1. Plant species removal:
   a) Shallow forb removal (all shallow-rooted forb species) [SR]
   b) Random forb biomass removal [BR]
   c) No removal [C]

2. Nitrogen addition:
   a) Addition of 6 $gN/m^2/yr$ (as ammonium-nitrate) [+N]
   b) No N addition [no N]

- Multi-Factorial Experiment = 3 x 2 treatments = 6 total treatment combinations.
- Randomized Block Design with 8 replicate blocks.

Removal Treatments

Control

Shallow Removal

Random Removal

Ecosystem Response Variables

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- **Primary production**
  - Aboveground (by plant type -- deep forbs, shallow forbs, grasses)
  - Belowground (fine roots in top 10cm)

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  - Net N mineralization and nitrification rates.
  - Ion exchange resin bags at 30cm depth.

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Ecosystem Response Variables

- **Primary production**
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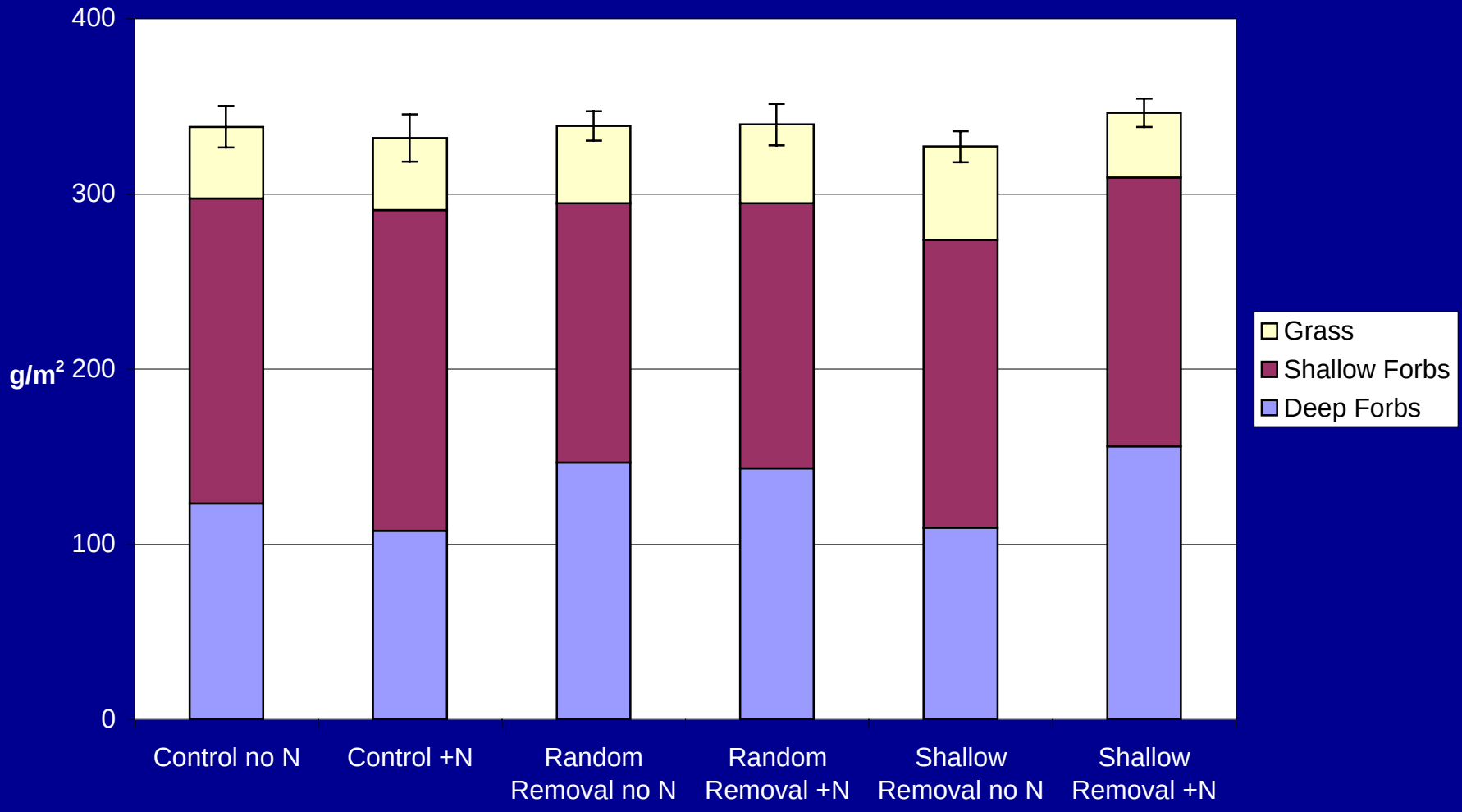
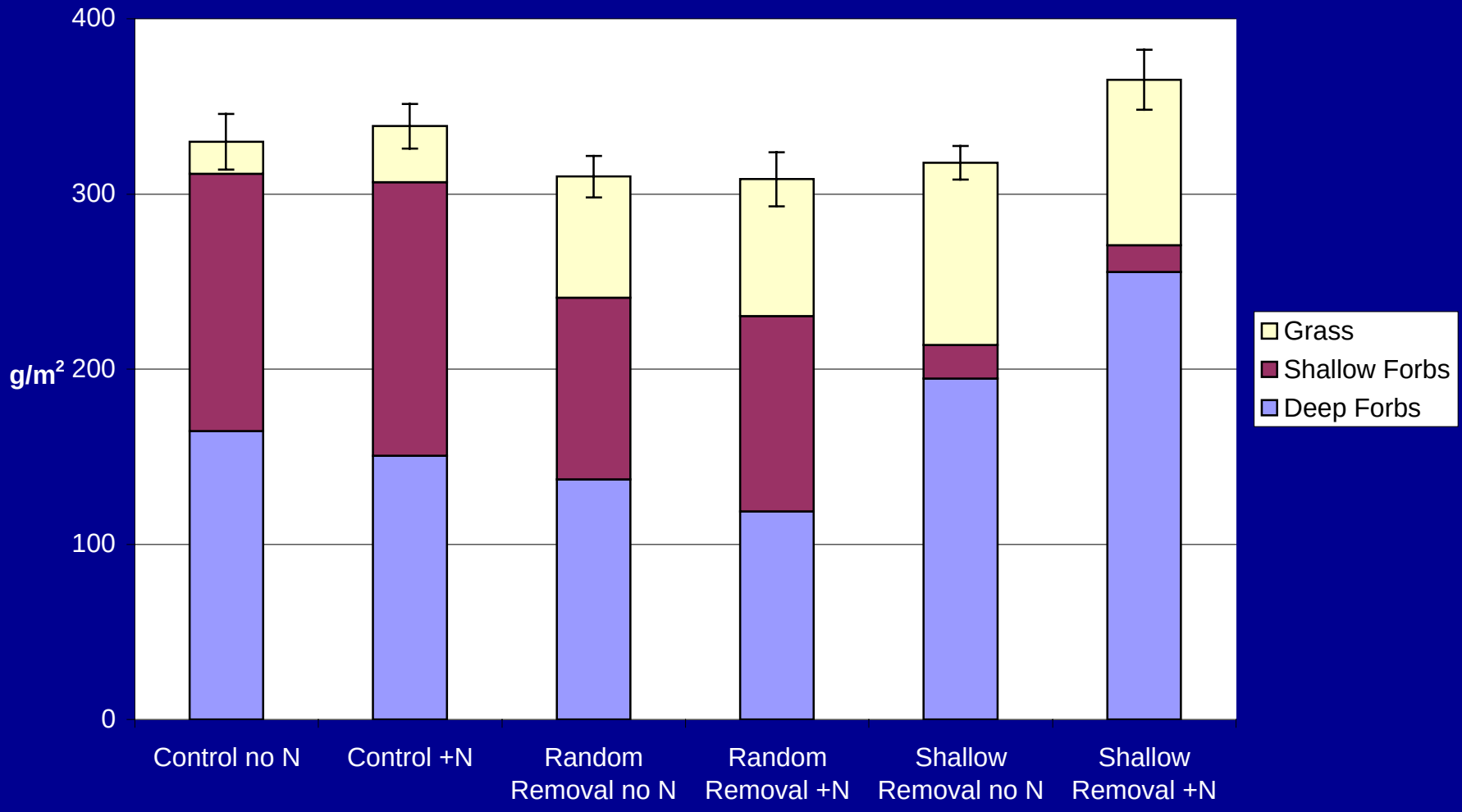
1. How the manipulation has affected community composition.
2. How the species removal treatments have affected Total AGB.
3. How nitrogen addition has affected Total AGB.
4. How the species removal treatments have affected Total AGB responses to nitrogen addition.

2001 Aboveground Biomass [Pre-Manipulation]



2004 Aboveground Biomass
[No Weeding, But Still +N]



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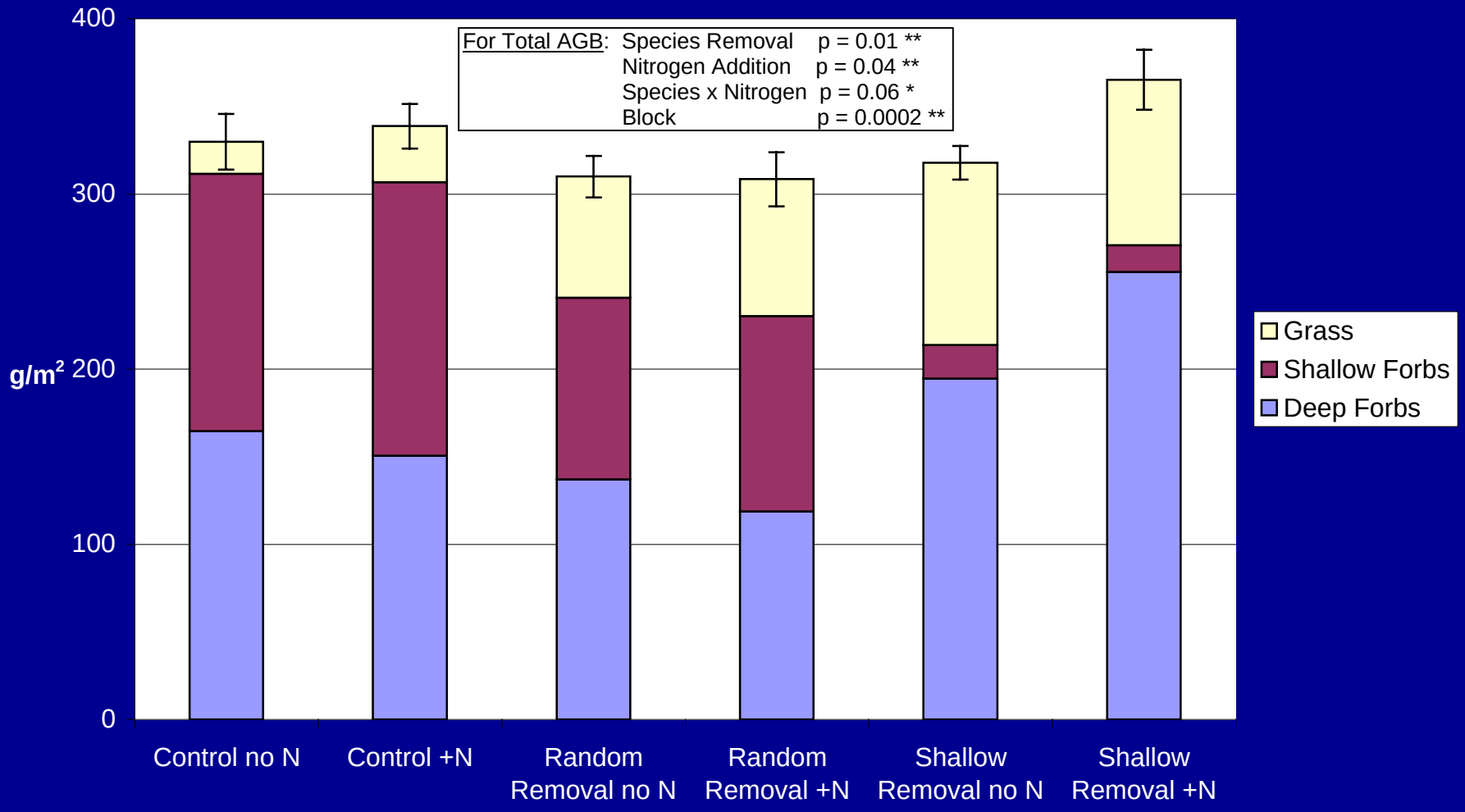
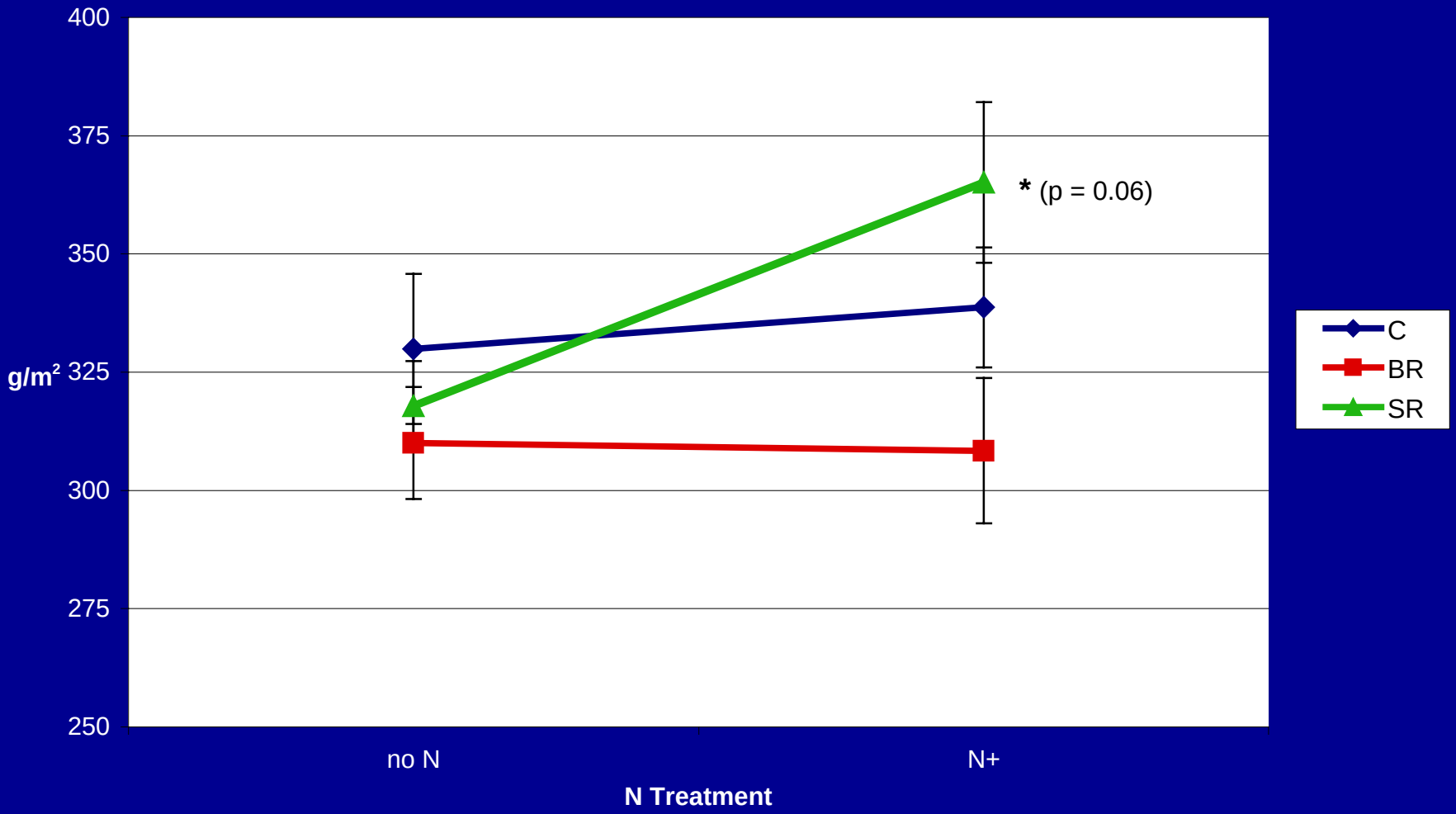


Effect of N Addition on Total AGB by Species Removal Treatment



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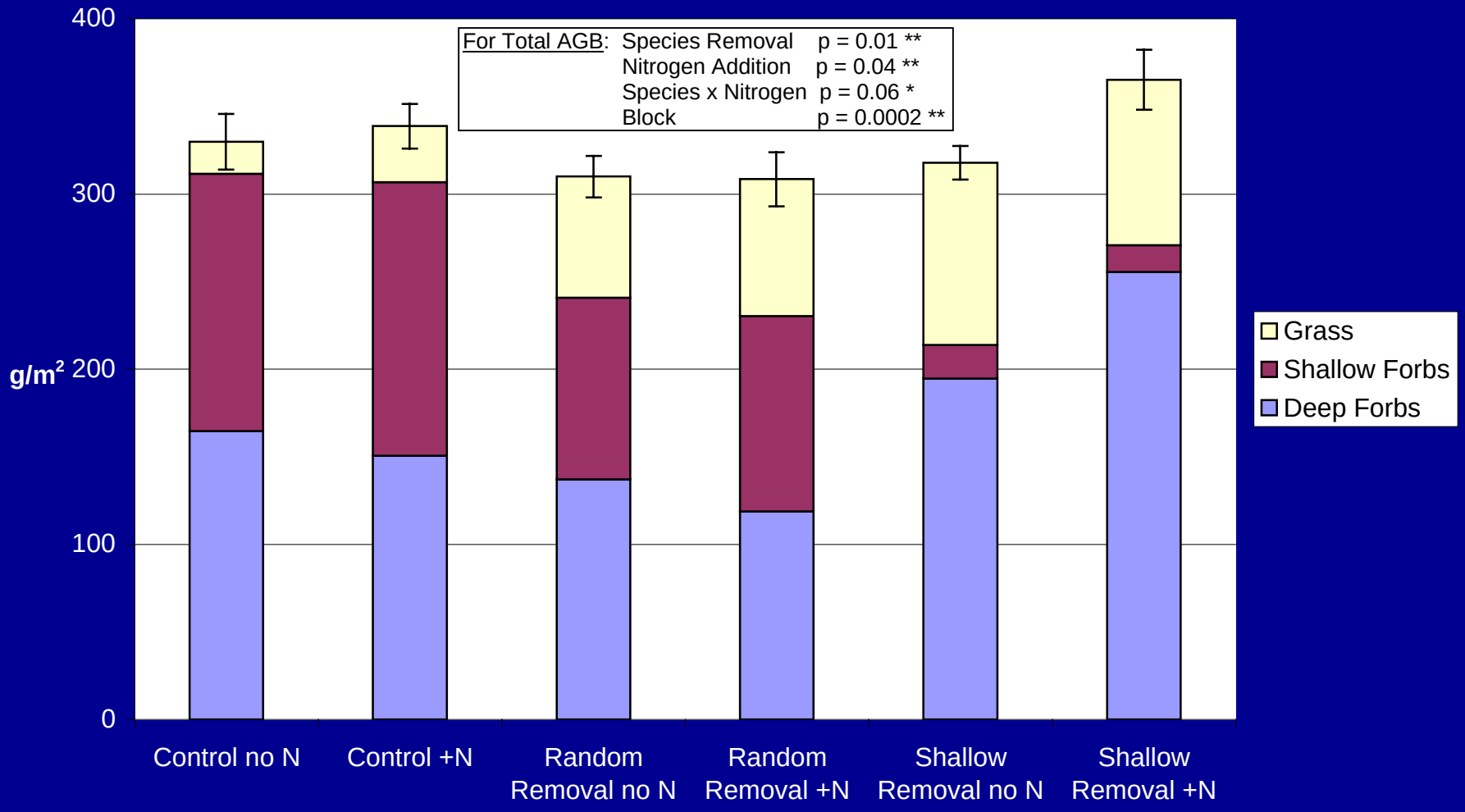

Summary of Preliminary Results

1) Manipulations have had a significant effect on plant community composition.

2) After 3 years of removals, Total AGB in removal plots has recovered to the same level as in the Controls…
…but not as much in the Random as in the Shallow Removal.

3) Nitrogen addition had a positive effect on Total AGB in Shallow Removal, but no effect on Total AGB in Control and Random Removal -- mainly due to increased growth by deep forbs.

Summary of Preliminary Results

4) It does matter who is lost from the system since Random Removal did not produce the same response in deep forb growth.

5) Results suggest that one highly productive functional group can fill in for the loss of another.

6) However, it remains to be seen whether other aspects of ecosystem functioning -- C and N cycling -- are affected by the loss in diversity.

Thanks to: NASA, DOE, NSF, John Harte, the Harte Lab, Doug Bushey, Andy Chau, Heather Cooley, Erin Conlisk, Lara Cushing, Chris DiVittorio, Zac German, Leah Goldstein, Mayme Grant, Ling Jin, Nathan Kraft, Katherine McClure, Cameron Pederson, Susan Palmer, Tracy Perfors, James Preist, Adam Smith, Curt Stumpf, Kimberly Trinh, Natalie Tsui, Mei Wang.