Response of soil nitrogen cycling to the interaction of invasive plants, simulated cattle grazing, and nitrogen additions

Chelsea J. Carey[1], Valerie T. Eviner[2], Stephen C. Hart[1]

1. University of California, Merced, Environmental Systems Program
2. University of California, Davis, Department of Plant Sciences

Outline

- Introduction
- Experimental design and methods
- Results
- Conclusions and implications

Why these global change factors?

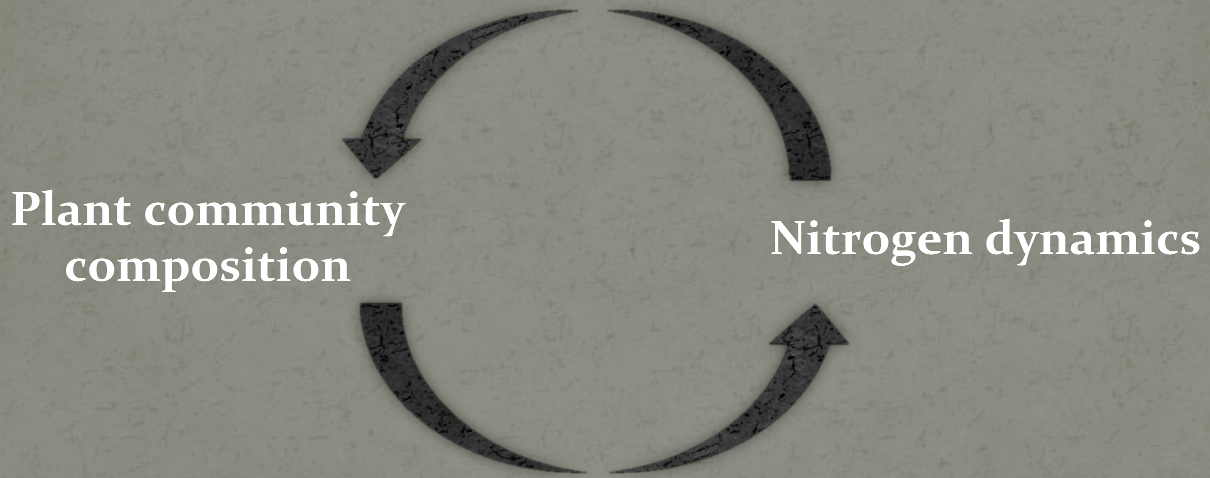
- Invasive species
  - 1,100 non-native species in CA
    - 300 in grasslands
    - 66 moderate or high concern (Cal-IPC)
  - Annual management cost in CA = $82 million
  - Potential impact on key ecosystem services
    - Forage quality, water retention, nutrient cycling
- Cattle grazing
  - Livestock grazing since 1769
  - ~5 million cattle
  - Potential impact on key ecosystem services
    - Soil compaction, redistribution of nutrients
- Nitrogen deposition
  - California experiences some of the highest rates in the U.S.
    - Southern California: ≤ 45 kg N / hectare / year
    - Northern California: ≤ 16 kg N / hectare / year
  - Acts as a nitrogen fertilizer

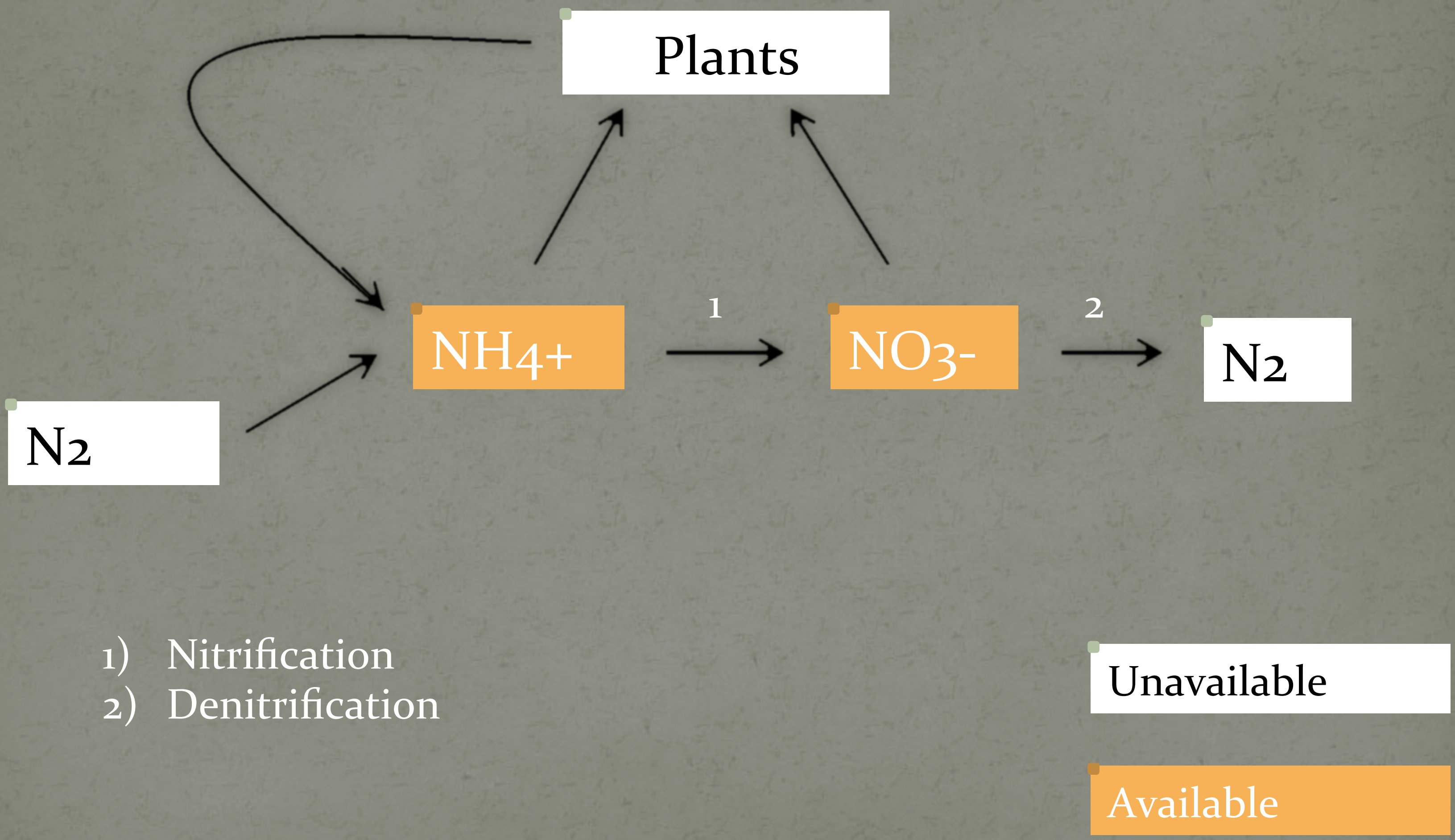

1 dot = 10,000 cattle

USDA-NASS 2012; Cal-IPC; D'Antonio et al. 2007; Jackson and Bartolome 2007; Fenn et al. 2003; Bytnerowicz and Fenn 1996; photo: cattlerange.com

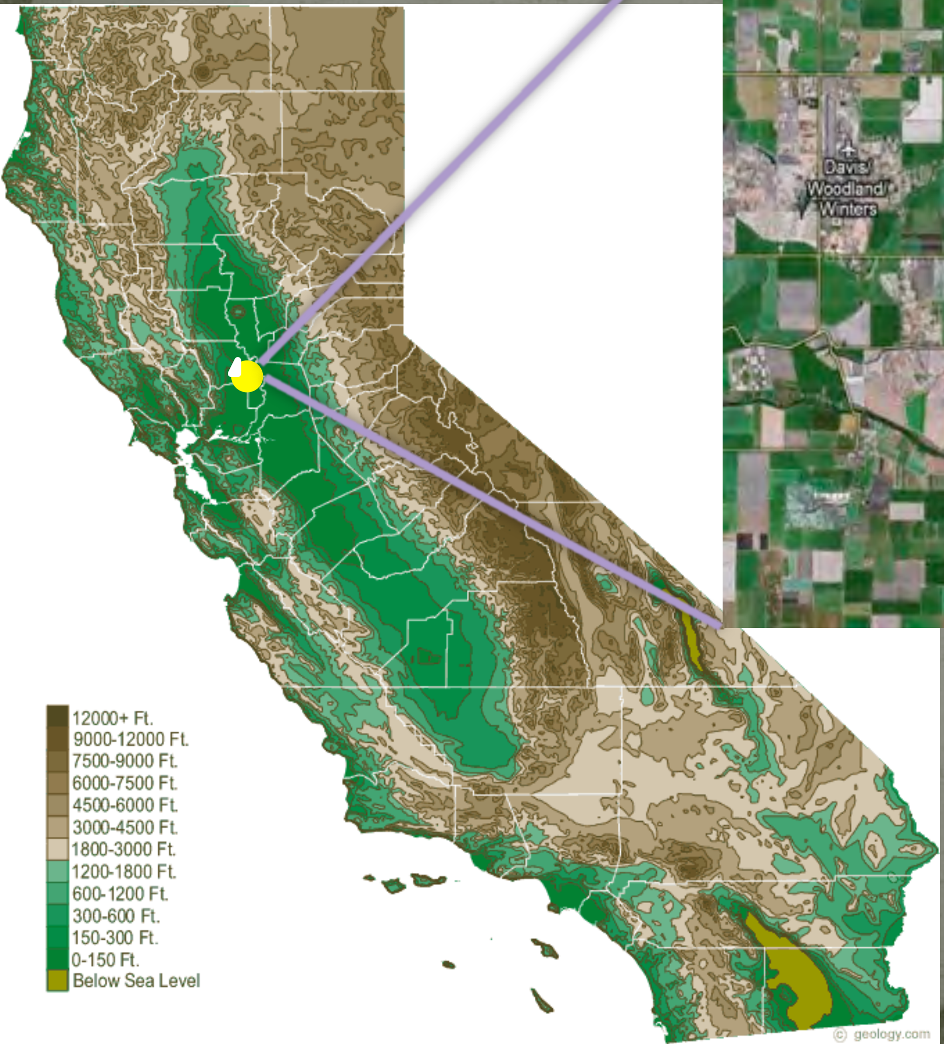
Why nitrogen?

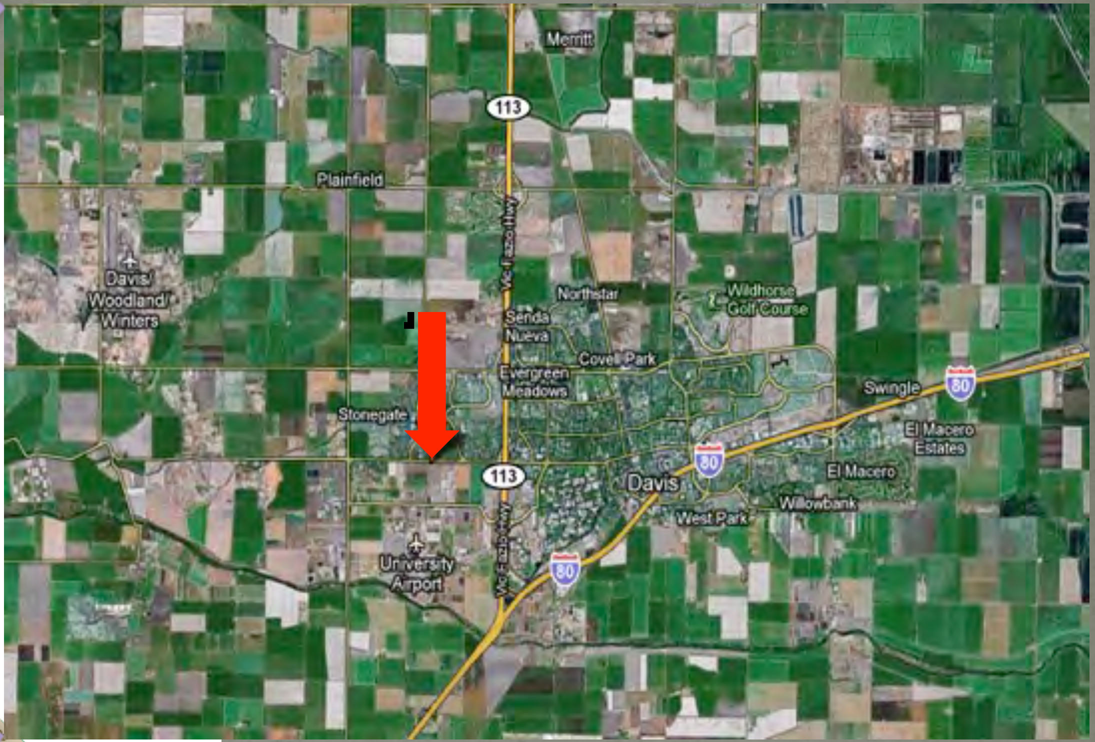
- Nitrogen is the limiting nutrient for plant growth in most temperate ecosystems




Plants
NH4+
1
NO3-
2
N2
N2
1) Nitrification
2) Denitrification
Unavailable
Available

Study site: Davis, CA





Experimental design

- Established 2006
- Randomized complete block design
- Factorially replicated treatments

Treatments

Treatment	Plant Community	N Addition	Clipping
1	Natives	No	No
2	Natives, Naturalized, New Invasives	No	No
3	Natives, Naturalized, New Invasives	Yes	No
4	Natives, Naturalized, New Invasives	No	Yes
5	Natives, Naturalized, New Invasives	Yes	Yes

Natives
Bromus carinatus
*Elymus glaucus**
*Elymus triticoides**
Acmispon americanus†
Lupinus bicolor †
*Stipa pulchra**
Poa secunda
Festuca microstachys

Naturalized exotics
Avena fatau
Bromus hordeaceus
Lolium multiflorum
Trifolium subteranneum†

New invasives
Aegilops triuncialis
Taeniatherum caput-medusae

N addition
November & February
Totaling 45 kg N/ha/yr
Applied as NH_4NO_3

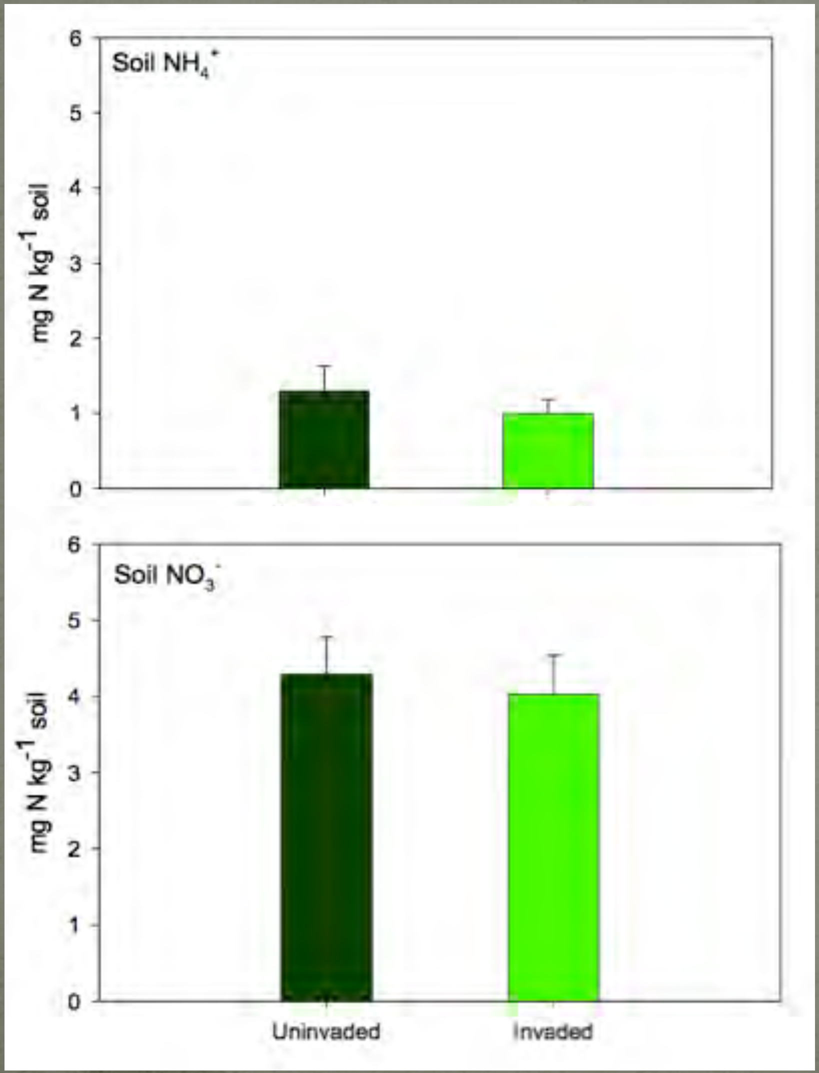
Clipping
April
Clipped to 5 cm above ground

*Perennials
†N fixer

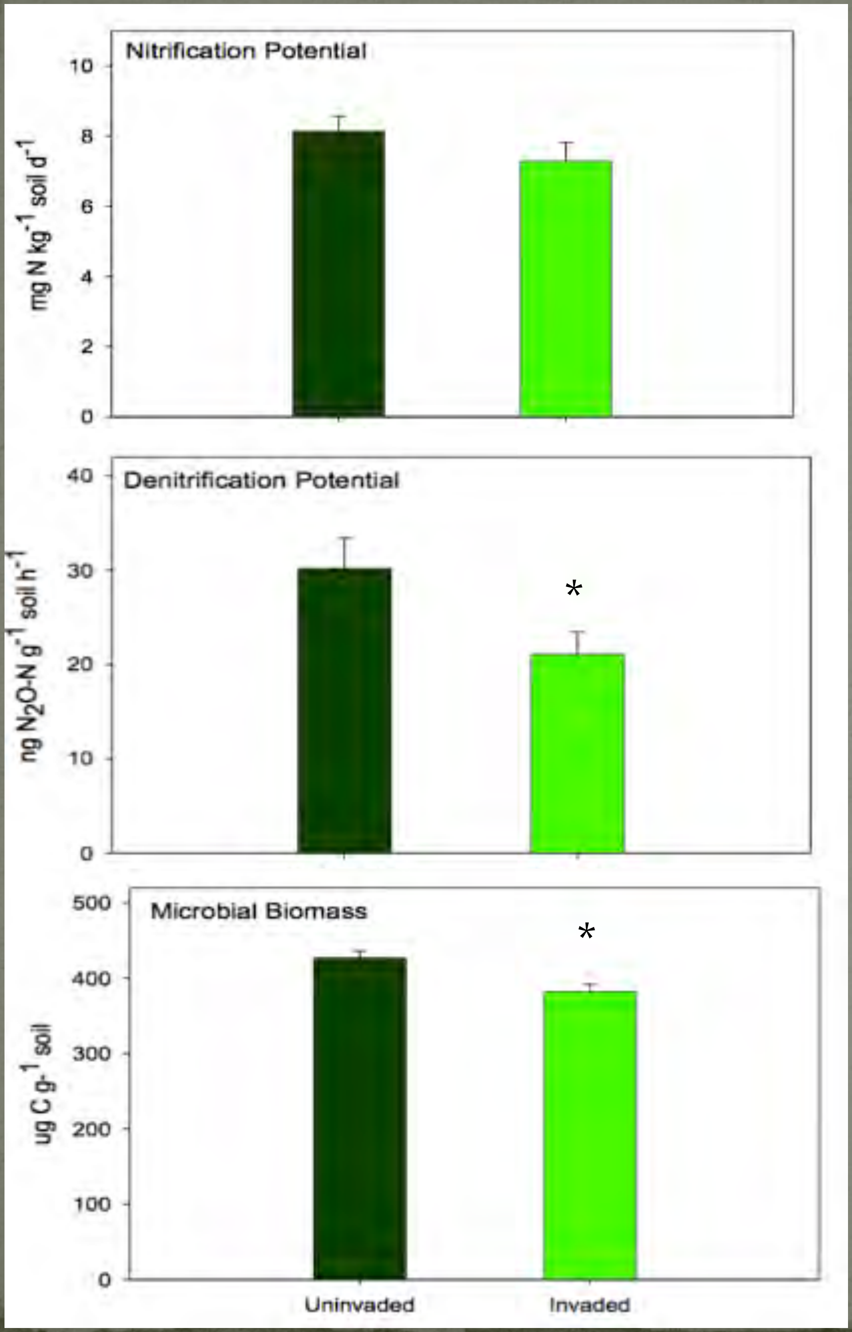
Data collection

- 8 replicate per treatment (n=8)
- 1.5 x 1.5 m plots
- Per plot: composited 5 randomly selected cores from top 15 cm of mineral soil
- Variables measured:
  - Potential nitrification
  - Potential denitrification
  - Available N (NH_4^+ & NO_3^-)
  - Soil microbial biomass
- Sampled seasonally
  - October, January, April, July

Treatment	Plant Community	N Addition	Clipping
1	Natives	No	No
2	Natives, Naturalized, New Invasives	No	No

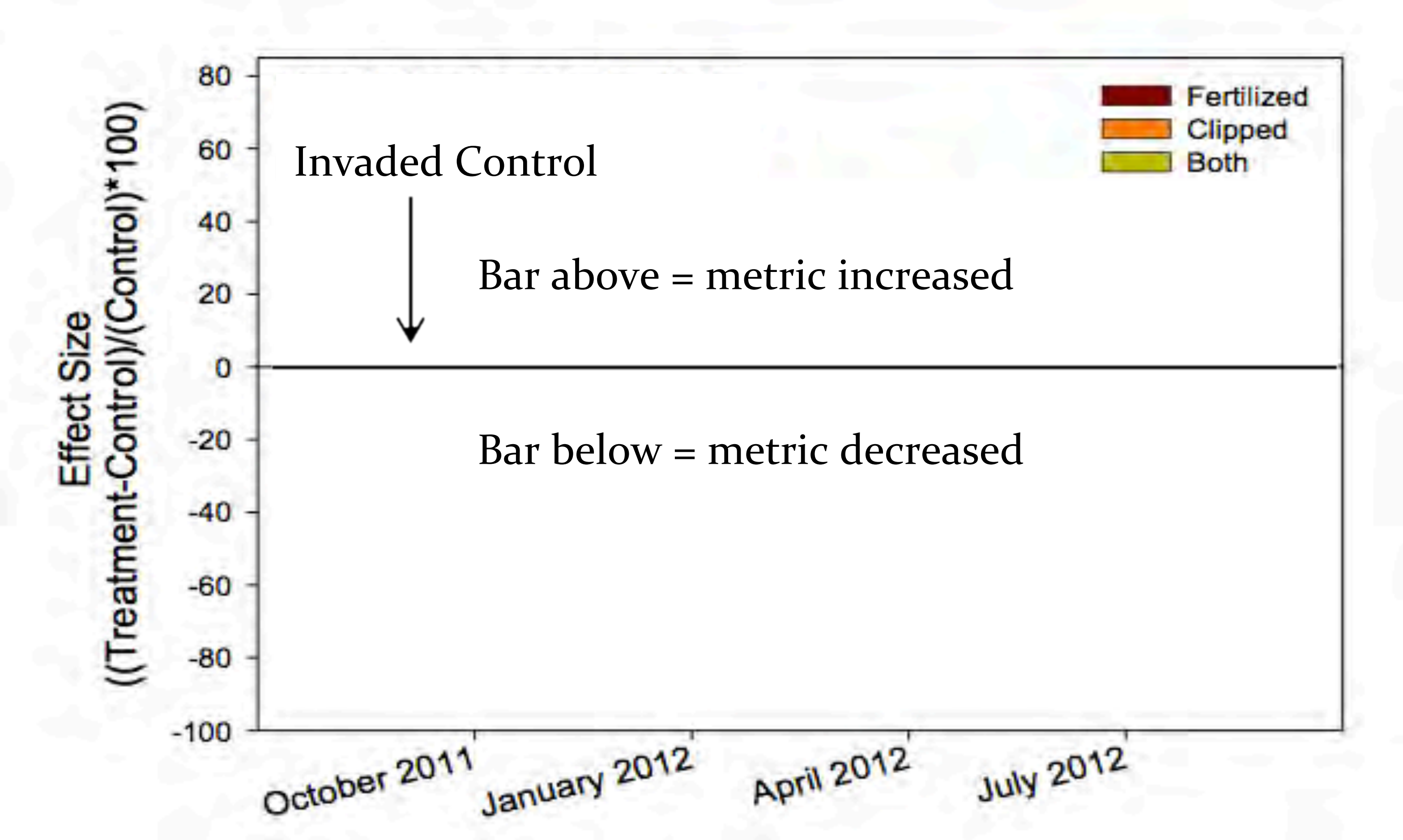


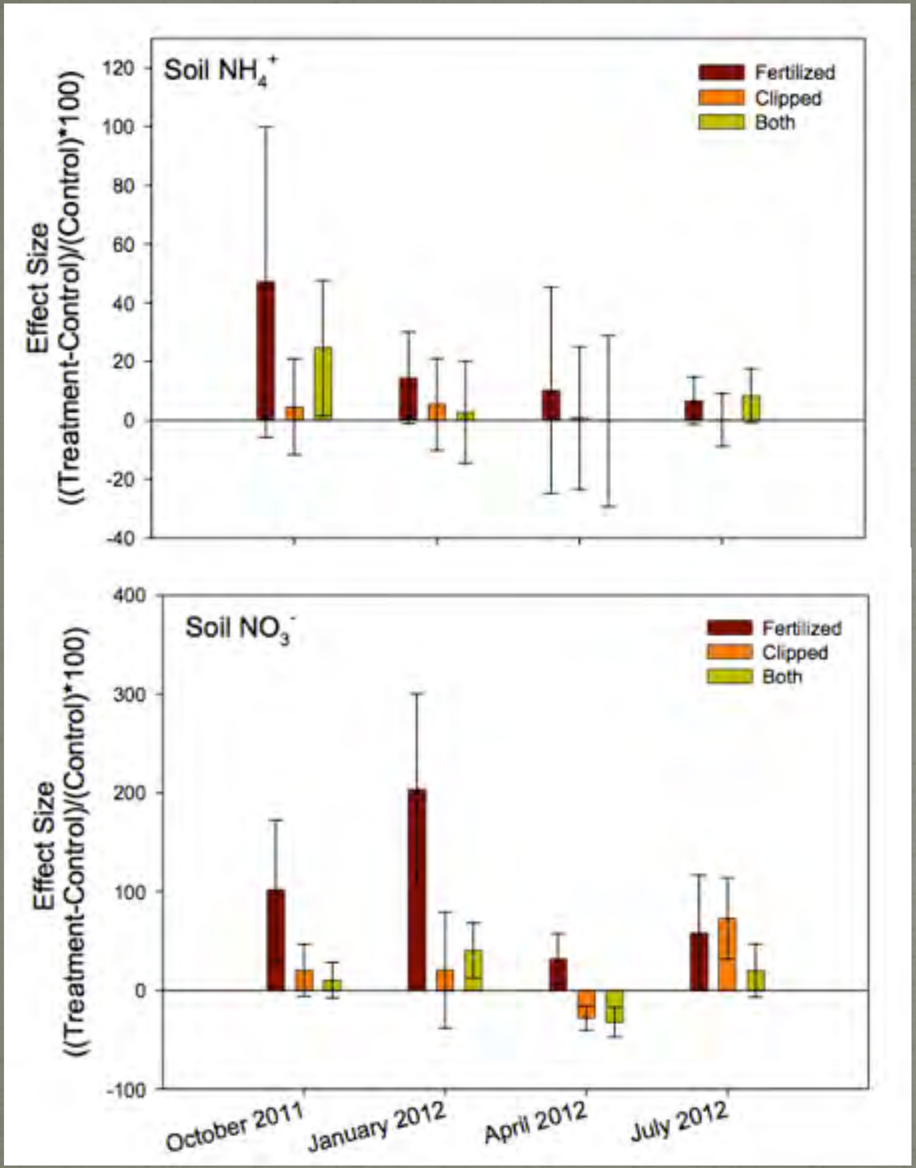
Neither soil NH4+ nor NO3- were affected by the presence of invasive species



Potential denitrification and microbial biomass were reduced in invaded stands

Treatment	Plant Community	N Addition	Clipping
2	Natives, Naturalized, New Invasives	No	No
3	Natives, Naturalized, New Invasives	Yes	No
4	Natives, Naturalized, New Invasives	No	Yes
5	Natives, Naturalized, New Invasives	Yes	Yes





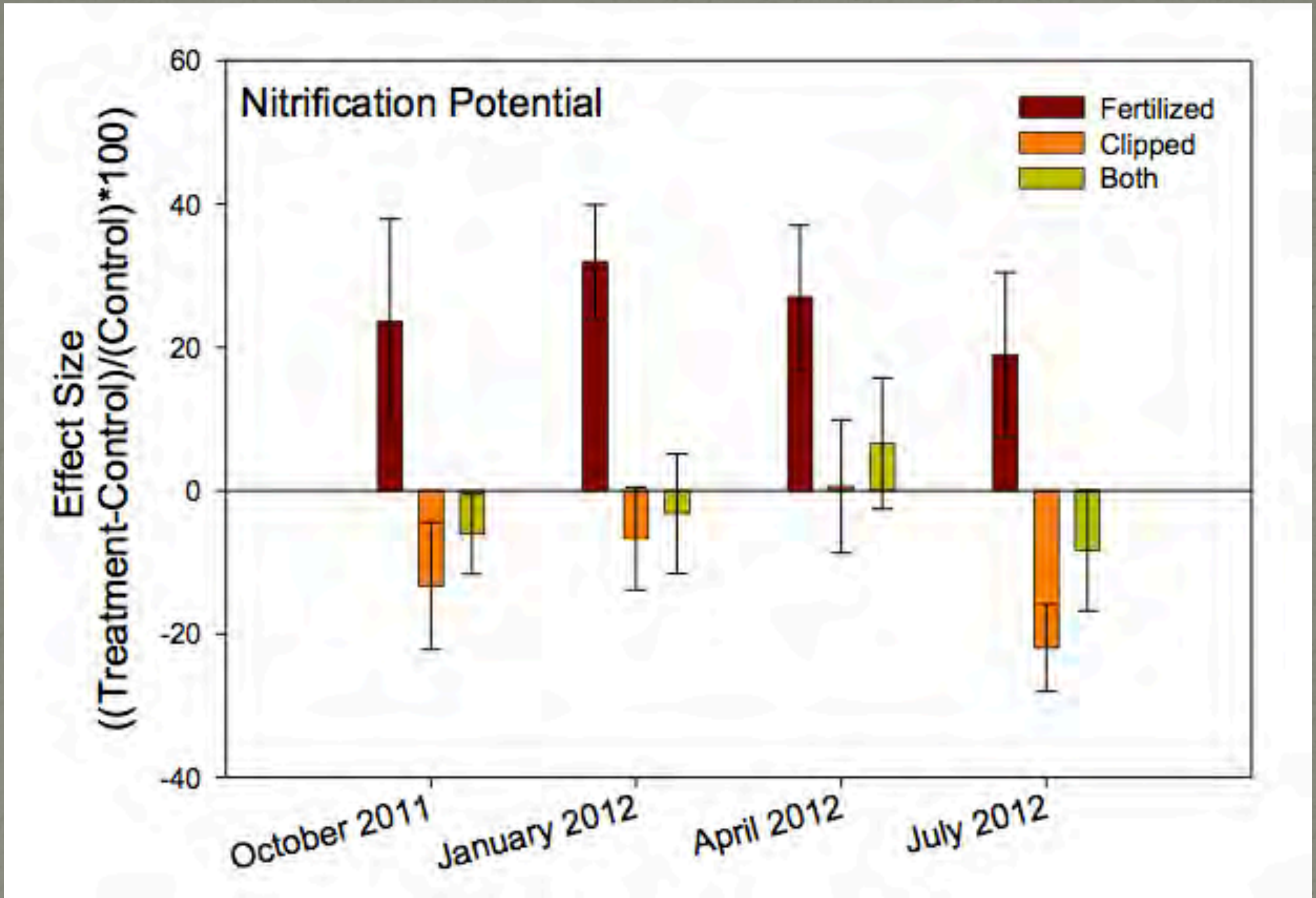
Soil NH4+

- Unaffected by treatment

Soil NO3-

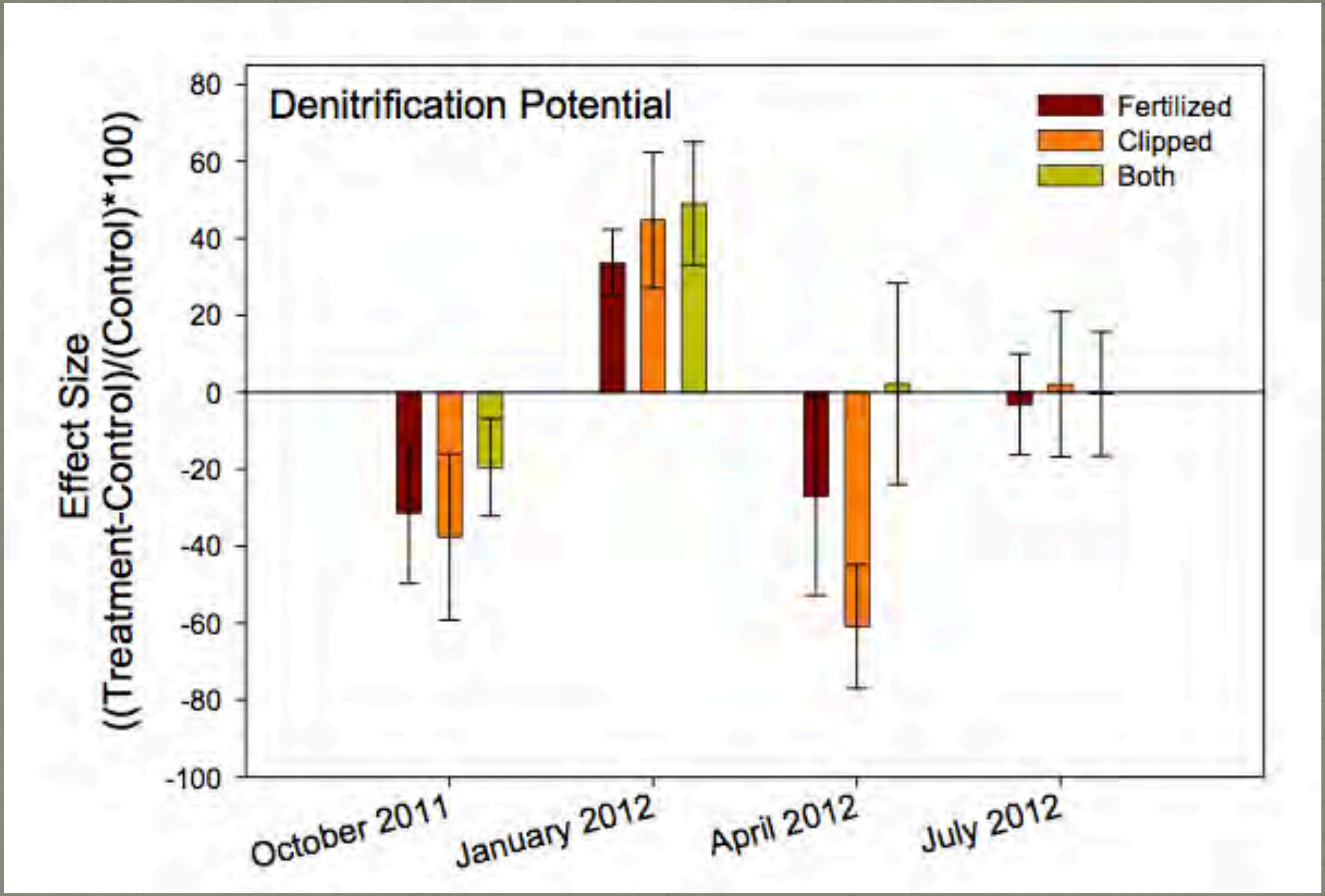
- Increased with fertilization
- When combined with clipping, returned to ambient levels

Treatment: $p < 0.001$
Time: $p < 0.001$
TreatmentxTime: $p = 0.30$



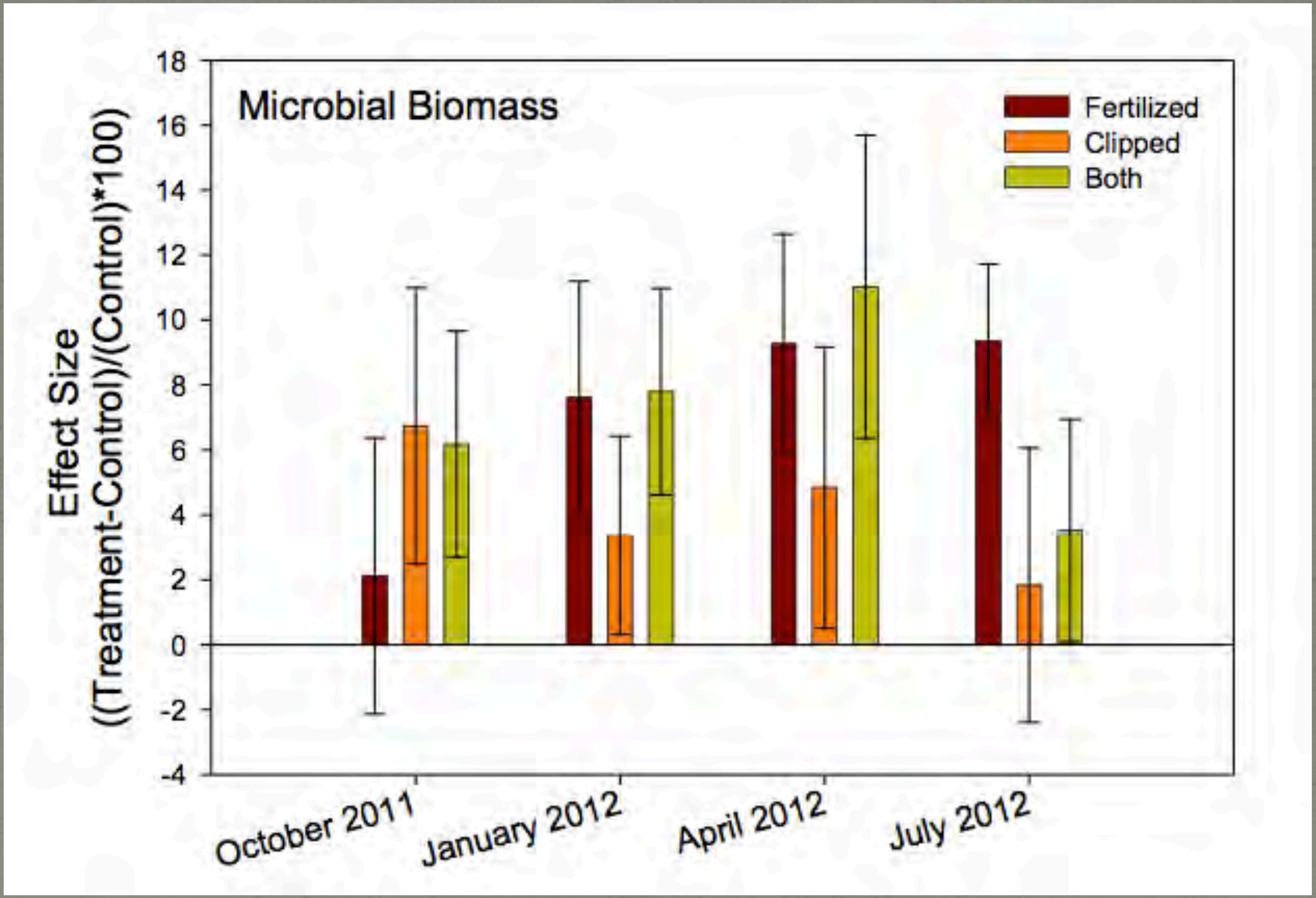
- Increased with fertilization
- Decreased with clipping
- When combined, nitrification potential returned to ambient levels

Treatment: $p = 0.939$
Time: $p < 0.001$
TreatmentxTime: $p = 0.38$



- No effect of treatment on denitrification potential

Treatment: $p = 0.02$
Time: $p < 0.001$
TreatmentxTime: $p = 0.83$



- Increased with fertilization
- Remained increased when combined with clipping

Summary

- Soil microbial biomass and rates of potential denitrification were lower in invaded communities
- By reducing nitrification potential, clipping compounded the effects of invasion
- Fertilization increased soil microbial biomass and potential rates of nitrification to, or above, native levels
- When combined, clipping and fertilization often had antagonistic effects; nitrification potential and microbial biomass returned to native levels

Implications

- Invasion can significantly alter key soil properties
- Alone, aboveground vegetation removal may inhibit successful restoration of soil N cycling
  - However, if increased N deposition is present, clipping may be an option to restore to native levels
- It is important to understand what global change factors are affecting a given site

Acknowledgements

- My PhD committee members
- The Hart Lab
  - Joey Blankinship
  - Abby Dziegel
  - Grant Iveson-Lane
  - Nick Marlowe
  - Emma McCorkle
  - Erin Stacy
- Funding
  - UC Merced Graduate Research Council
  - UC Merced Environmental Systems Program

Questions??