BELOWGROUND EFFECTS OF HERBICIDES FOR INVASIVE PLANT MANAGEMENT

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OCTOBER 16, 2019
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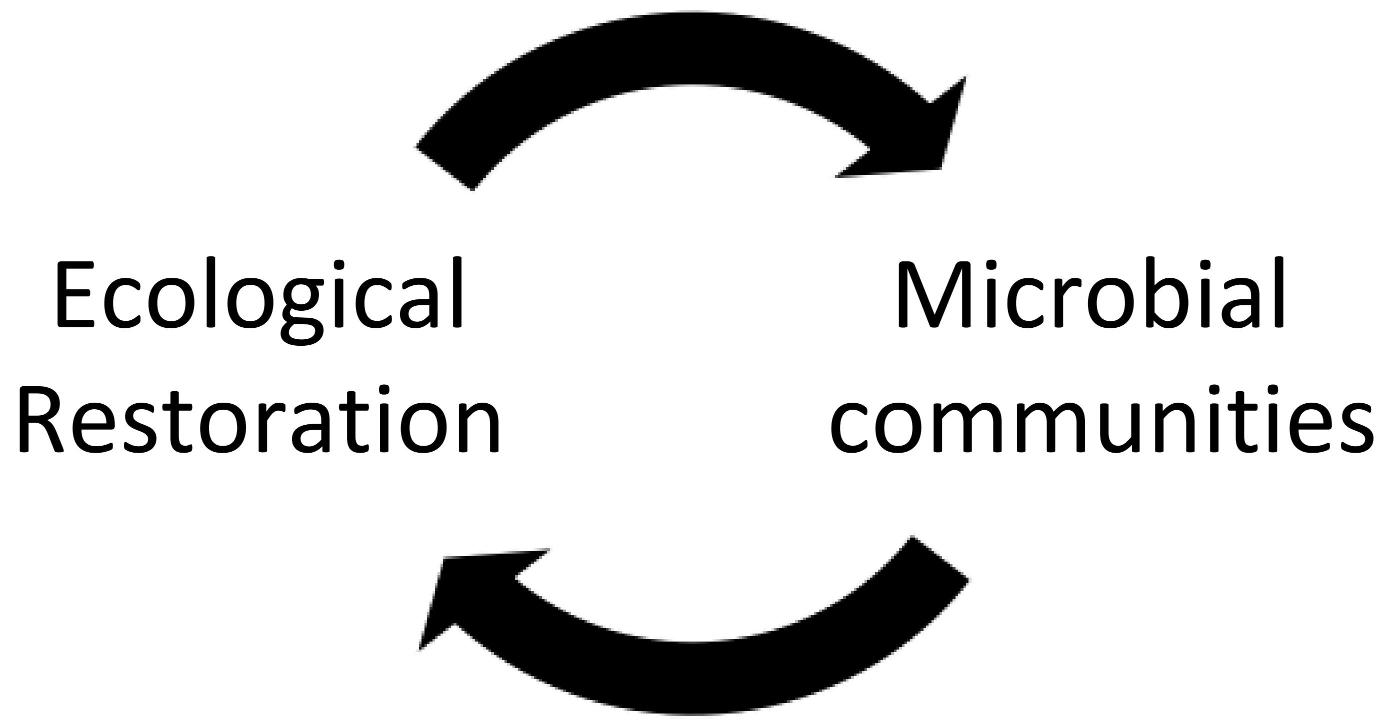
Community dynamics in natural systems

Soil microbes in restored systems


Ecological
Restoration
Microbial
communities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The effects of glyphosate, glufosinate, paraquat and paraquat-diquat on soil microbial activity and bacterial, archaeal and nematode diversity

Received: 10 February 2017
Accepted: 22 January 2018
Published online: 01 February 2018

Paul G. Dennis[1], Tegan Kukulies[2], Christian Forstner[1], Thomas G. Orton[1] & Anthony B. Pattison[2]

Herbicide treatment	Herbicide active	Corresponding commercial herbicide	Active concentration in commercial herbicide (g/L or kg)	Upper limit of recommended application rate for each commercial herbicide (L or kg/ha)	Concentration of herbicide active applied to soil (ppm)
1) Glyphosate	Glyphosate	Roundup	360	9.00	33.03
2) Glufosinate	Glufosinate	Basta	200	5.00	10.19
3) Paraquat	Paraquat	Gramoxone	250	3.20	8.16
4) Paraquat-diquat	Paraquat	Sprayseed	135	3.20	4.40
4) Paraquat-diquat	Diquat	Sprayseed	115	3.20	3.75

Table 1. Application rates for each herbicide active.

Dennis et al. 2018

Applied Soil Ecology 64 (2013) 99–103

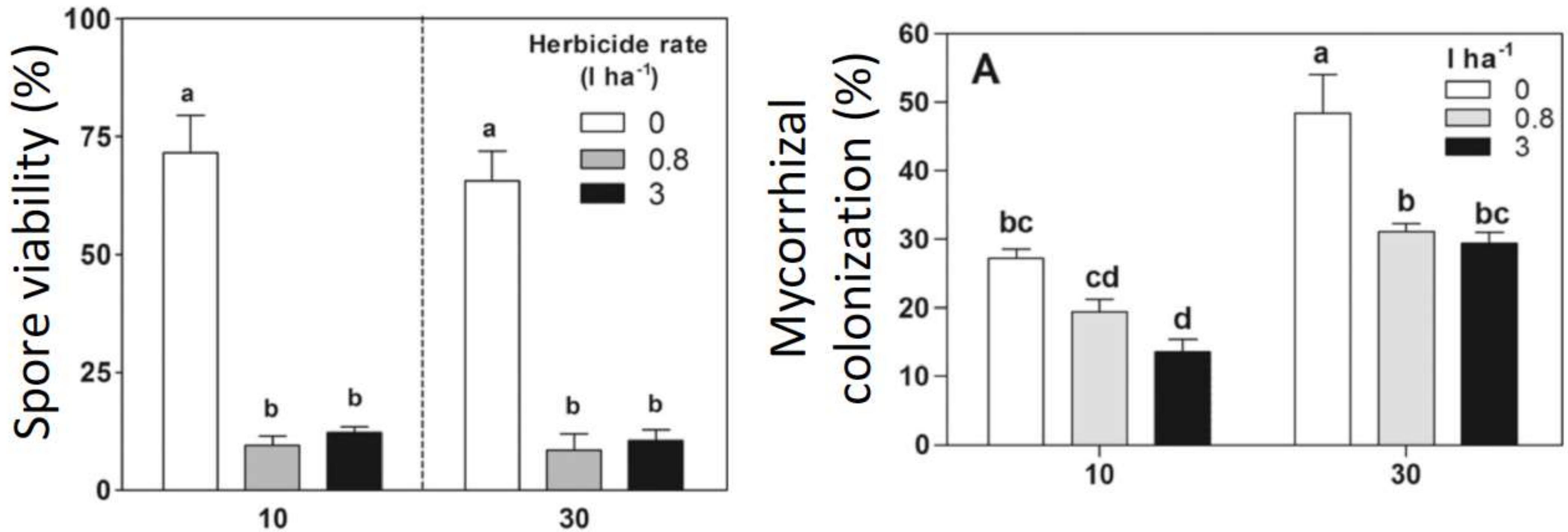
Contents lists available at SciVerse ScienceDirect

Applied Soil Ecology

journal homepage: www.elsevier.com/locate/apsoil

Glyphosate reduces spore viability and root colonization of arbuscular mycorrhizal fungi

Magdalena Druille[a,*], Marta N. Cabello[b,c], Marina Omacini[a], Rodolfo A. Golluscio[a]



Time (days after application)

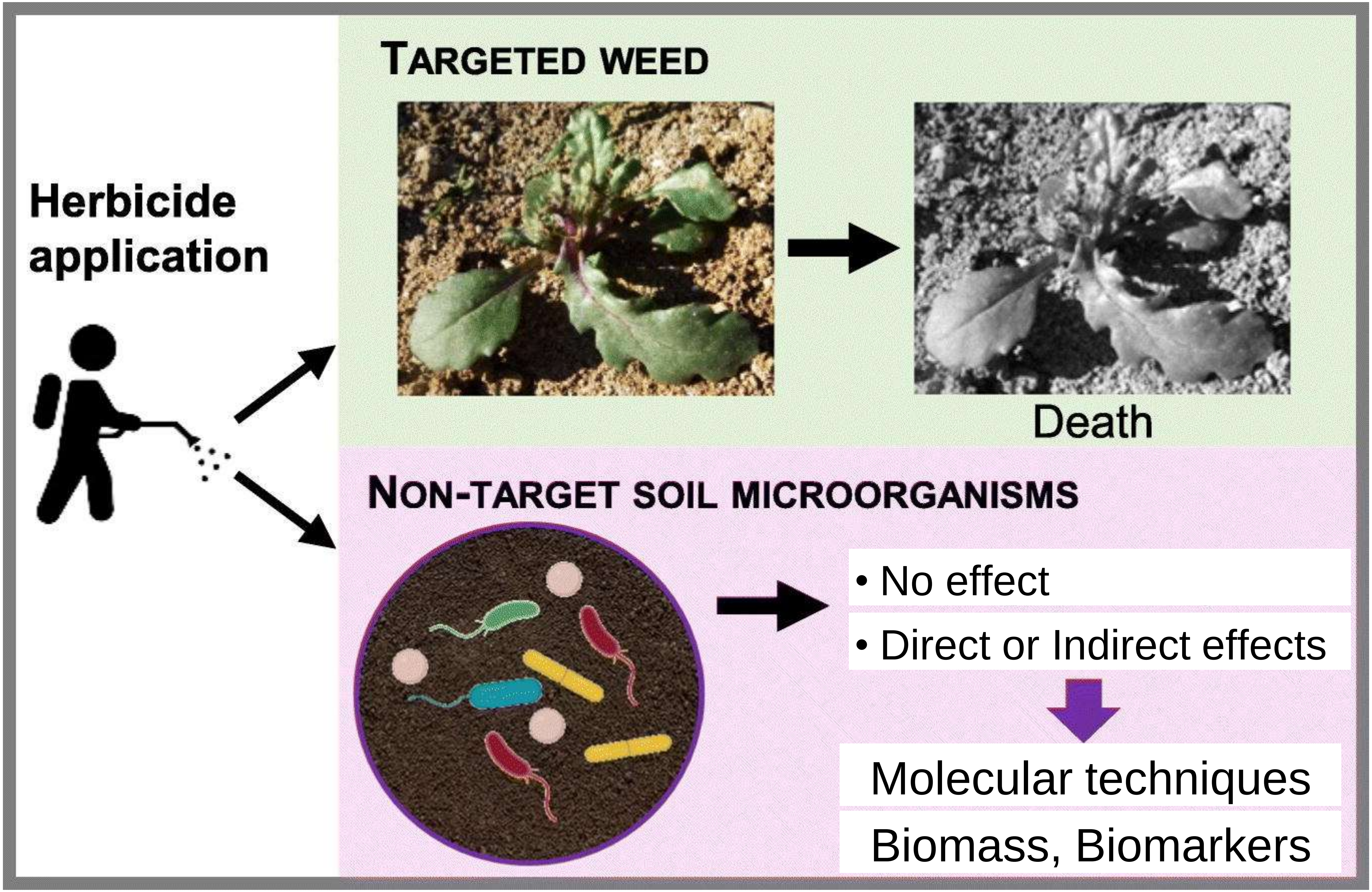
Indirect effects of forb-specific picloram

Spotted knapweed (*Centaurea stoebe)* and native bunchgrass

Ecological Applications, 27(8), 2017, pp. 2359–2368

Strong indirect herbicide effects on mycorrhizal associations through plant community shifts and secondary invasions

YLVA LEKBERG,[1,2,4] VIKTORIA WAGNER,[3] ALEXII RUMMEL,[1] MORGAN MCLEOD,[1] AND PHILIP W. RAMSEY[1]



Modified from
Thiour-Mauprivez et al. 2019

Science of The Total Environment
Volume 684, 20 September 2019, Pages 314-325

Belowground effects of herbicide

southern California

Crystal Cove State Park, Laguna Beach
UC Irvine Ecological Preserve, Irvine

Synthetic herbicides and mycorrhizal fungi

Bommer Canyon
Irvine, California

Organic herbicides and bacteria

Broad spectrum synthetic herbicide: Glyphosate

Invaded coastal sage scrub and grassland

Brassica nigra: non-native and non-mycorrhizal

Grow Kill Manipulation

applied annually for 5 years

Herbicide	No weed Control	Mow

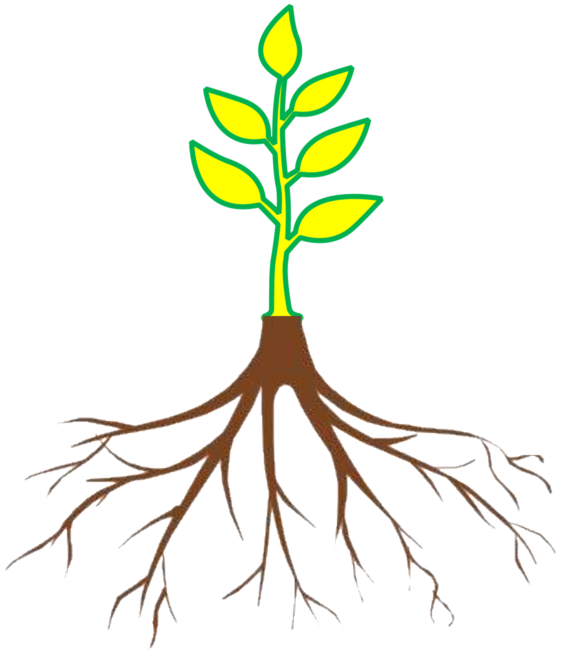
6 replicate plots

2 sites: Crystal Cove State Park (coastal)

UCI Eco Preserve (interior)

HYPOTHESES

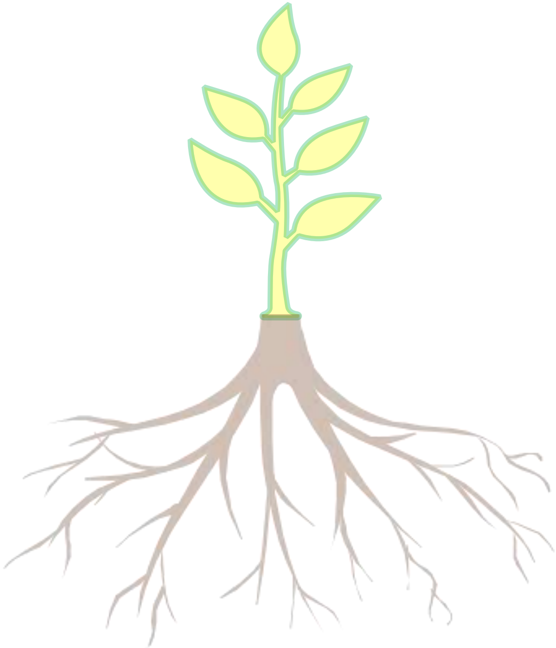
Treating non-mycorrhizal forbs with broad spectrum synthetic herbicides will:



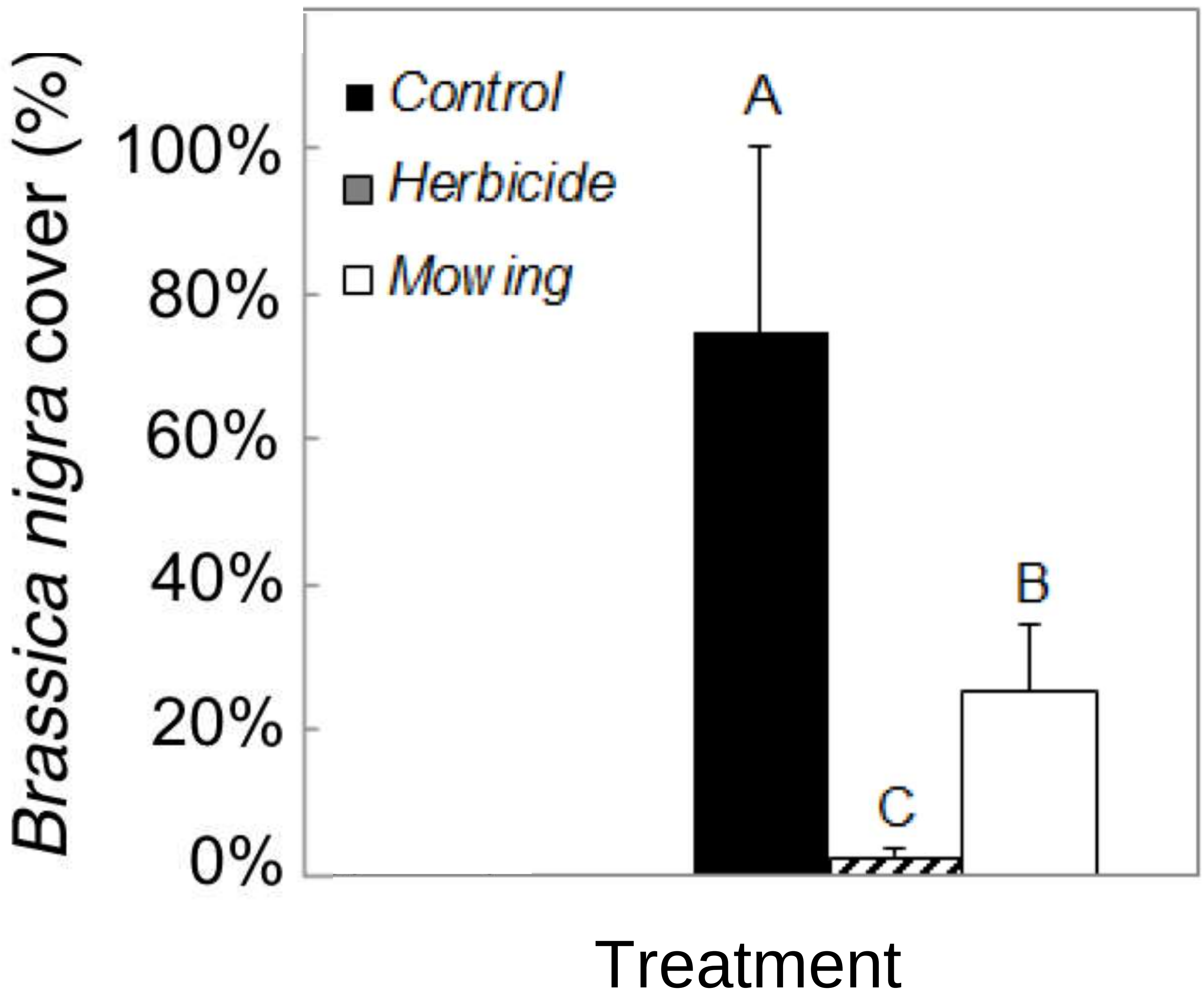
HYPOTHESES

Treating forbs with herbicide will:

- ↓ *B. nigra* cover
- ? Mycorrhizal fungal abundance
- △ Fungal communities



Restoration treatments reduced non-native *B. nigra* cover



$X^2 = 321$, df = 2, $p < 0.001$

Modified from
Maltz et al. (2016) **34**:2
Ecological Restoration

Methods

Percent invasive cover / Native plant richness

Measured fungal / AM hyphal length

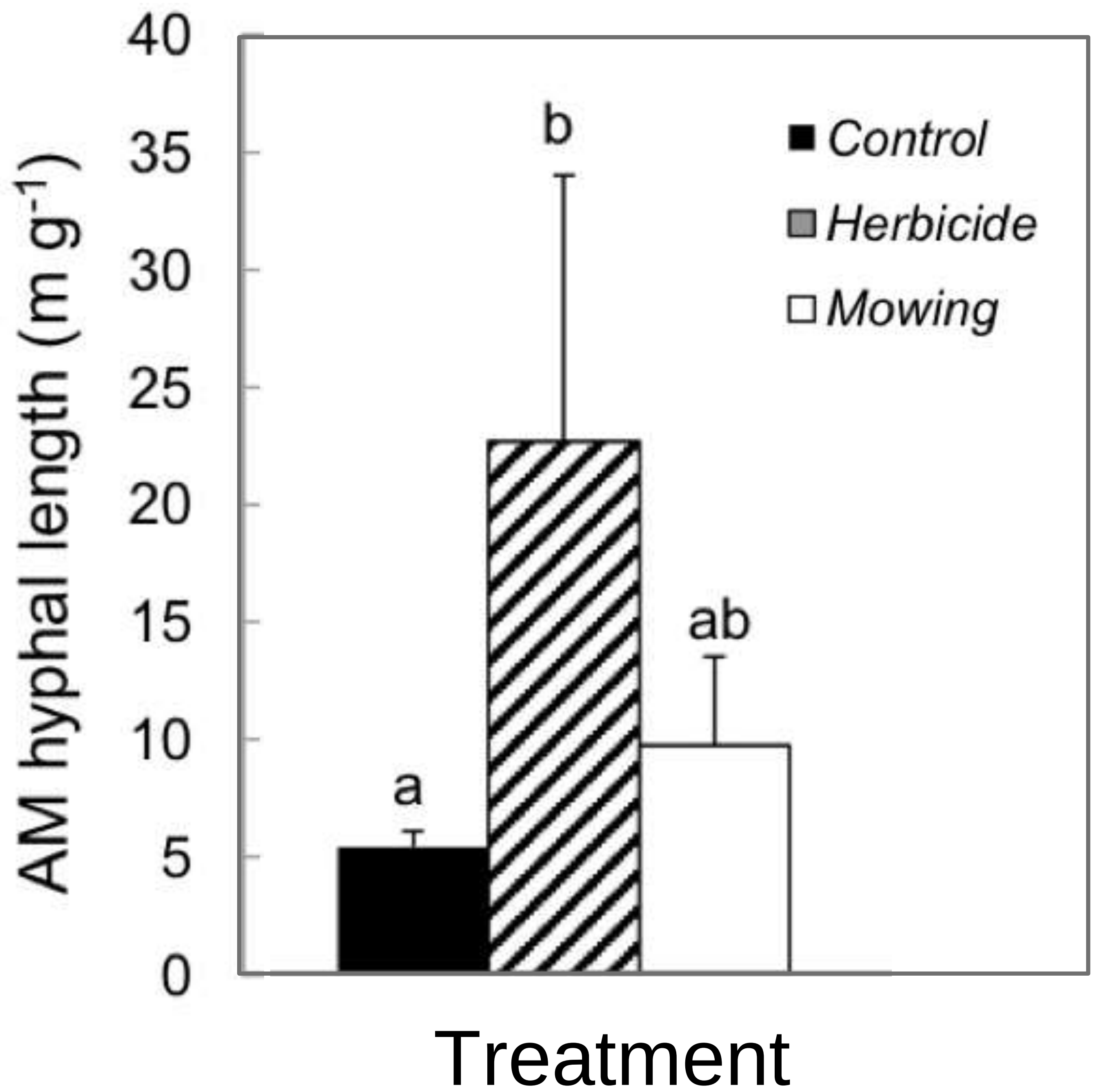
Molecular work and bioinformatics

PCR ITS1

Illumina MiSeq sequencing

Fungal community composition

Glyphosate may have increased AM hyphal length

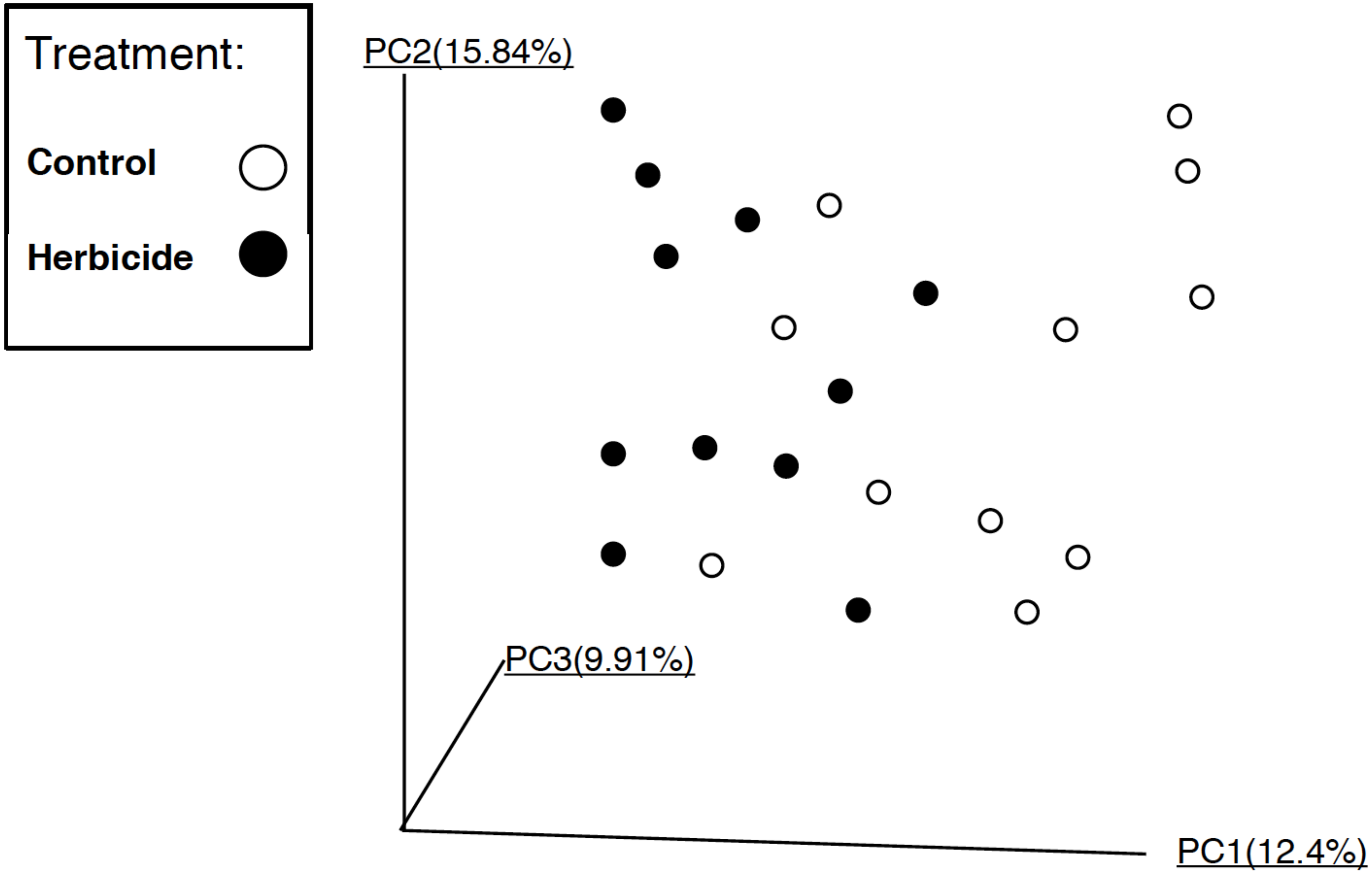


$F_{2,12} = 3.95$, $p = 0.048$

herbicide $p = 0.039$

Modified from
Maltz et al. (2016) **34**:2
Ecological
Restoration

Fungal communities differed by treatment



- Lower diversity of AM fungal taxa (OTU taxa richness)
- Diversisporaceae and *Funneliformis* absent

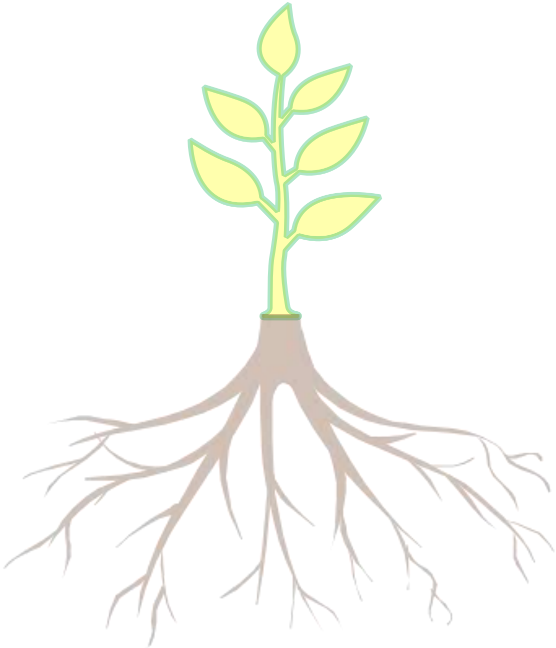
Maltz et al. unpublished data

CONCLUSIONS

Treating non-mycorrhizal forbs with broad spectrum synthetic herbicides will:

- ↑ mycorrhizal fungal abundance
- △ fungal communities

Likely because of △ plant hosts



Belowground effects of herbicide

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Synthetic herbicides and mycorrhizal fungi

Bommer Canyon
Irvine, California

Organic herbicides and bacteria

Four organic herbicides:

Invaded grassland: Bommer Canyon

Herbicide	Type
FinalSanO (FSO)	Strong acid
Suppress (Su)	Strong acid
Avenger (Av)	Orange-based oil
Fiesta (Fi)	Chelated iron product

Four organic herbicides:

Invaded grassland: Bommer Canyon

Herbicide	Type
FinalSanO (FSO)	Strong acid
Suppress (Su)	Strong acid
Avenger (Av)	Orange-based oil
Fiesta (Fi)	Chelated iron product

Bromus diandrus and Avena fatua

Four organic herbicides:

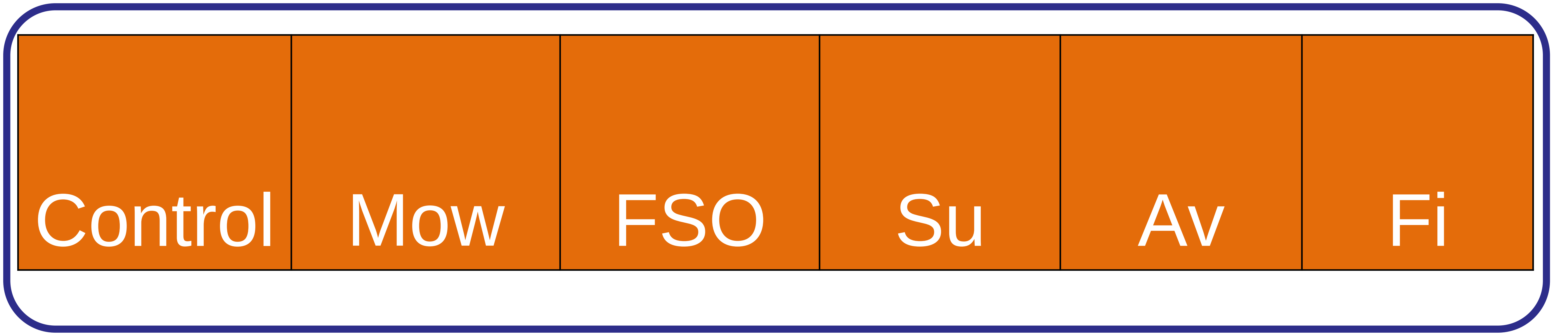
Invaded grassland: Bommer Canyon

Herbicide	Application Rate
FinalSanO (FSO)	26 oz./gal
Suppress (Su)	8 oz./gal
Avenger (Av)	16 oz./gal
Fiesta (Fi)	5 oz./gal

5-week intervals; Feb - May 2018

Four organic herbicides:

Invaded grassland

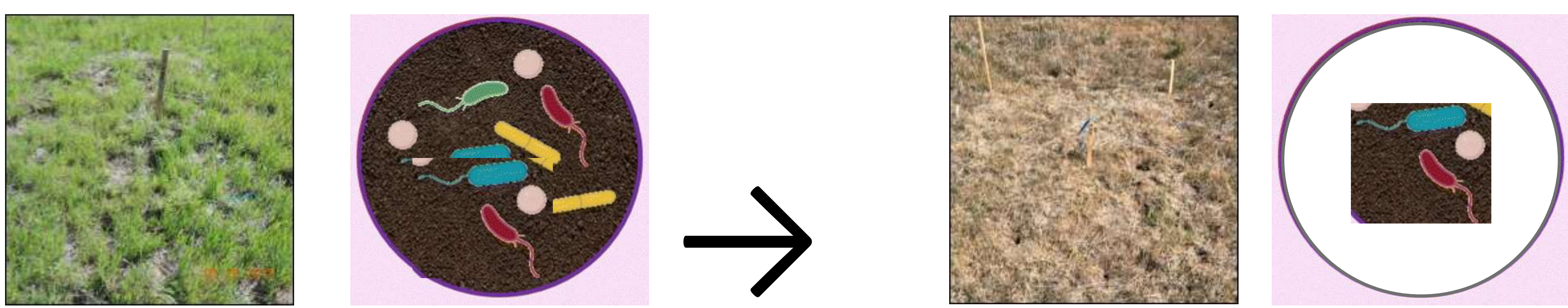


5 replicate blocks (randomized block)

HYPOTHESES

Treating non-native grasses (NNG) with organic herbicides will:

- △ microbial community composition
- be marginally effective at controlling NNG



Methods

Qualitative and quantitative analysis of non-native cover

- Mature seed heads (*B. diandrus, A. fatua)*
- Vegetative growth (all NNG and forbs)

→

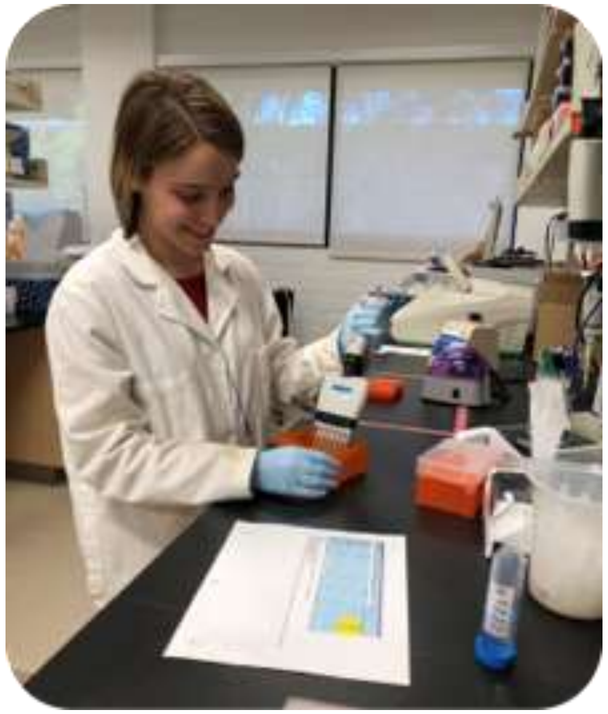
Methods

Molecular work and bioinformatics

PCR 16S

Illumina MiSeq sequencing

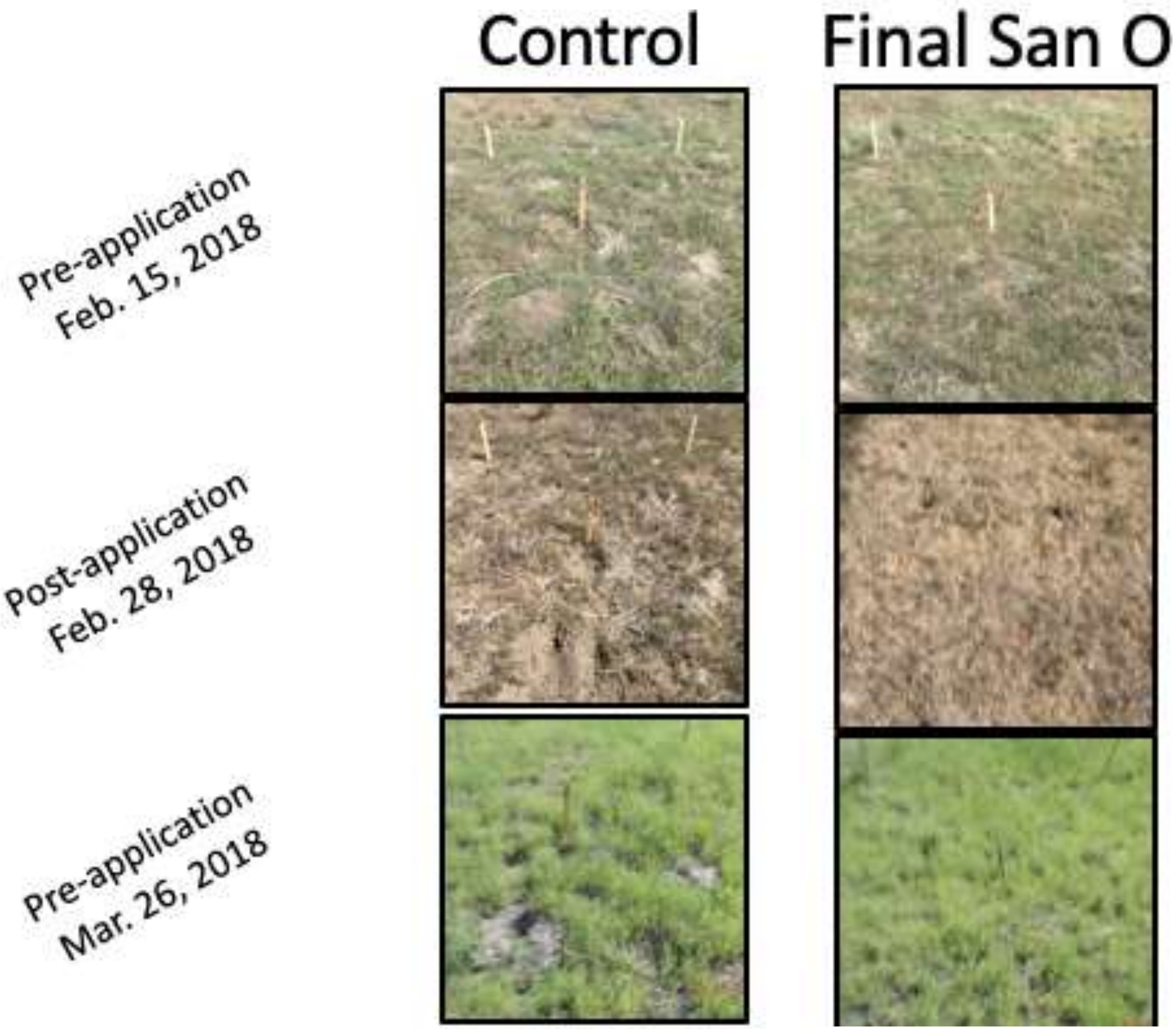
Bacterial community composition



Lauren Dagan

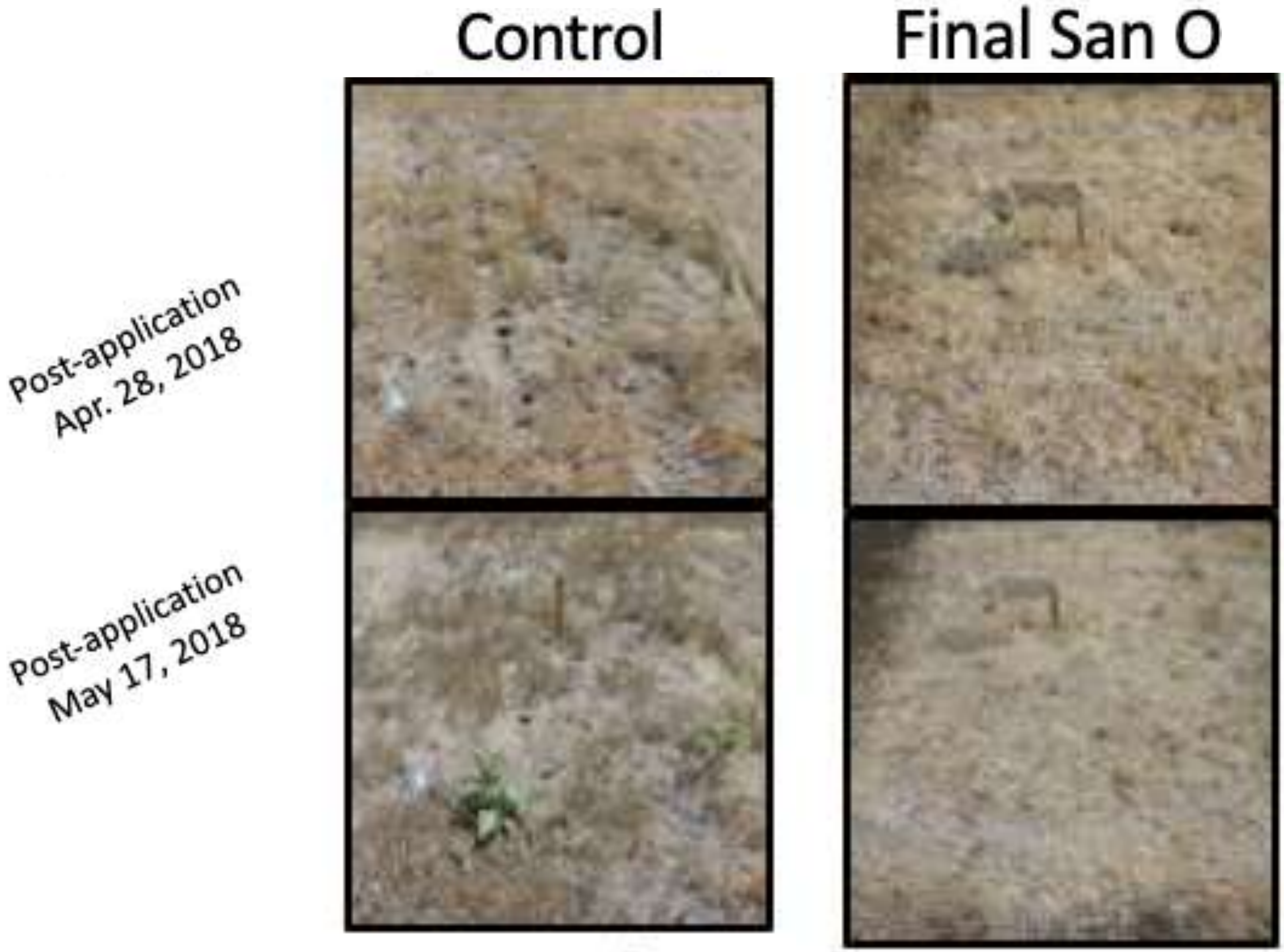
Natalie Rodriguez

Results

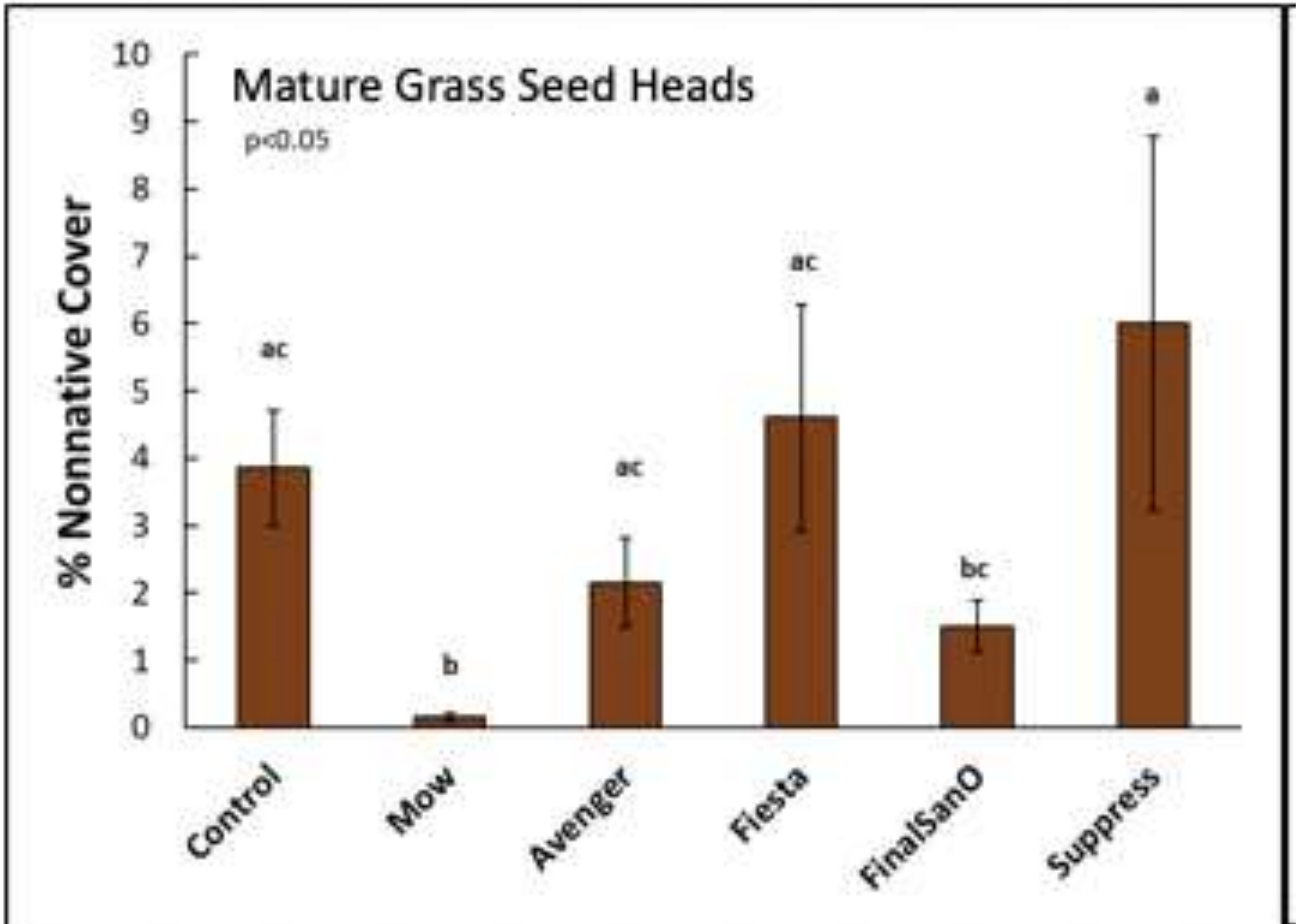


Control
Final San O
Pre-application
Feb. 15, 2018
Post-application
Feb. 28, 2018
Pre-application
Mar. 26, 2018

RESULTS


Control
Final San O
Post-application
Apr. 28, 2018
Post-application
May 17, 2018

RESULTS



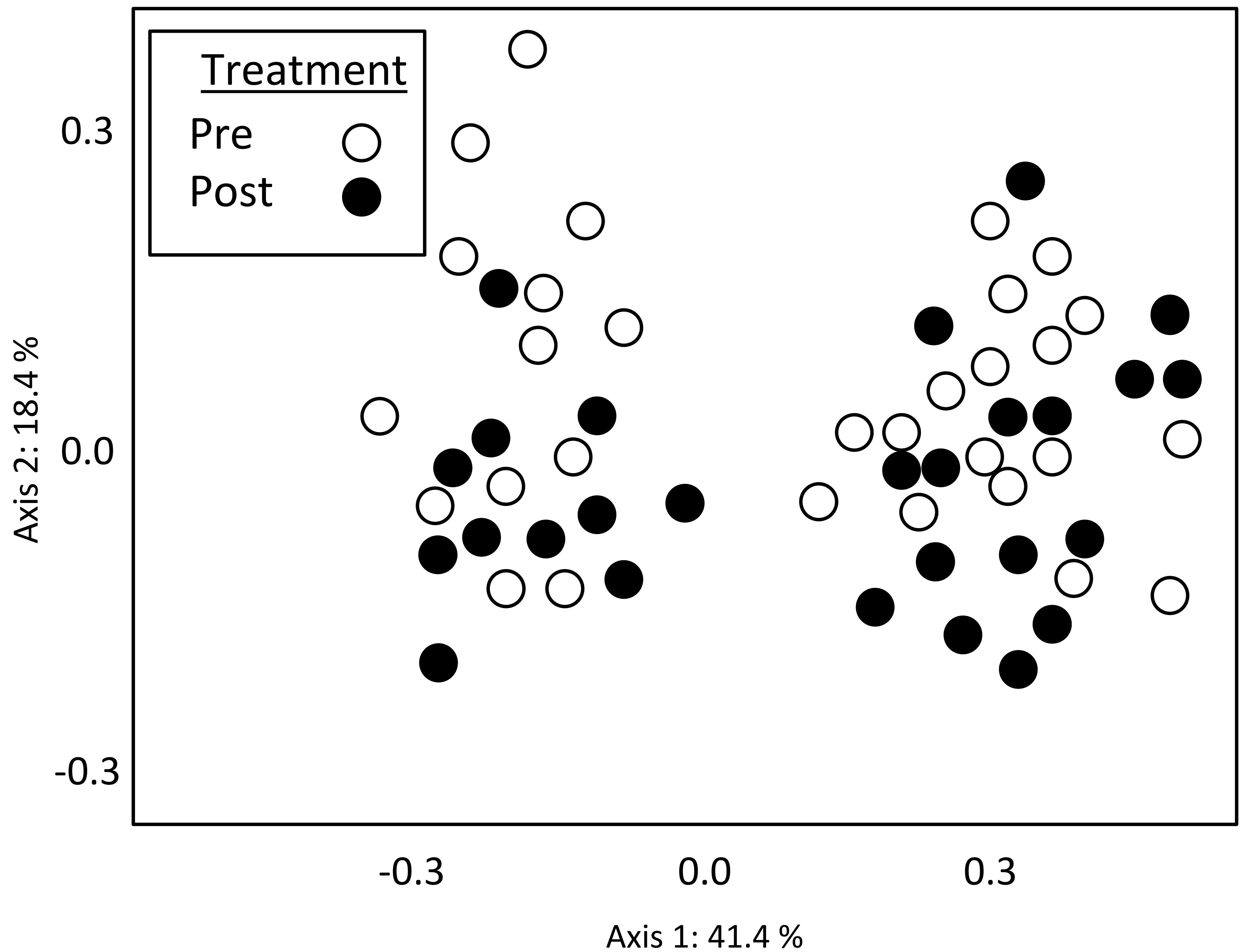
Swanson et al. unpublished data

Organic herbicide treatment and bacterial communities

Permanova
Bray Curtis

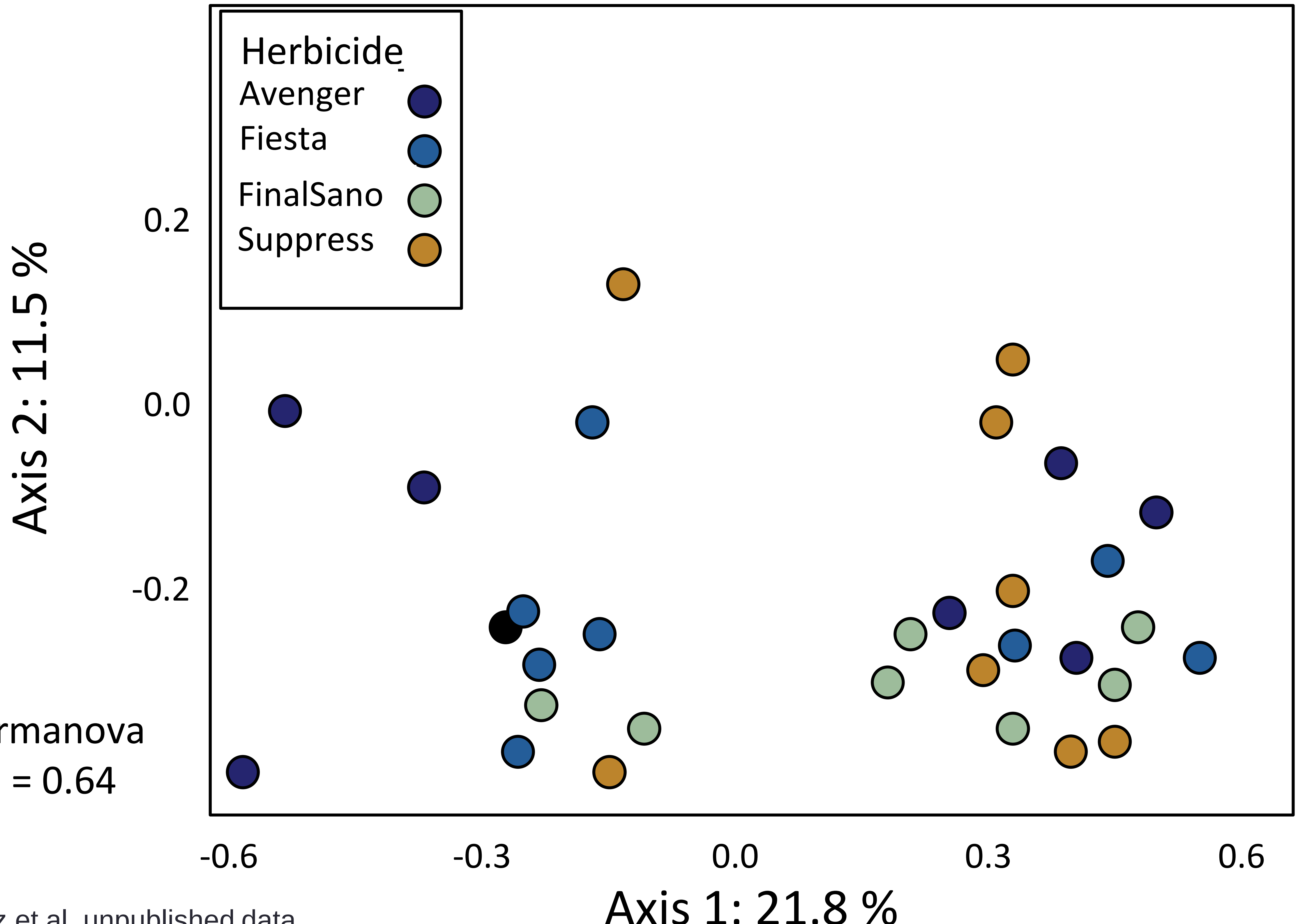
Herbicide + Treatment * Block

Treatment $P = 0.02^*$
Herbicide $P = 0.3$
Block $P < 0.001^*$
Treatment * Block $P = 0.45$



Maltz et al. unpublished data

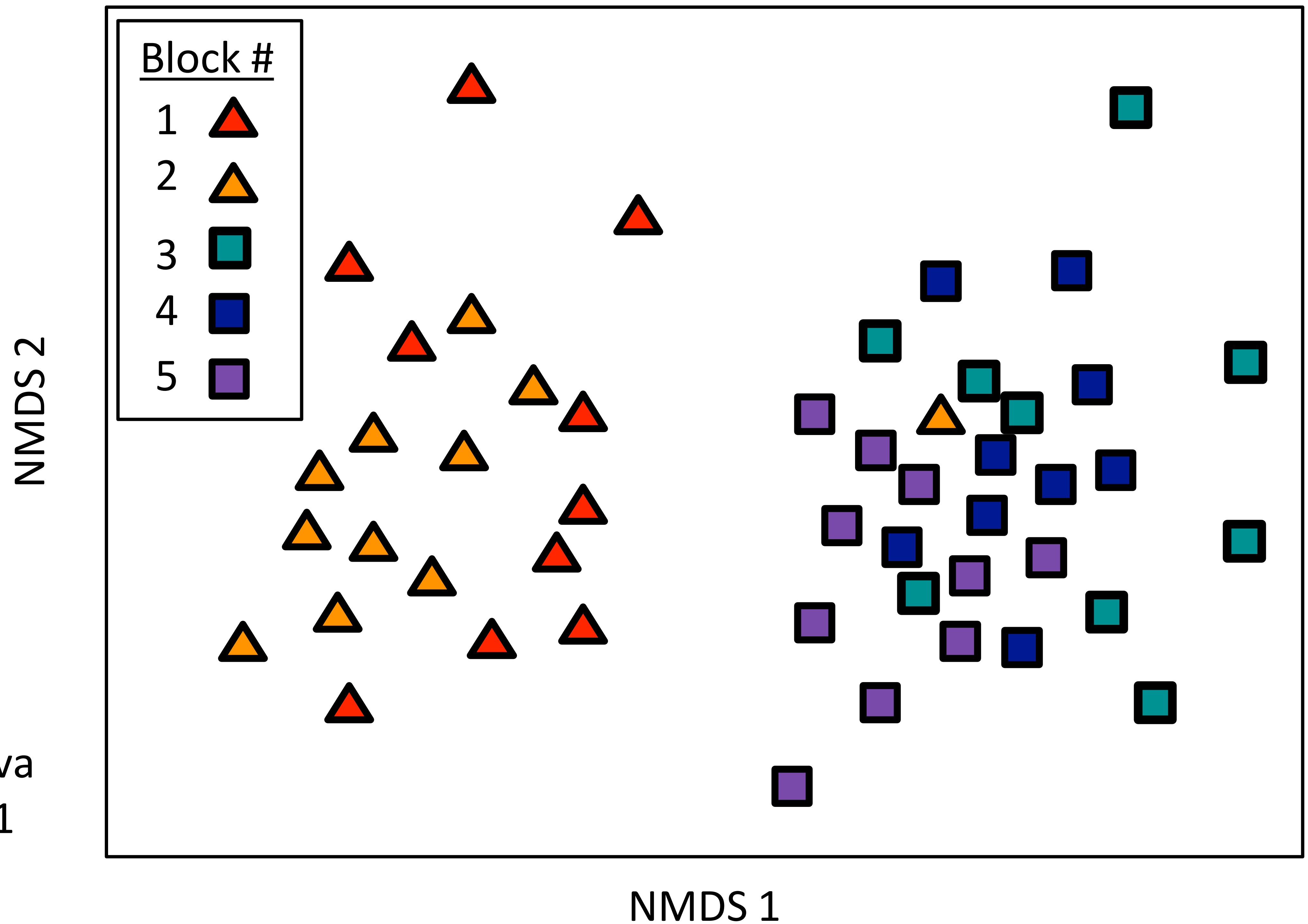
No effect of organic herbicide treatment on bacteria



Permanova
P = 0.64

Maltz et al. unpublished data

Spatial heterogeneity among blocks influenced microbial communities



Permanova
$P < 0.001$
R^2=0.37

Maltz et al. unpublished data

CONCLUSIONS

- Mowing is more effective than organic herbicides at managing NNG.
- Bacterial communities varied strongly by block, and to a lesser extent, by invasive plant management
- Long term monitoring and herbicide treatments may reveal greater changes to belowground communities, especially for plant-associated fungi.

Ecological Restoration

Microbial communities

Acknowledgements

Cal-IPC

Aronson Lab members

Natalie Rodriguez, Liliana Garcia

Lauren Dagan, Vanessa Montellano

IRC – Kalee Koeslag, Nicole Tamura, Riley Pratt

City of Irvine

Collaborators on the mustard control experiment:

Natural Communities Coalition - Milan Mitrovich

Crystal Cove State Park - Lana Meade

SoCal Invasives - Carl Bell

Endemic Ecological - Barry Nerhus

UCI Ecological Preserve - Peter Bowler

The University of California Irvine

Natural Communities COALITION restoration | management | partnership

Center for Conservation Biology University of California, Riverside

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Questions?