Maintaining genetic diversity during the agricultural increase of native seeds: insights from workhorse grass species

Rob Massatti & Trevor Faske
Landscape Stewardship Collective
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Landscape Stewardship Collective

www.landscollective.org

USGS
science for a changing world

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Introduction

Restoration – an inherently difficult process

Site specific challenges

- Land use history
- Invasive species
- Ongoing disturbance
- Weather
- Climate (aridlands notoriously difficult)

Procedural challenges

- How do we restore?
  - Seeding rate, seed coatings, weather forecasting, seed application, etc…
- What should we use for restoration?
  - Local adaptation, species mixes, composite sources vs. cultivars, etc…
- How do we account for changing climates?
  - Present climate, future climate, or both?

Cameron Peak Fire. Courtesy photo USDA Forest Service.

Milford Flat Fire. Photo: M.E. Miller, NPS. Public domain.

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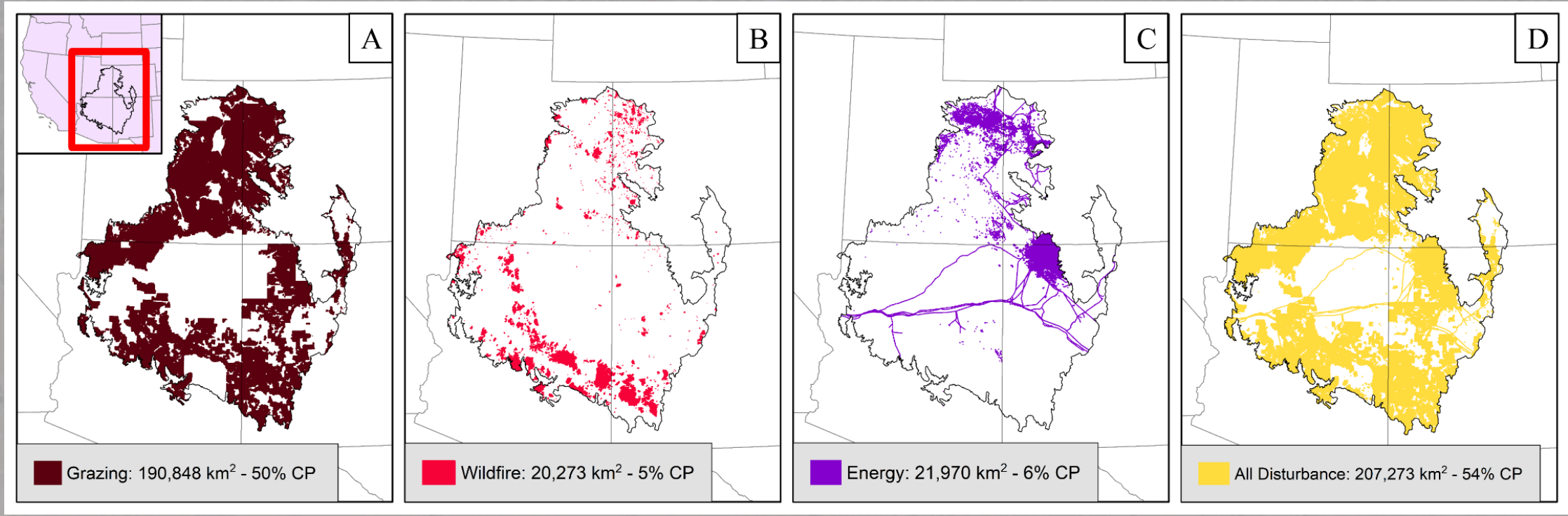
Disturbances are common!



Winkler et al., 2025

- On average, 2.4 million pounds of seed are purchased annually for use on BLM land
- Average annual cost: $20 million

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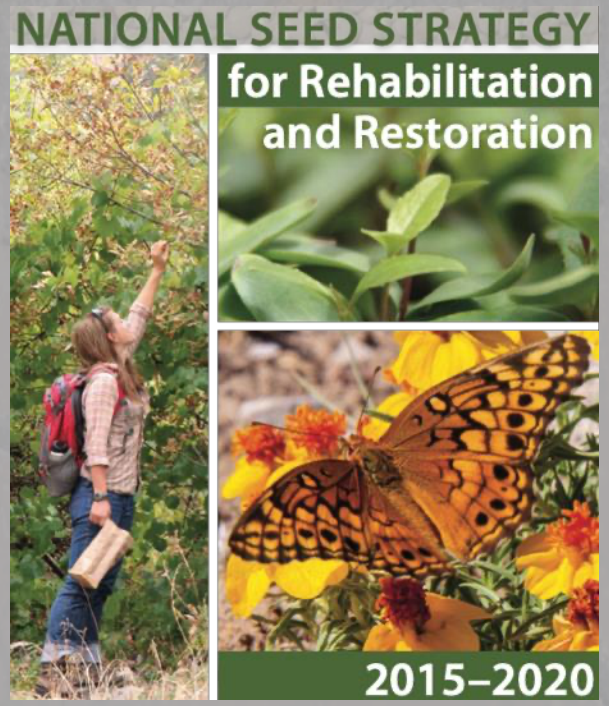
Increasing the diversity of restoration species and sources

The National Seed Strategy

Mission: *To ensure the availability of genetically appropriate seed to restore viable and productive plant communities and sustainable ecosystems.*

Vision: *The right seed in the right place at the right time.*



www.blm.gov/programs/natural-resources/native-plant-communities/national-seed-strategy

McCormick et al. 2021

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Increasing the diversity of restoration species and sources

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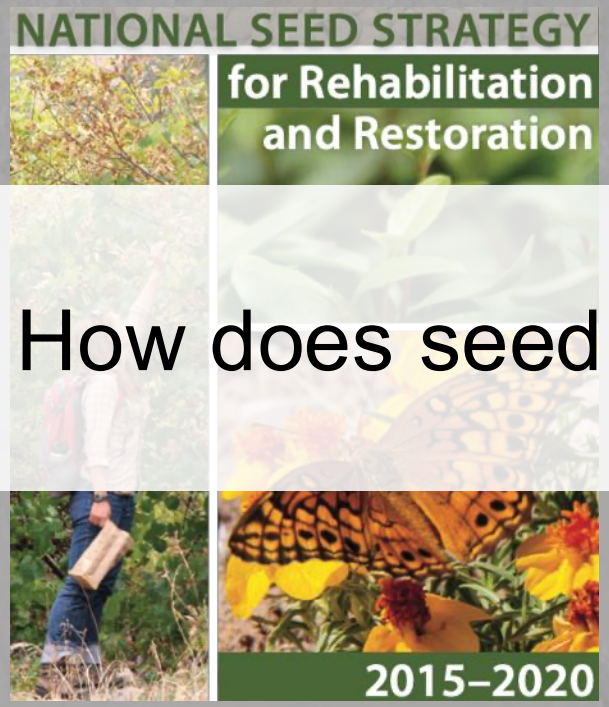

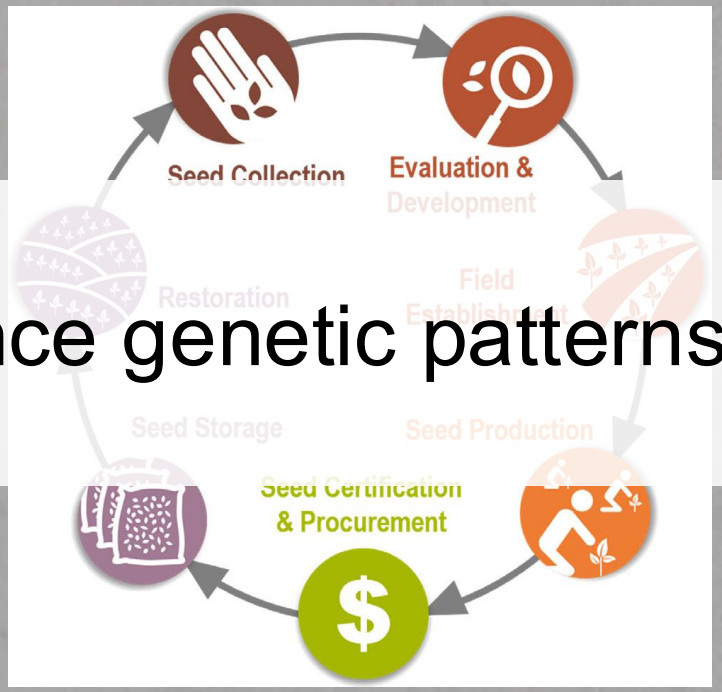

How does seed production influence genetic patterns?

www.blm.gov/programs/natural-resources/native-plant-communities/national-seed-strategy

McCormick et al. 2021

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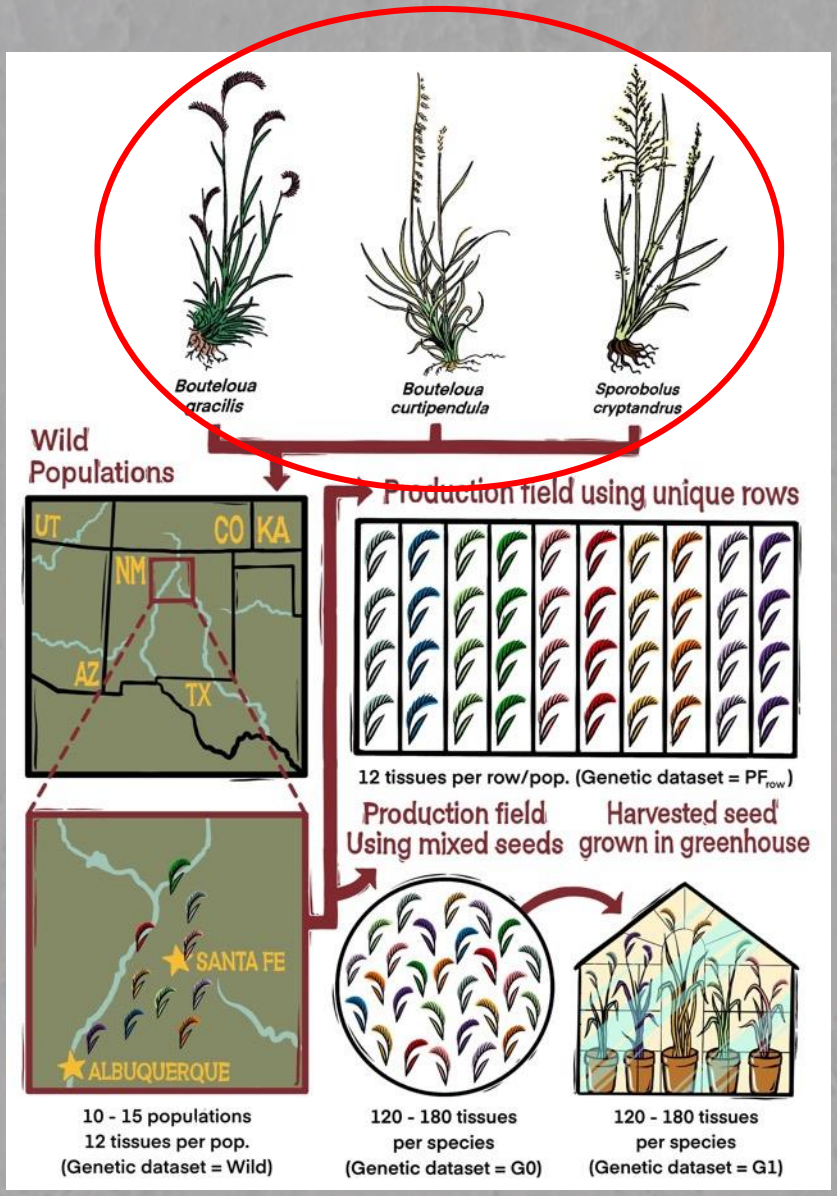
Investigating the effects of seed increase



Faske et al., *In review*

3 species:

- *Bouteloua gracilis* (blue grama grass)
- *Bouteloua curtipendula* (sideoats grama grass)
- *Sporobolus cryptandrus* (sand dropseed)

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Bouteloua gracilis

Polyploidy (2N = 20, 21, 24, 28, 35, 40, 42, 60, 61, 77, 84)

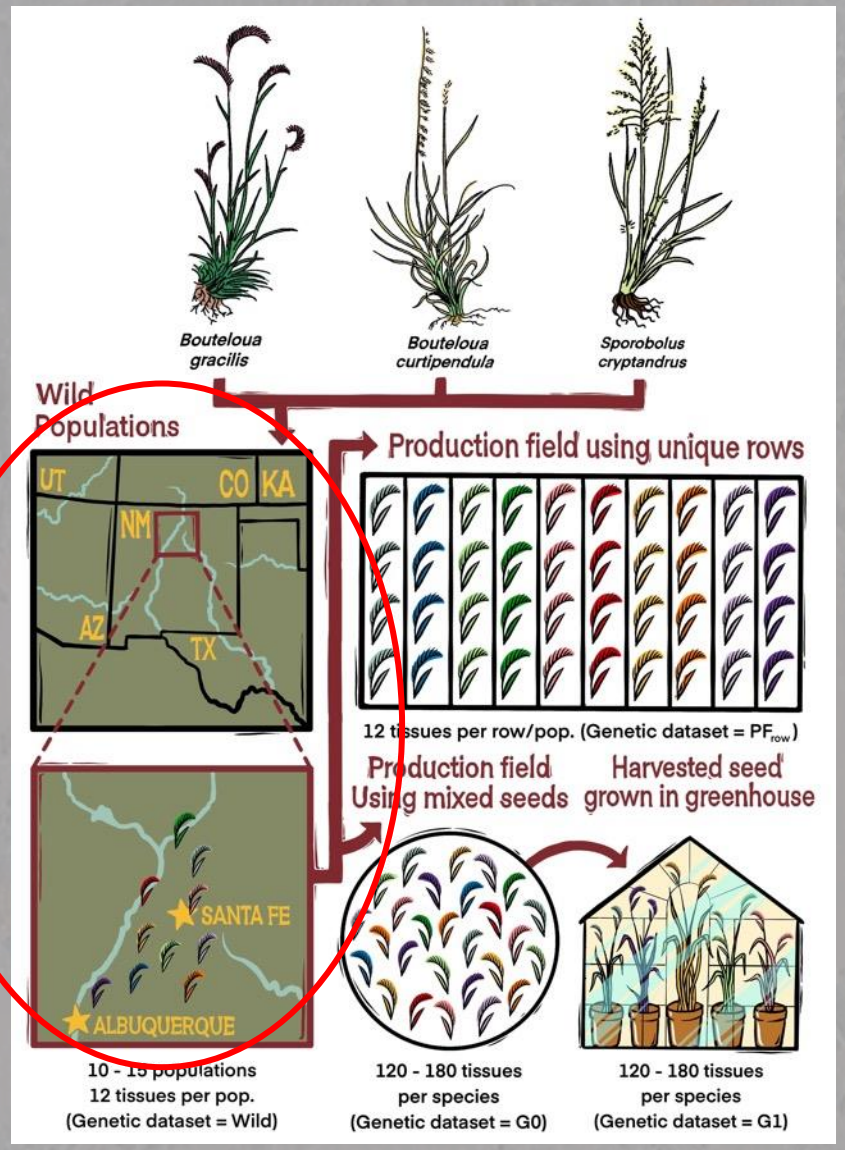
Bouteloua curtipendula

Polyploidy (2N = 20, 28, 35, 40-43, 41-64, 42, 45, 52, 56, 58-64, 69-103, 70, 74, 80, 82, 85-101, 86, 96, 98)

Sporobolus cryptandrus

Self-fertilizing

Investigating the effects of seed increase



Faske et al., *In review*

Seed collected from 10-15 wild populations

- Seeds of Success protocols
- Institute for Applied Ecology & NM BLM
- Environmentally similar collection sites

Genetic data from wild collected tissues = **Wild**
Collected seed = G0

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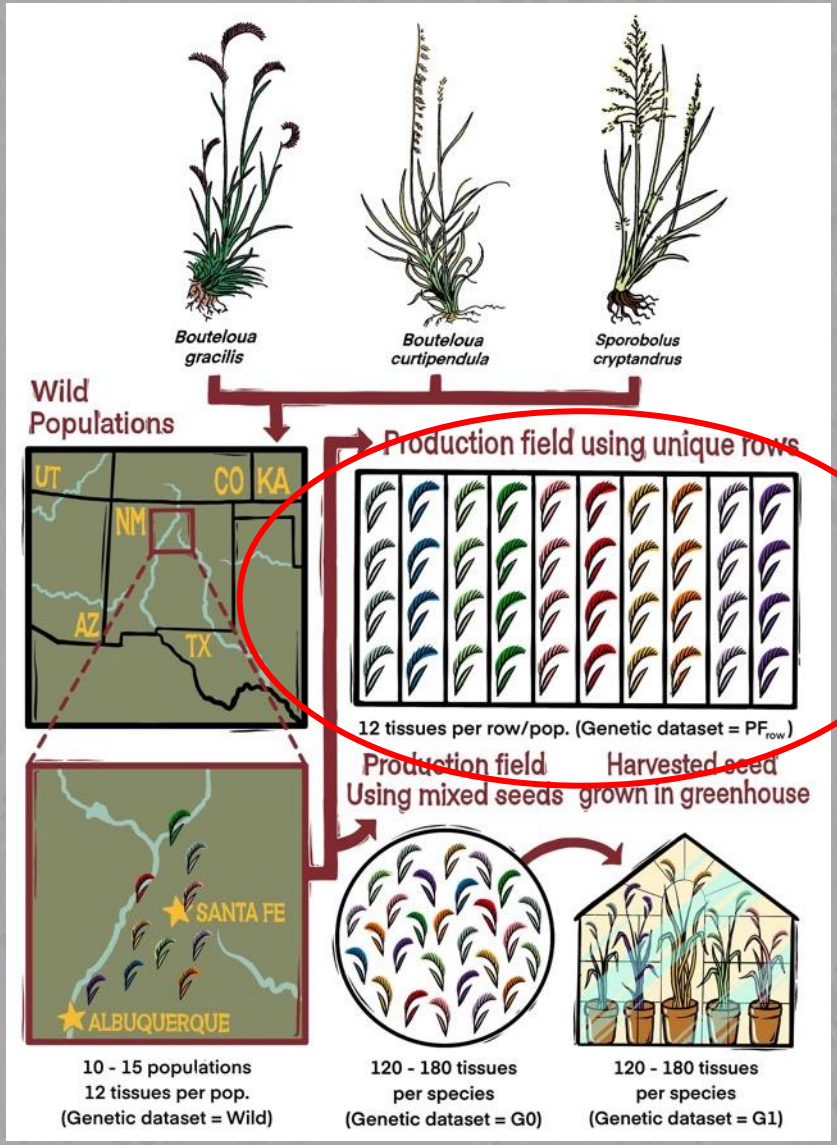
Investigating the effects of seed increase



Faske et al., *In review*

G0 sources grown separately

- Genetic dataset = **G0 (rows)**

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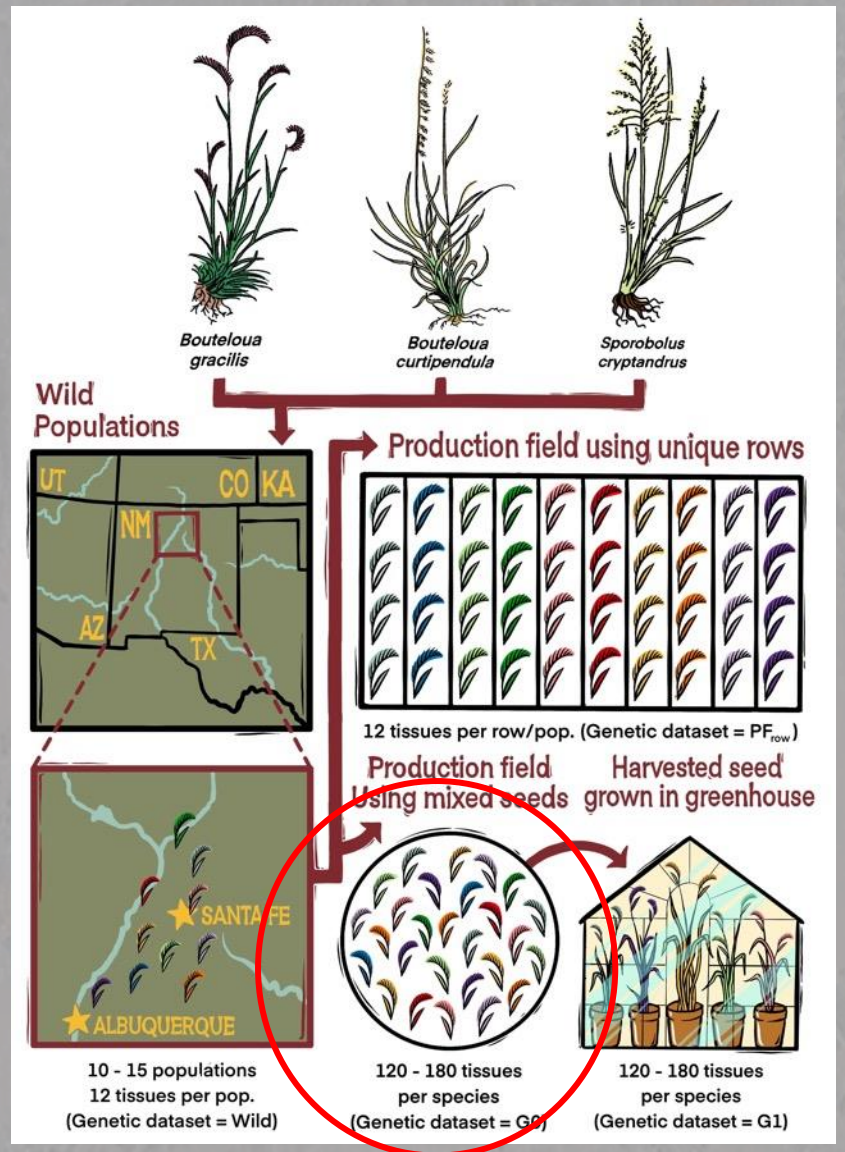
Investigating the effects of seed increase



Faske et al., *In review*

G0 sources grown separately

- Genetic dataset = **G0 (rows)**

G0 sources pooled

- Genetic dataset = **G0 (pooled)**
- THIS IS THE COMMON SCENARIO

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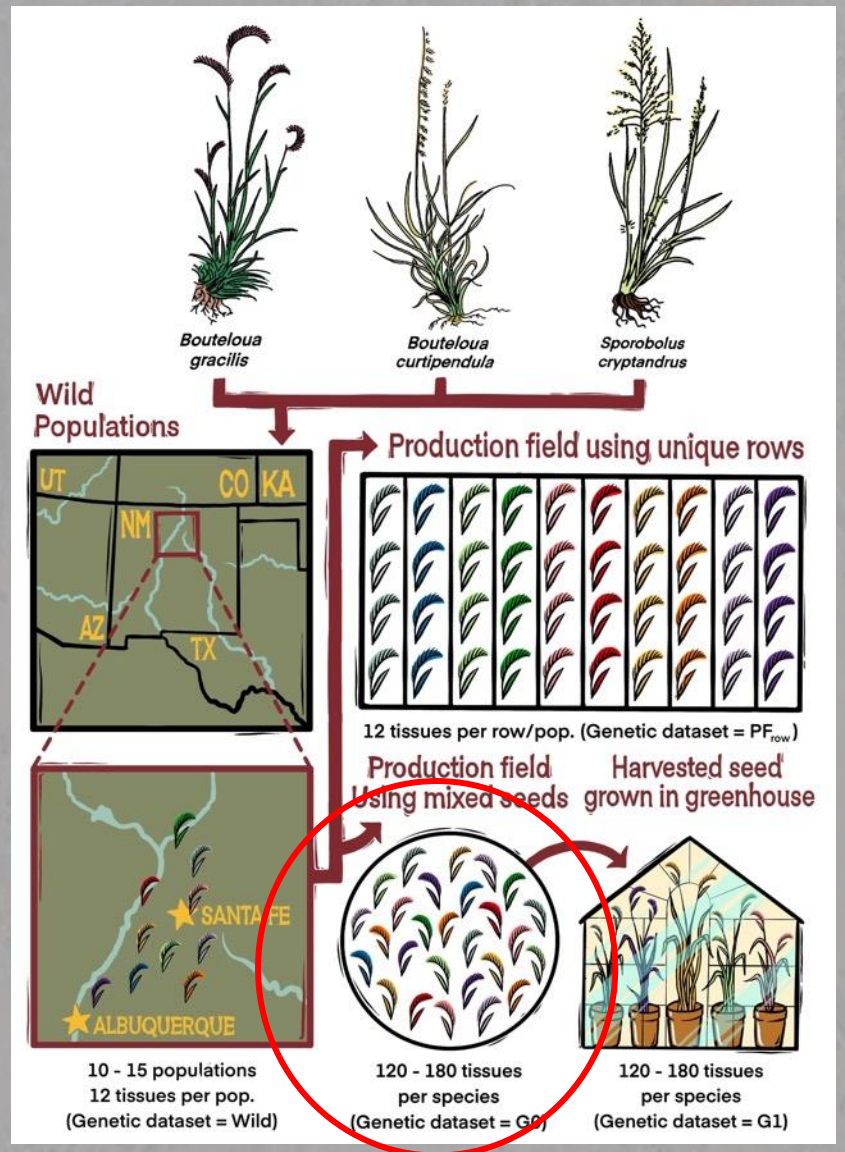
Investigating the effects of seed increase



Faske et al., *In review*

***All fields established from greenhouse grown transplants**

G0 sources grown separately

- Genetic dataset = **G0 (rows)**

G0 sources pooled

- Genetic dataset = **G0 (pooled)**
- THIS IS THE COMMON SCENARIO

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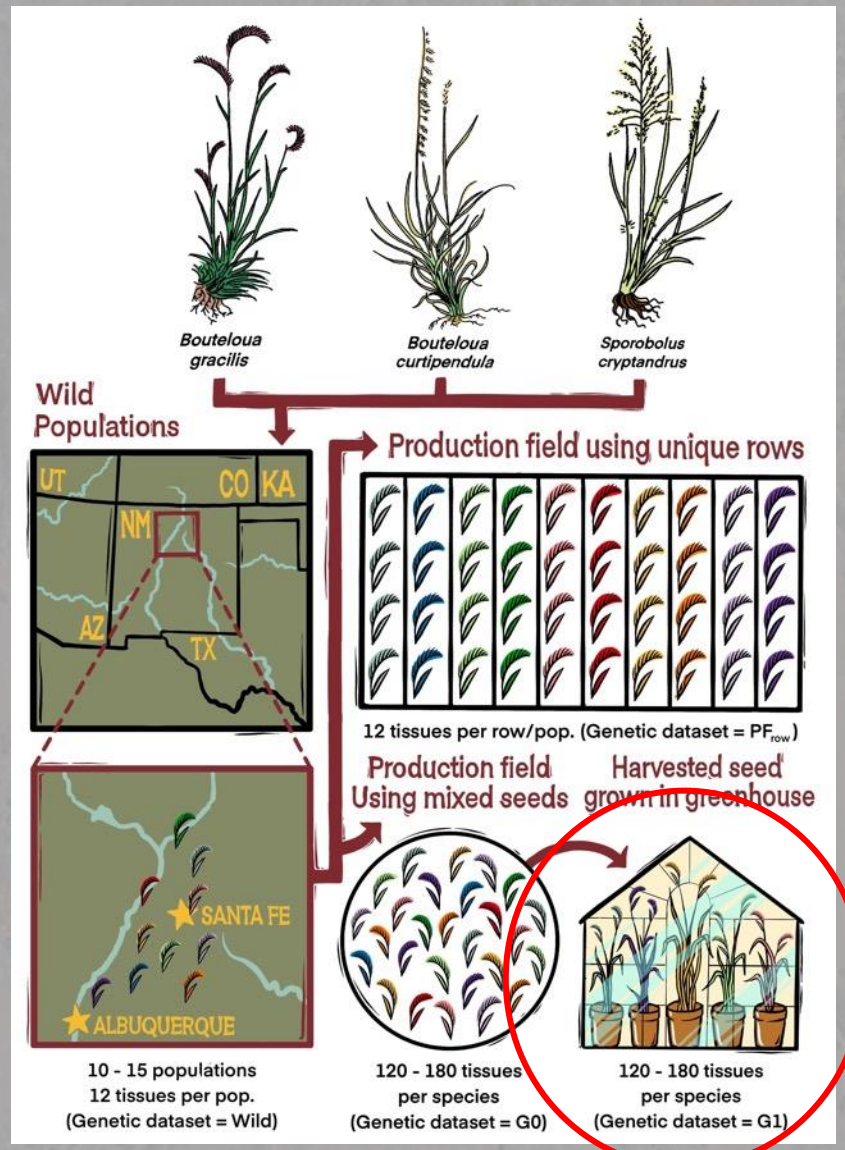
Investigating the effects of seed increase



Faske et al., *in review*

G1 seed harvested from G0 pooled

- Genetic dataset = **G1**

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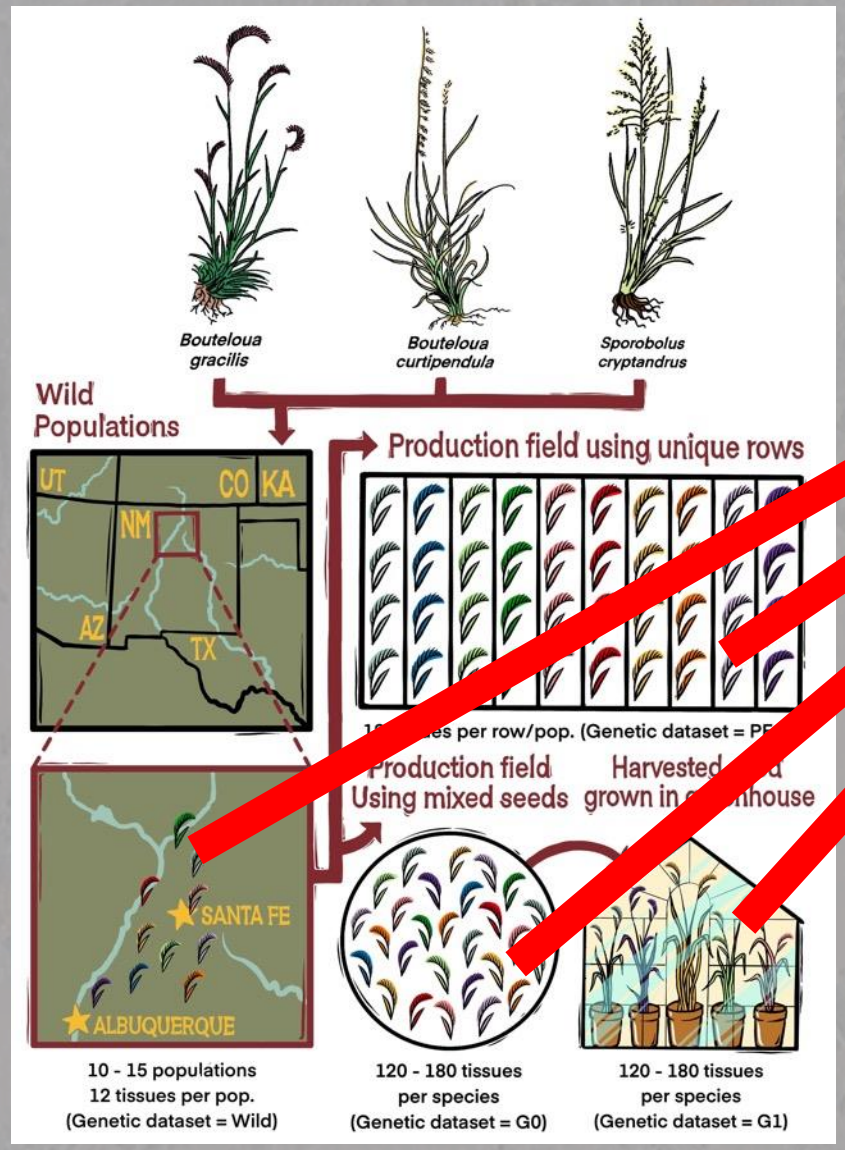
Investigating the effects of seed increase



Faske et al., *In review*

4 datasets per species

- **Wild**
- **G0 (rows)**
- **G0 (pooled)**
- **G1**

Questions:

How do genetic patterns shift between Wild and G1?

Are there differences among species?

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Bouteloua gracilis

15 sources, 555 plants
19,324 genetic markers

Bouteloua curtipendula

10 sources, 557 plants
18,881 genetic markers

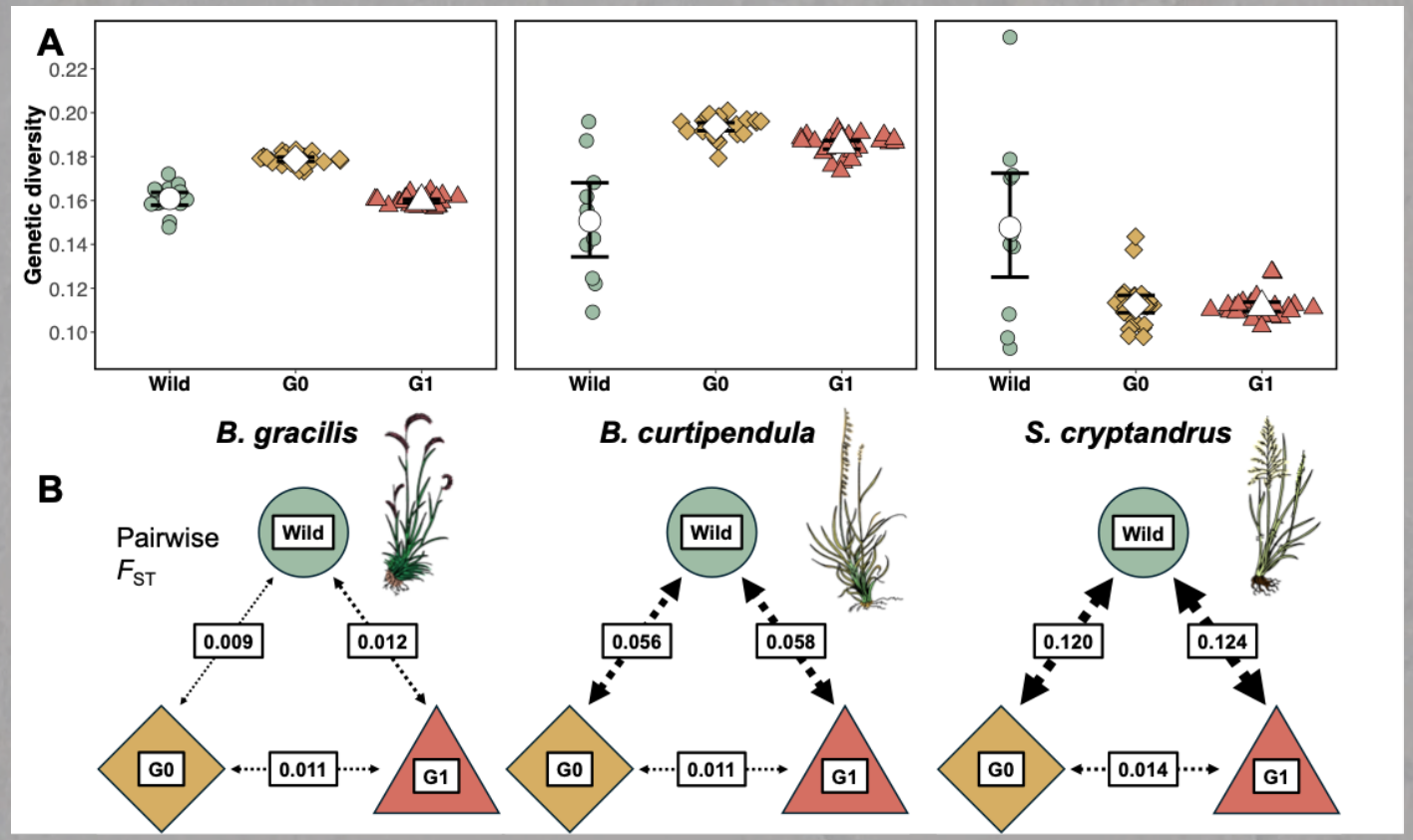
Sporobolus cryptandrus

10 sources, 594 plants
27,925 genetic markers

Artwork by Leigh Ellexson

Results: How do genetic patterns shift from wild sources to harvested seed?

Genetic diversity and differentiation among Wild, G0, and G1 generations



Faske et al., *In review*

Genetic diversity

Genetic differentiation

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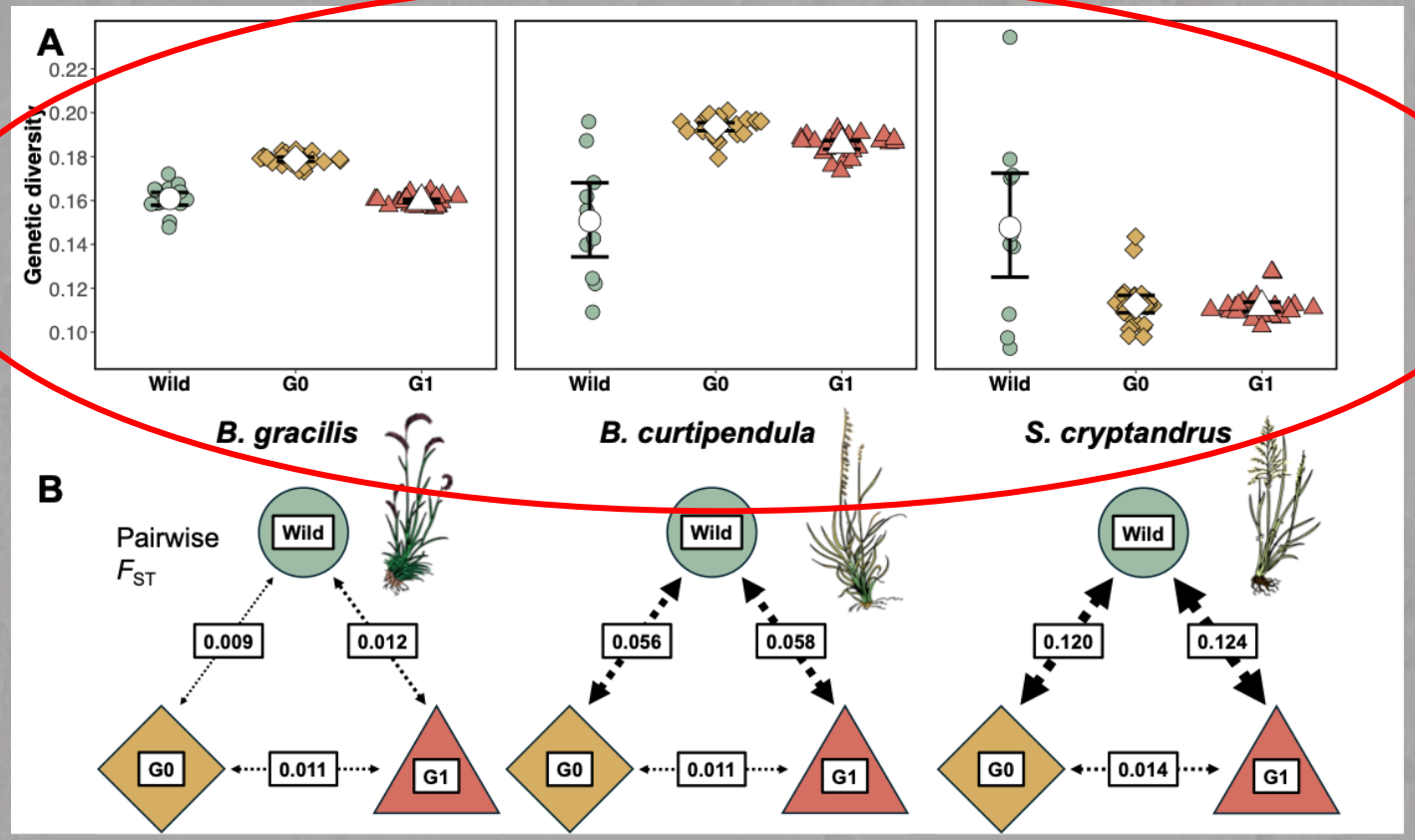
Results: How do genetic patterns shift from wild sources to harvested seed?

Genetic diversity and differentiation



Faske et al., *In review*

- Genetic diversity patterns across generations are unique

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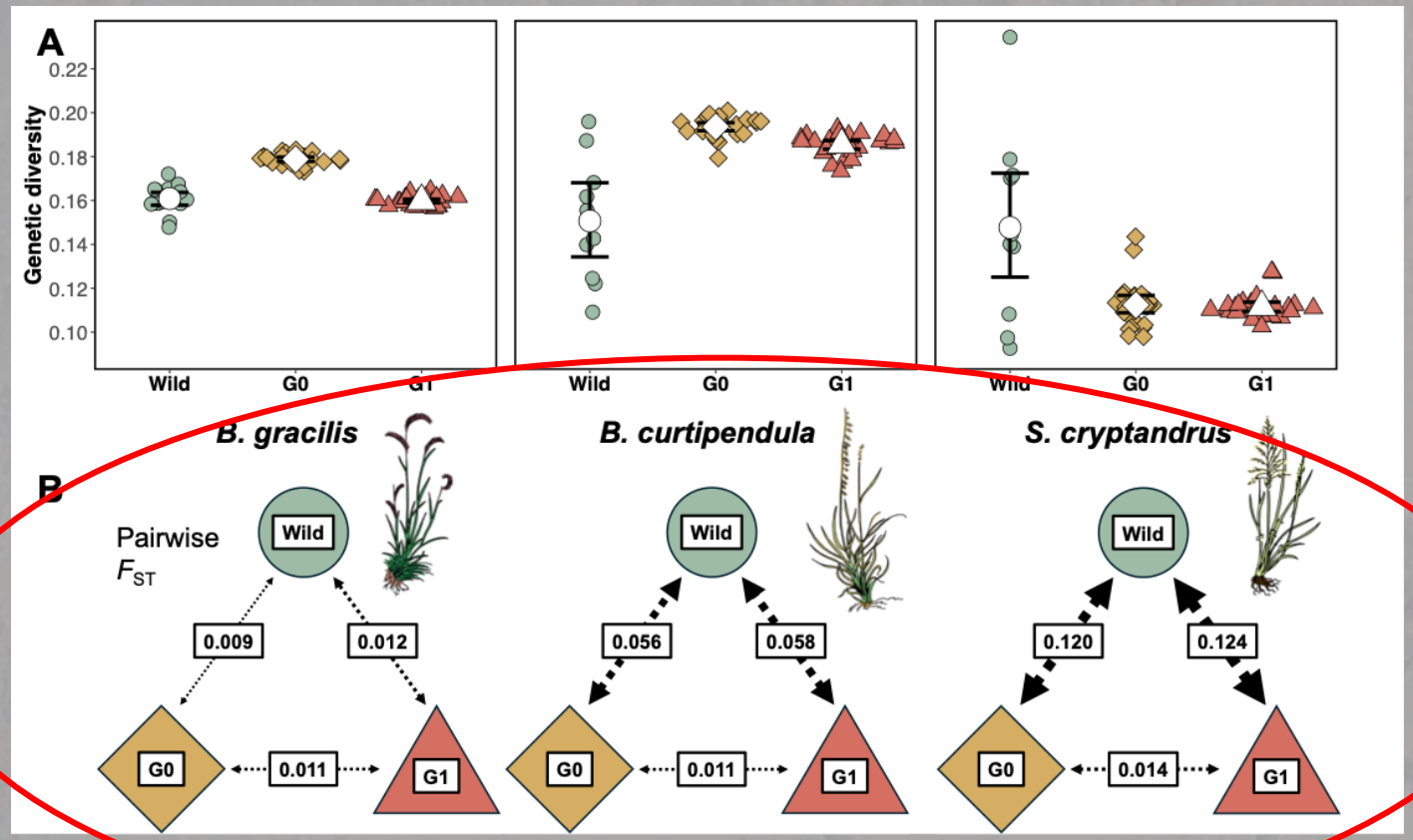
Results: How do genetic patterns shift from wild sources to harvested seed?

Genetic diversity and differentiation



Faske et al.. *In review*

- Genetic diversity patterns across generations are unique
- Genetic differentiation varies across species between Wild and G0/G1
  - 0 = completely the same
  - 1 = completely different

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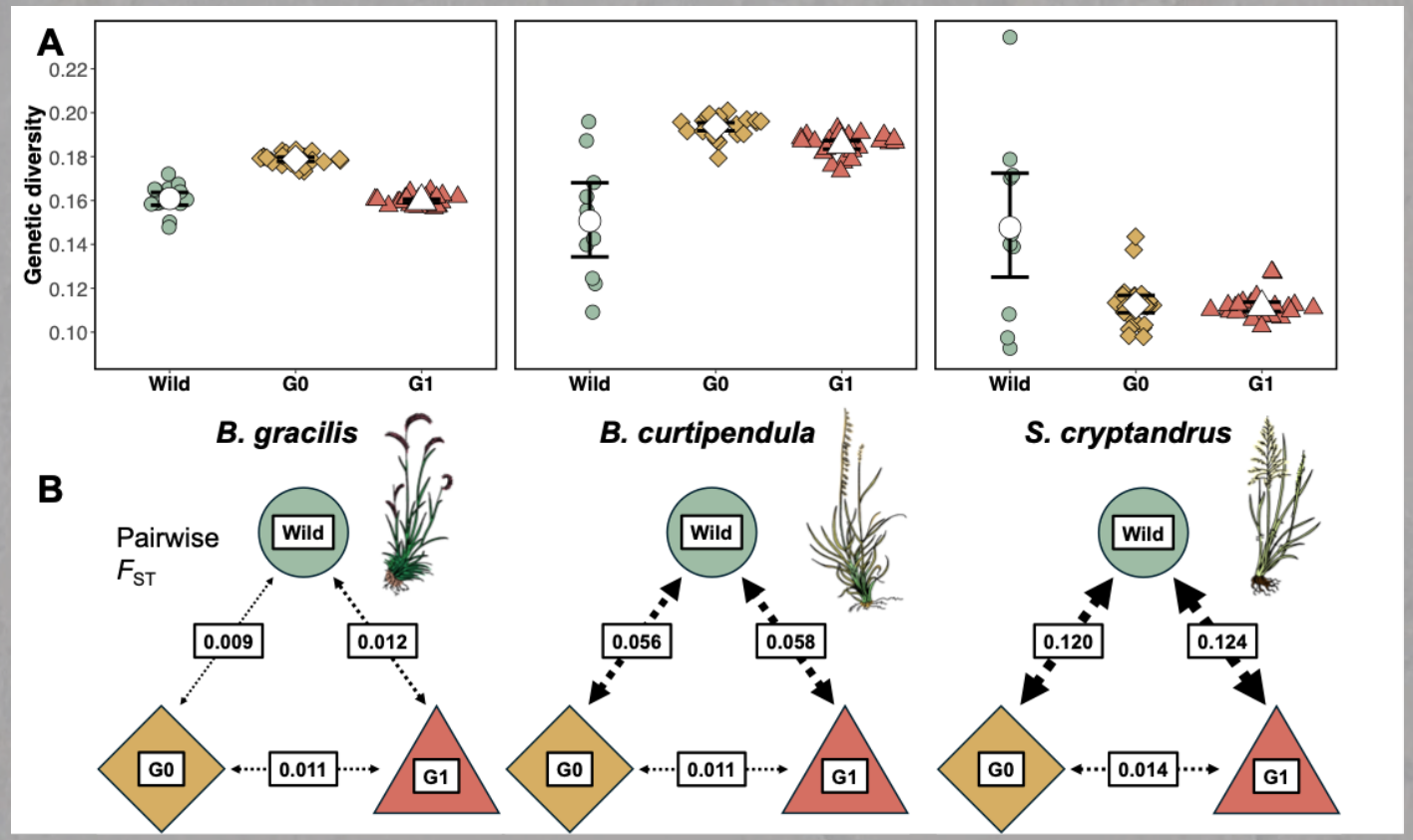
Results: How do genetic patterns shift from wild sources to harvested seed?

Genetic diversity and differentiation



Faske et al., *In review*

- Genetic diversity patterns across generations are unique
- Genetic differentiation varies across species between Wild and G0/G1

What's driving differences among species?

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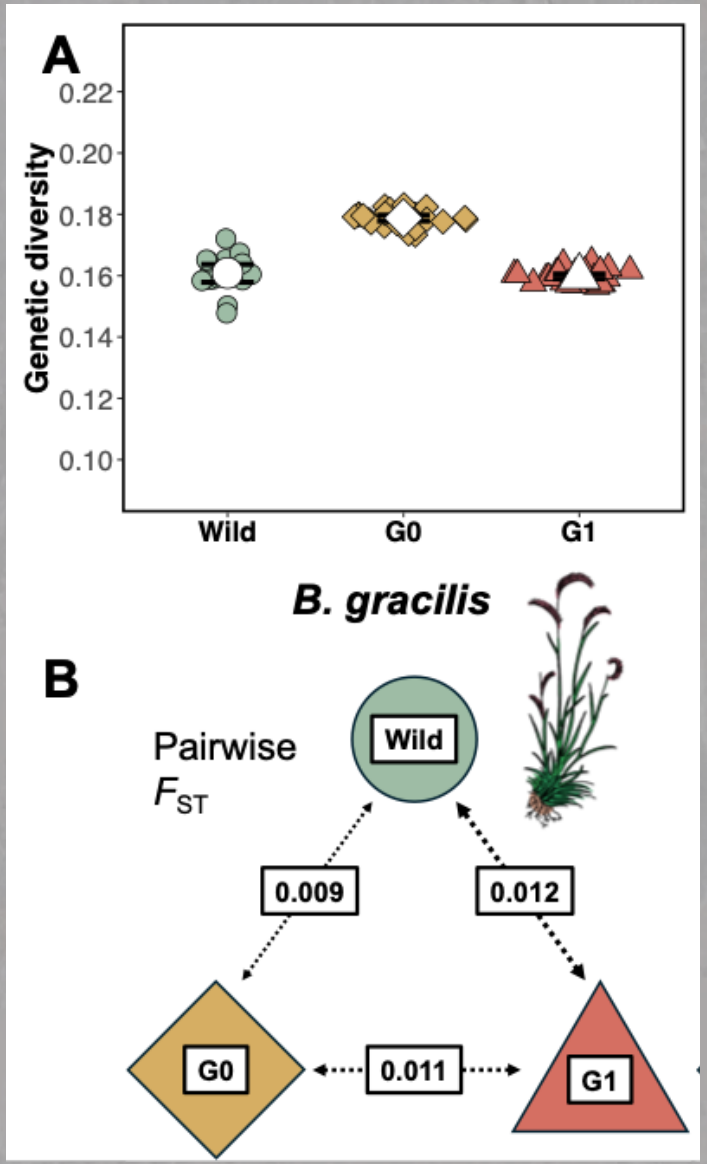
Results: *Bouteloua gracilis*



Faske et al., *In review*

- Small changes in genetic diversity among Wild, G0, G1
- Genetic differentiation low

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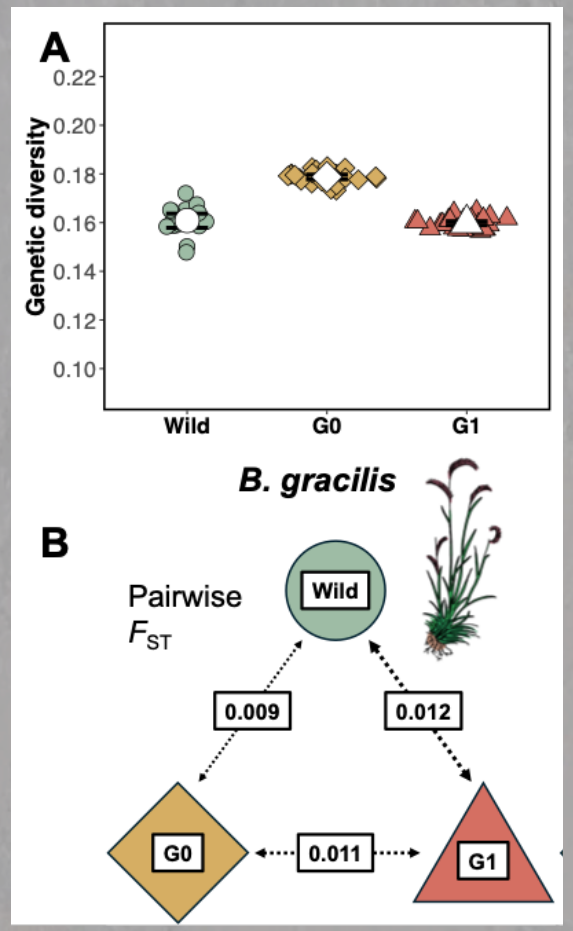
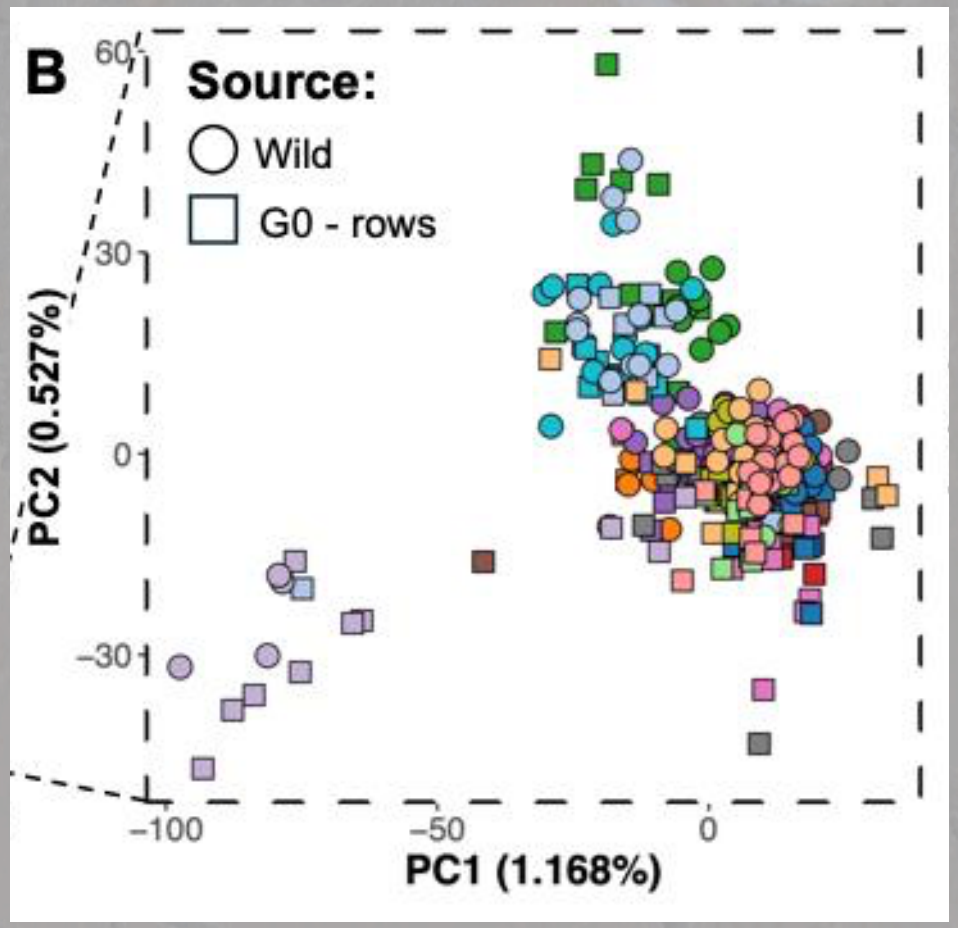
Results: *Bouteloua gracilis*





- Individuals from Wild and G0 overlap according to their source identity

Colors represent source population

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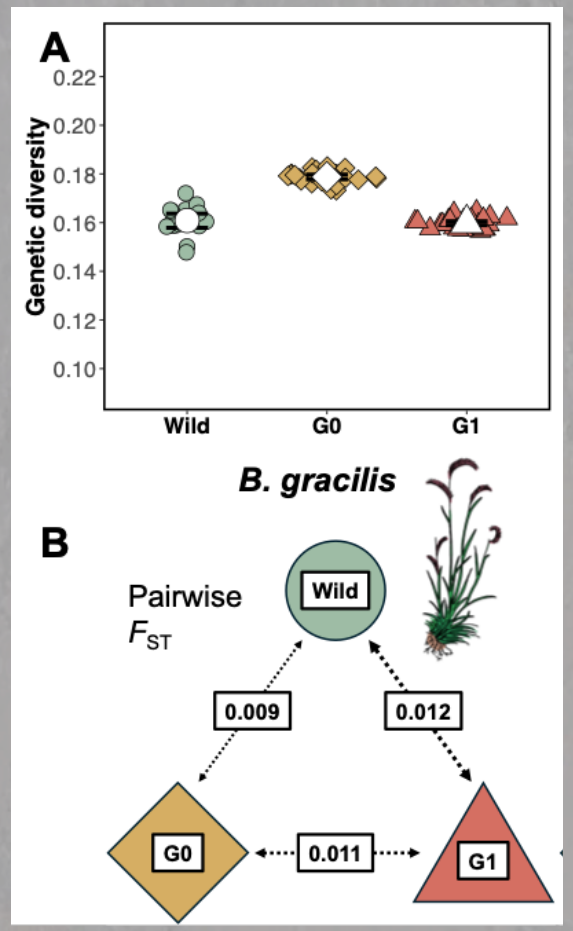
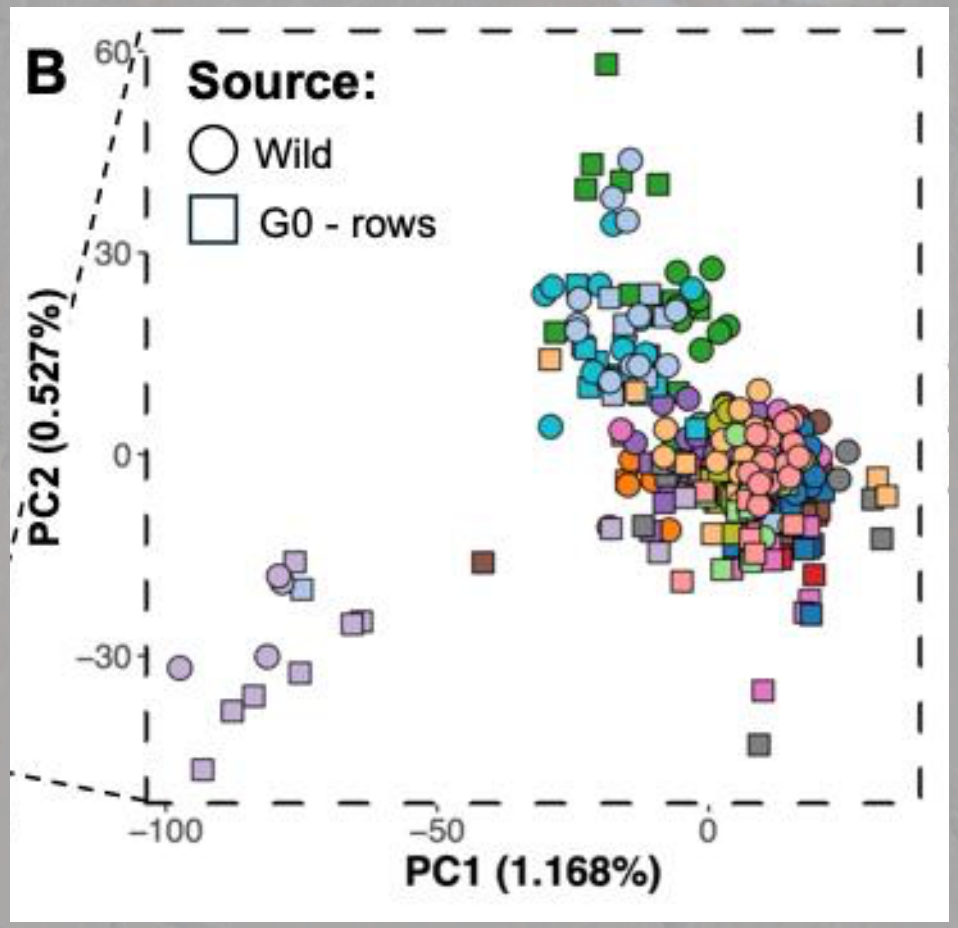
Results: *Bouteloua gracilis*





- Individuals from Wild and G0 overlap according to their source identity
- Meets expectations for an outcrossing species

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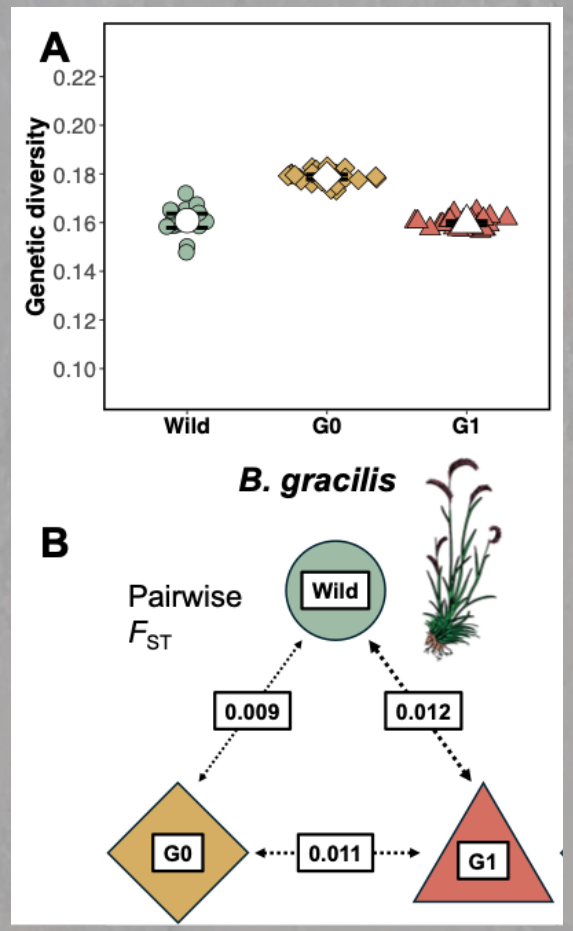
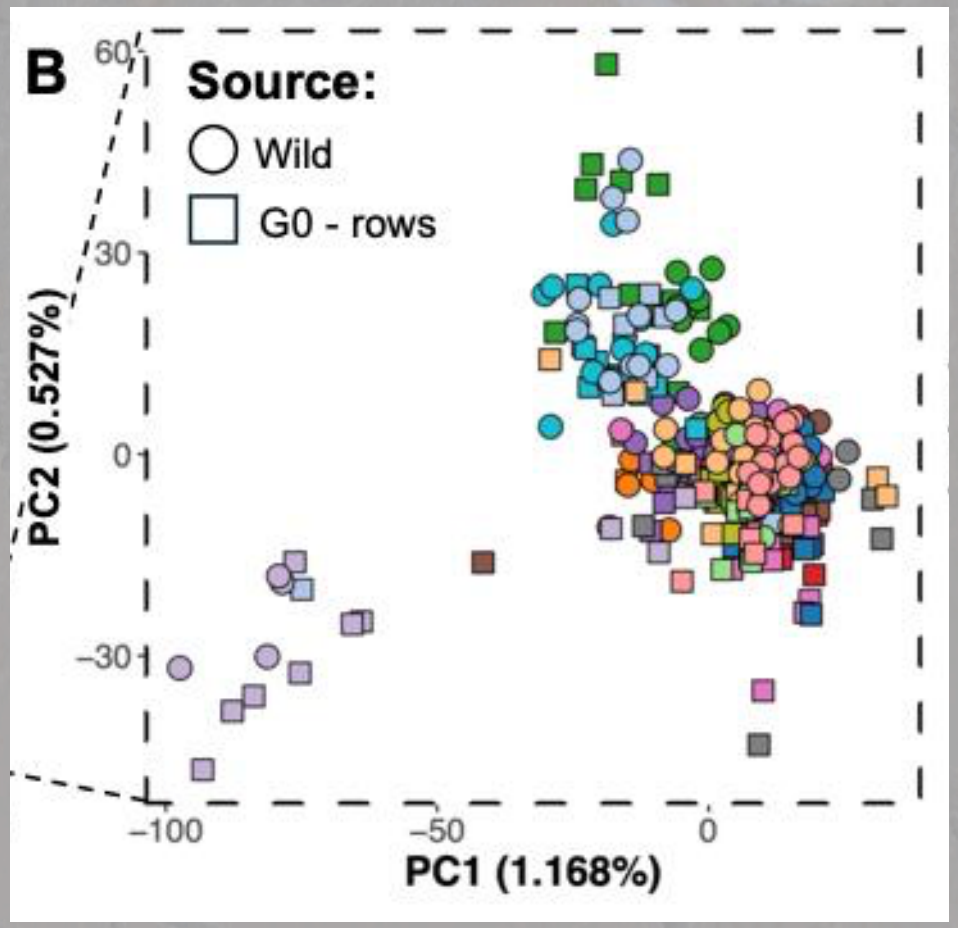
Landscape Stewardship Collective

Results: *Bouteloua gracilis*





- Individuals from Wild and G0 overlap according to their source identity
- Meets expectations for an outcrossing species

Wild and G0 represent the same genetic pool, hence:

- **consistent genetic diversity**
- **low genetic differentiation**

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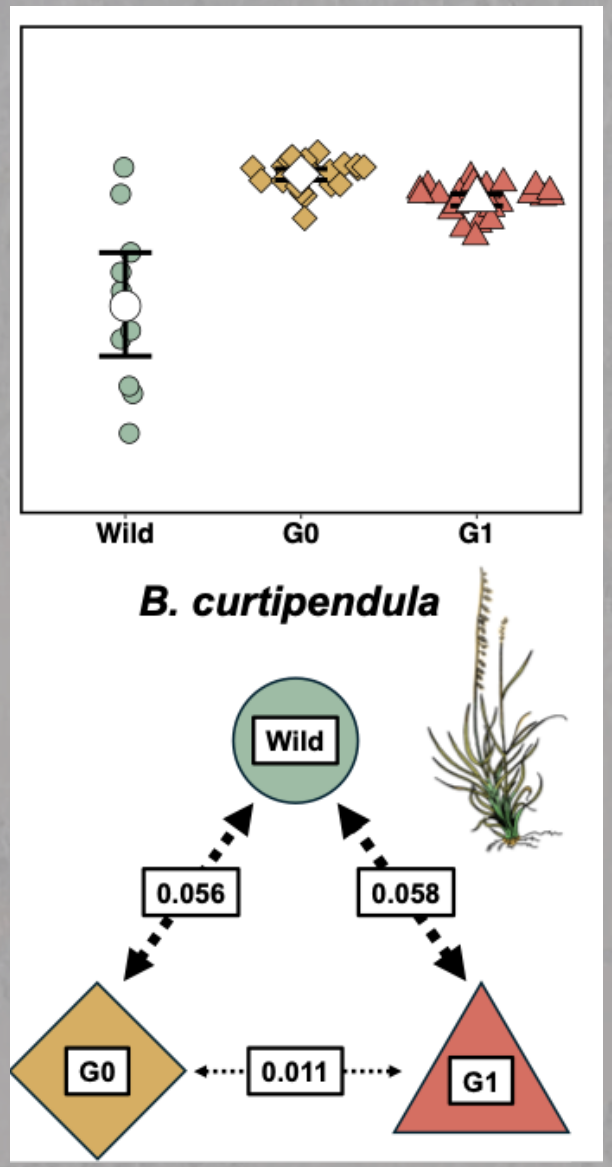
Results: *Bouteloua curtipendula*



Faske et al., *In review*

- Higher genetic diversity among in G0 and G1
- Wild genetically differentiated from G0/G1

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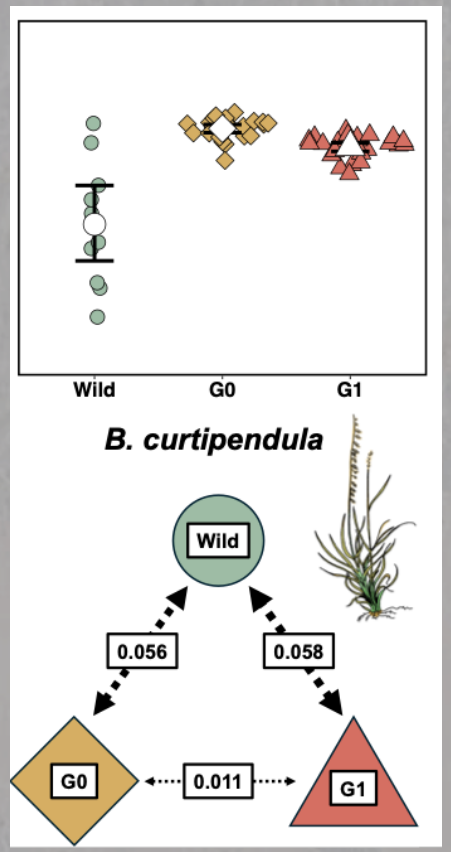
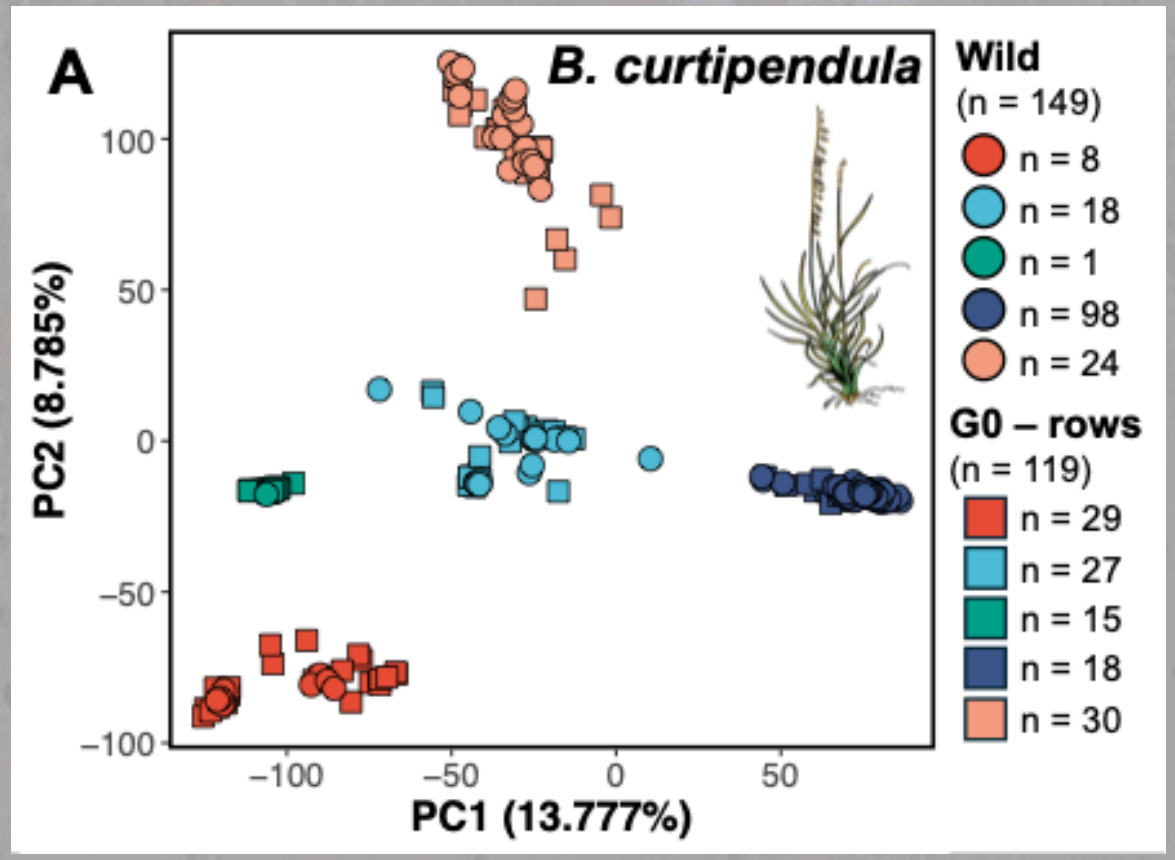
Results: *Bouteloua curtipendula*





- Individuals from Wild and G0 cluster into 5 genetic groups

Colors represent assigned genetic cluster

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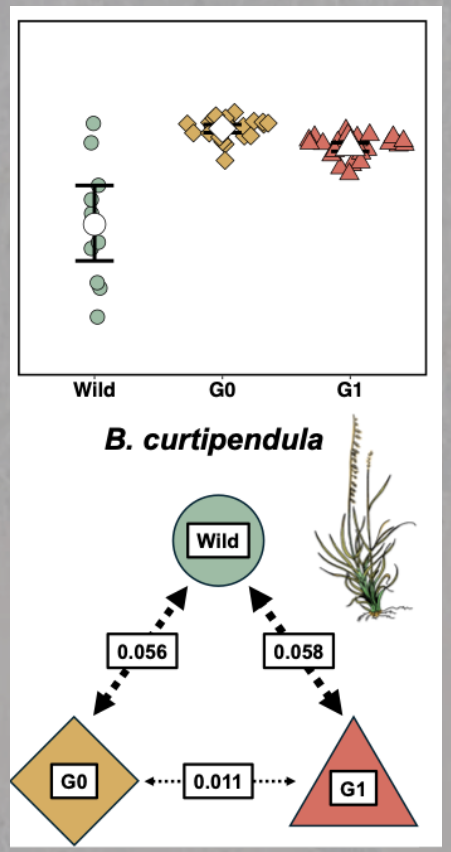
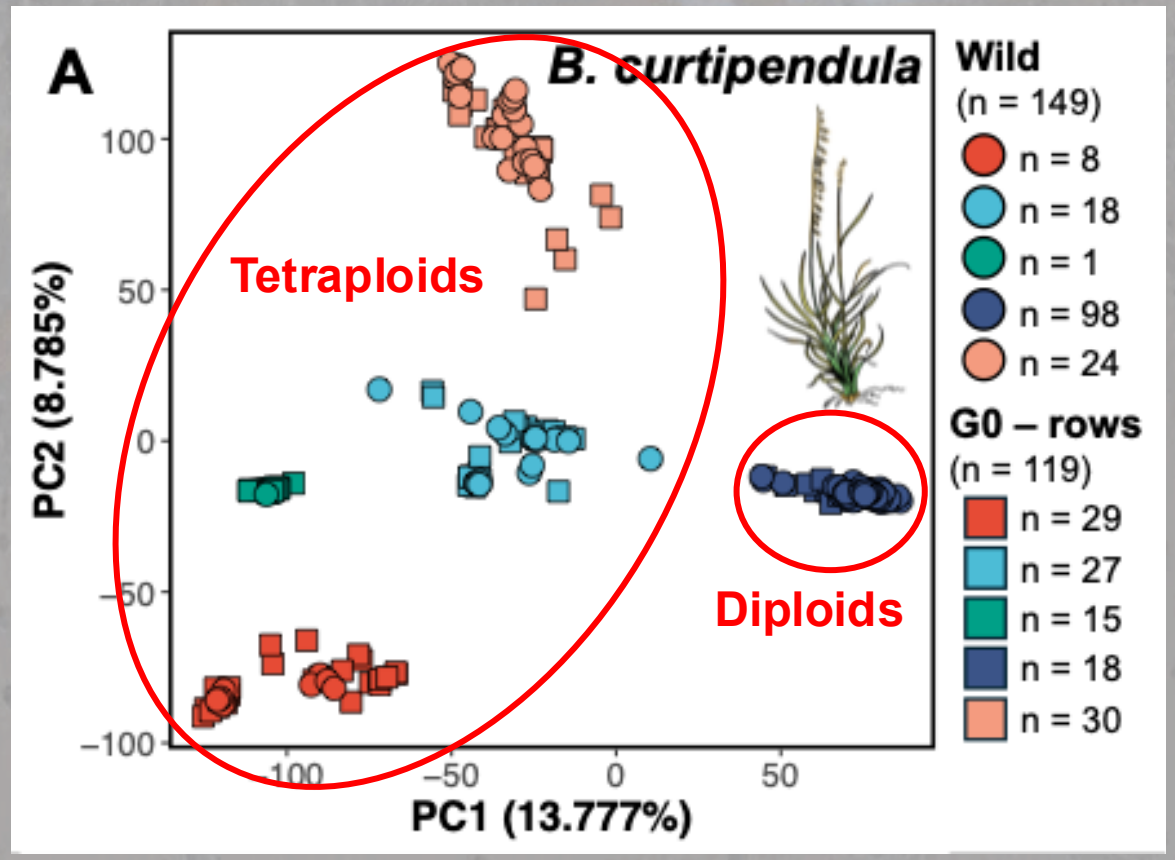
Results: *Bouteloua curtipendula*





- Individuals from Wild and G0 cluster into 5 genetic groups
- Groups represent different ploidy levels

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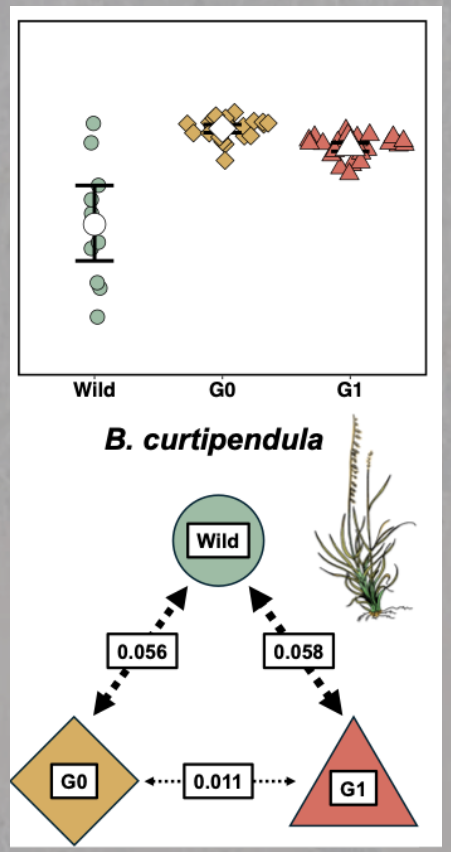
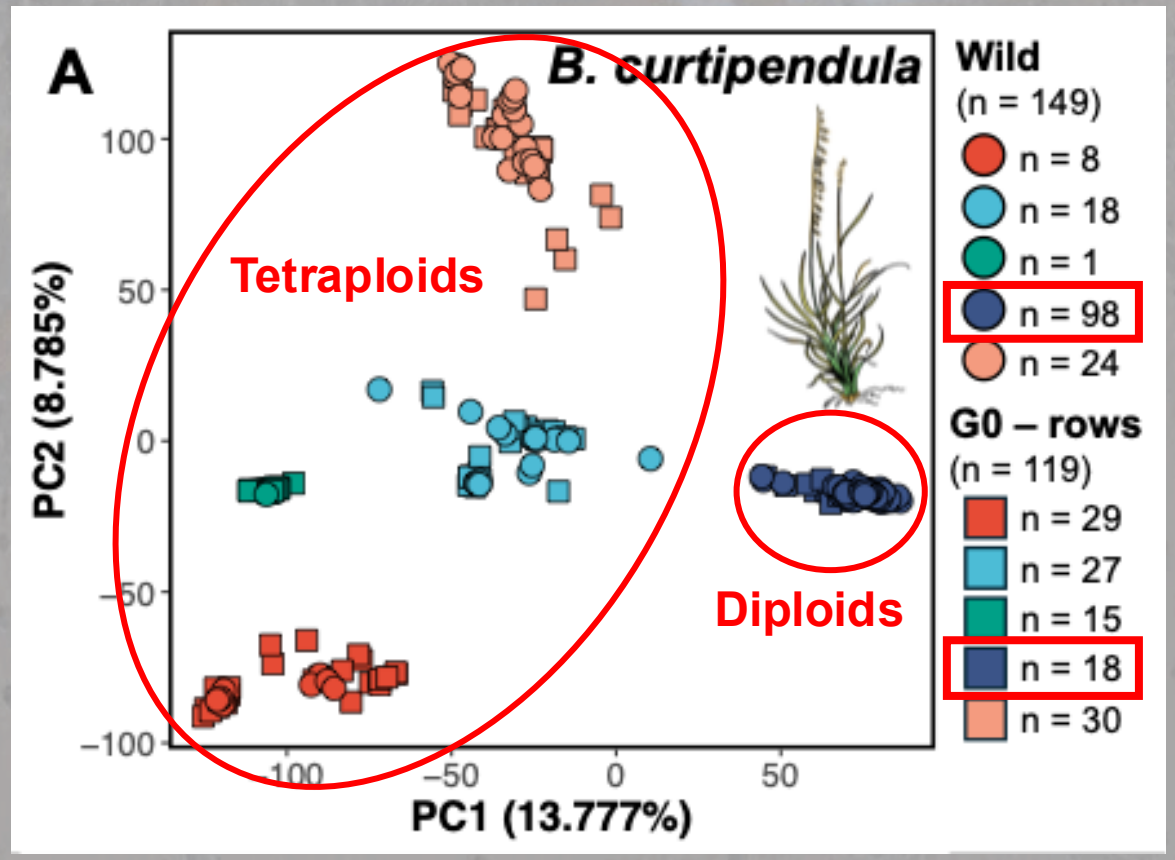
Results: *Bouteloua curtipendula*





- Individuals from Wild and G0 cluster into 5 genetic groups
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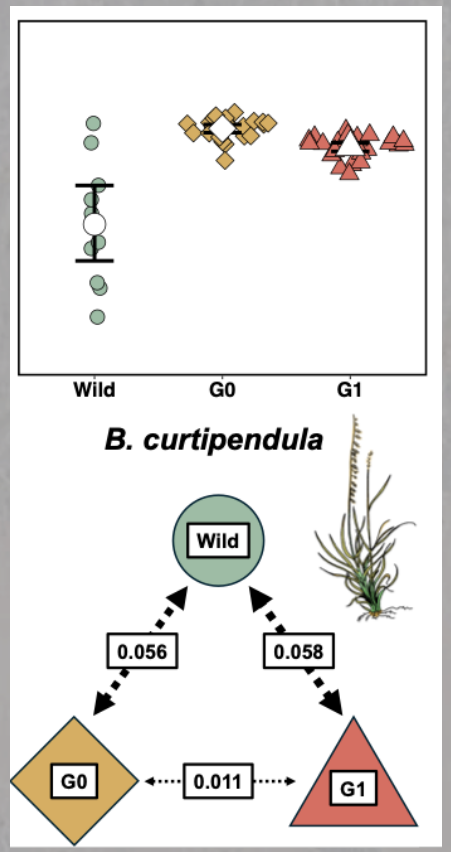
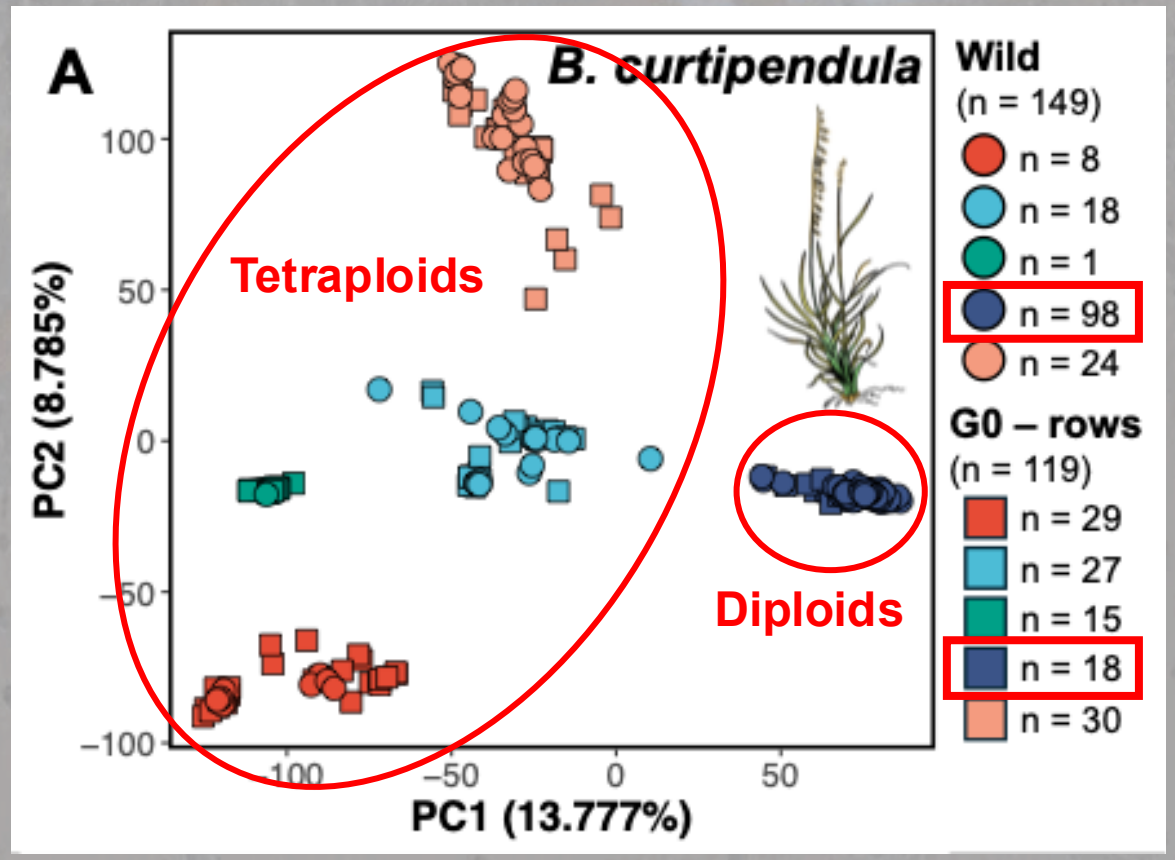
- Tetraploids much more common in G0 compared to Wild!!!

Colors represent assigned genetic cluster

Landscape Stewardship Collective

Results: *Bouteloua curtipendula*





- Individuals from Wild and G0 cluster into 5 genetic groups
- Groups represent different ploidy levels
- Tetraploids much more common in G0 compared to Wild!!!

Tetraploids are overrepresented in agricultural fields, hence:

- **higher genetic diversity**
- **higher genetic differentiation**

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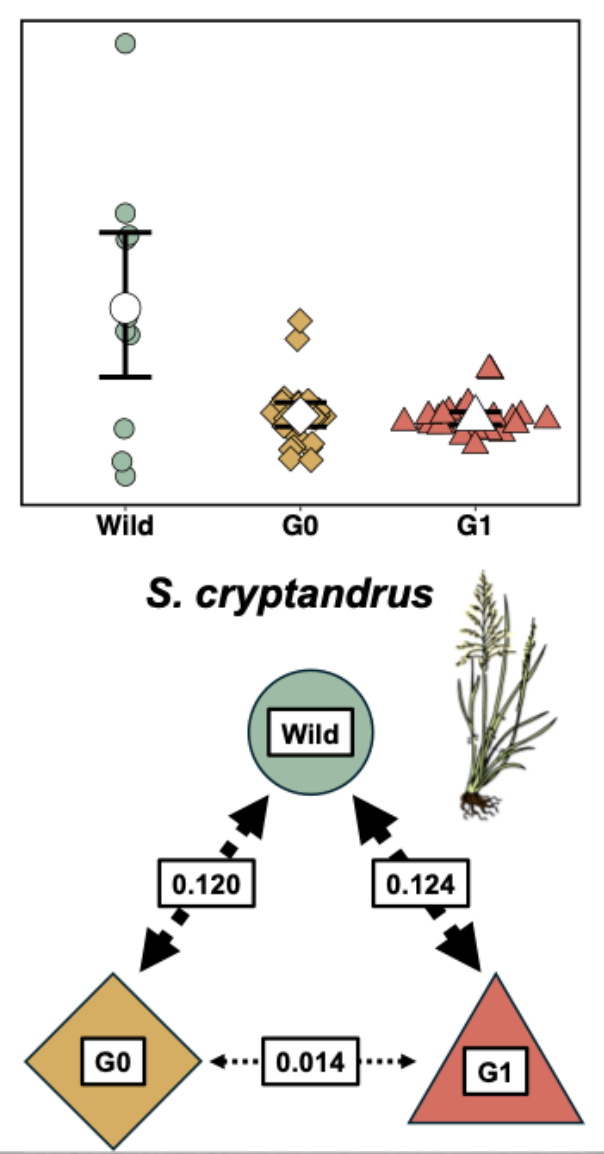
Results: *Sporobolus cryptandrus*

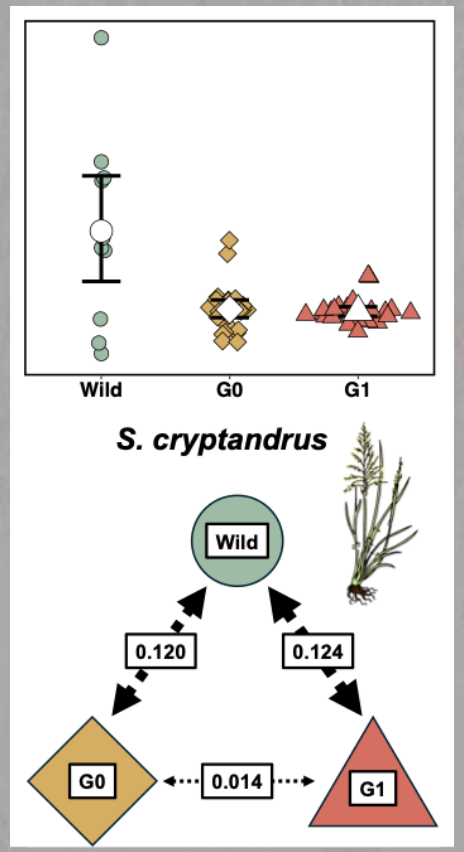


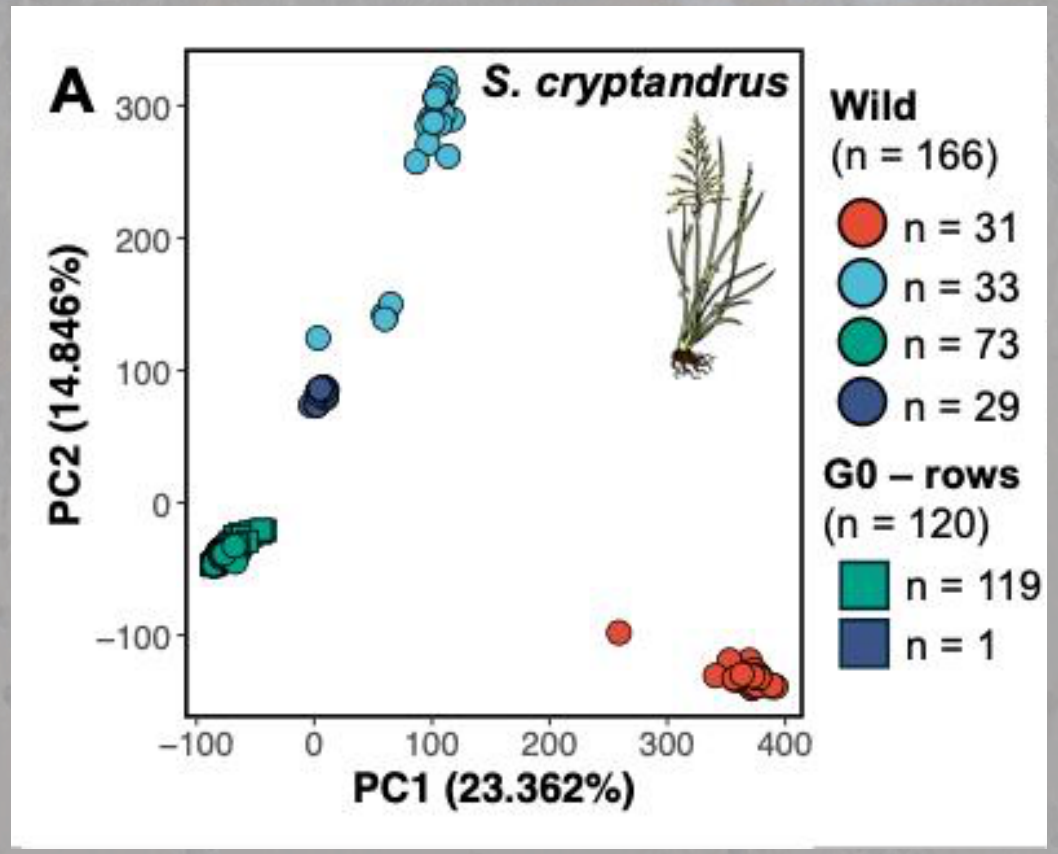
Faske et al., *In review*

- Lower genetic diversity among in G0 and G1
- Wild genetically differentiated from G0/G1

Landscape Stewardship Collective

Results: *Sporobolus cryptandrus*



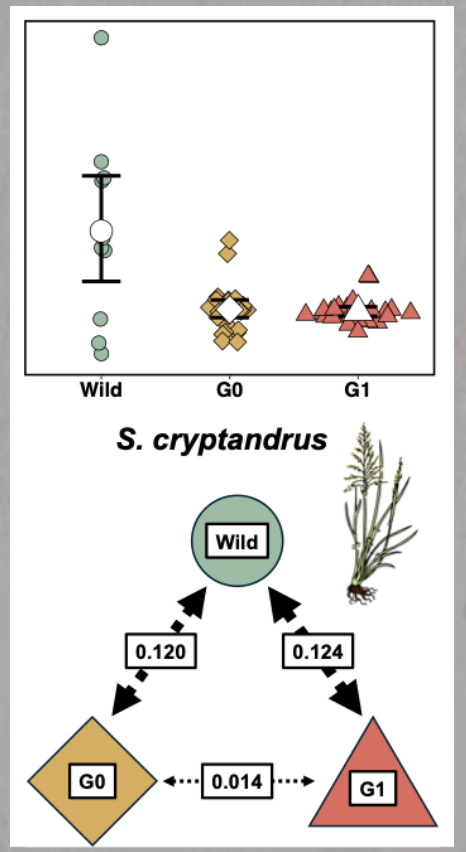


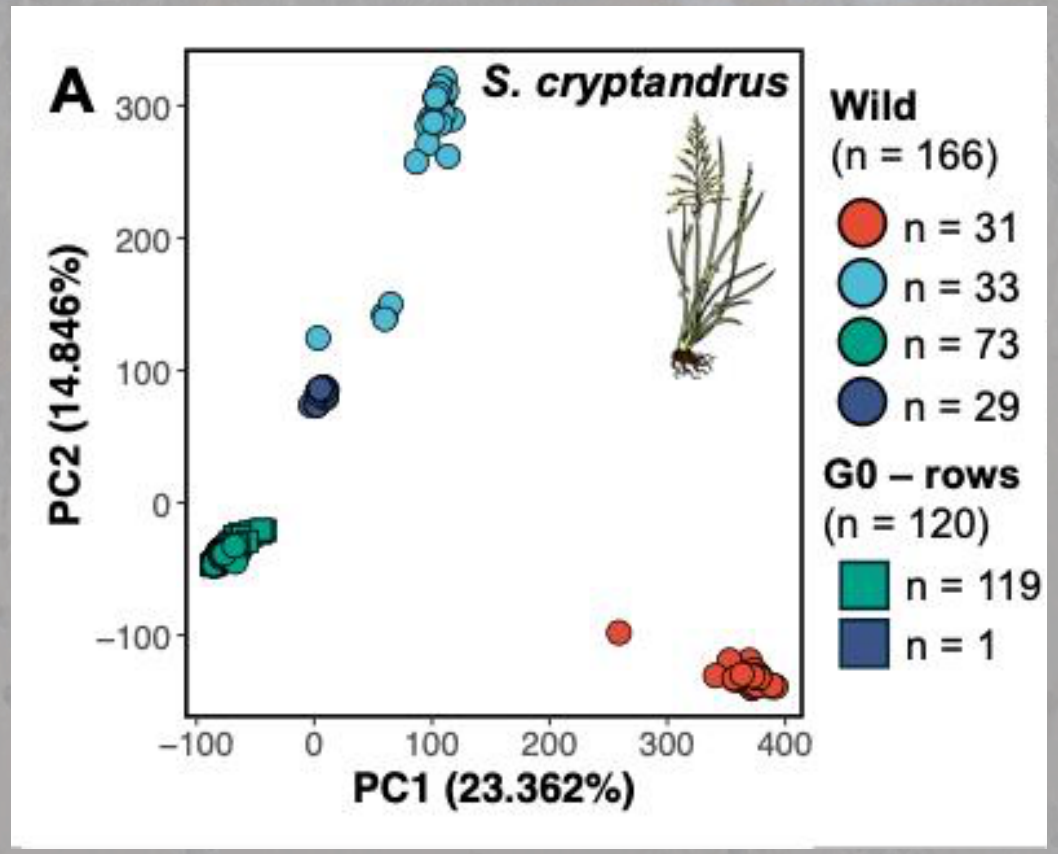
- 4 genetic lineages (Wild)

Colors represent assigned genetic cluster

Landscape Stewardship Collective

Results: *Sporobolus cryptandrus*



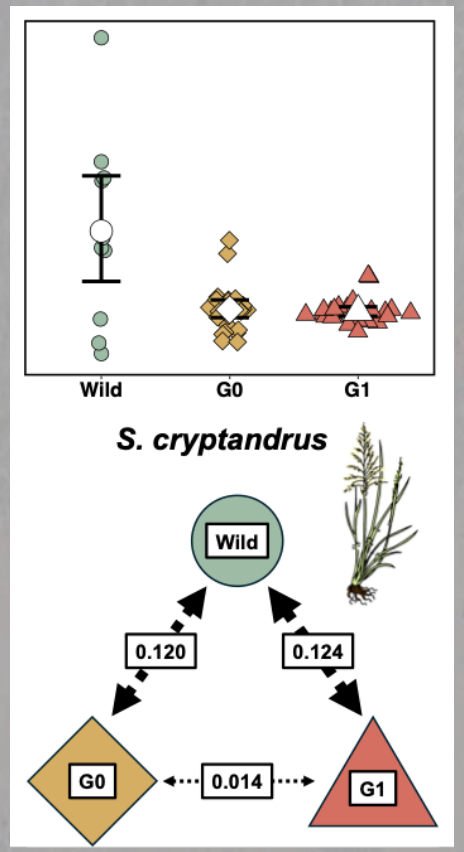


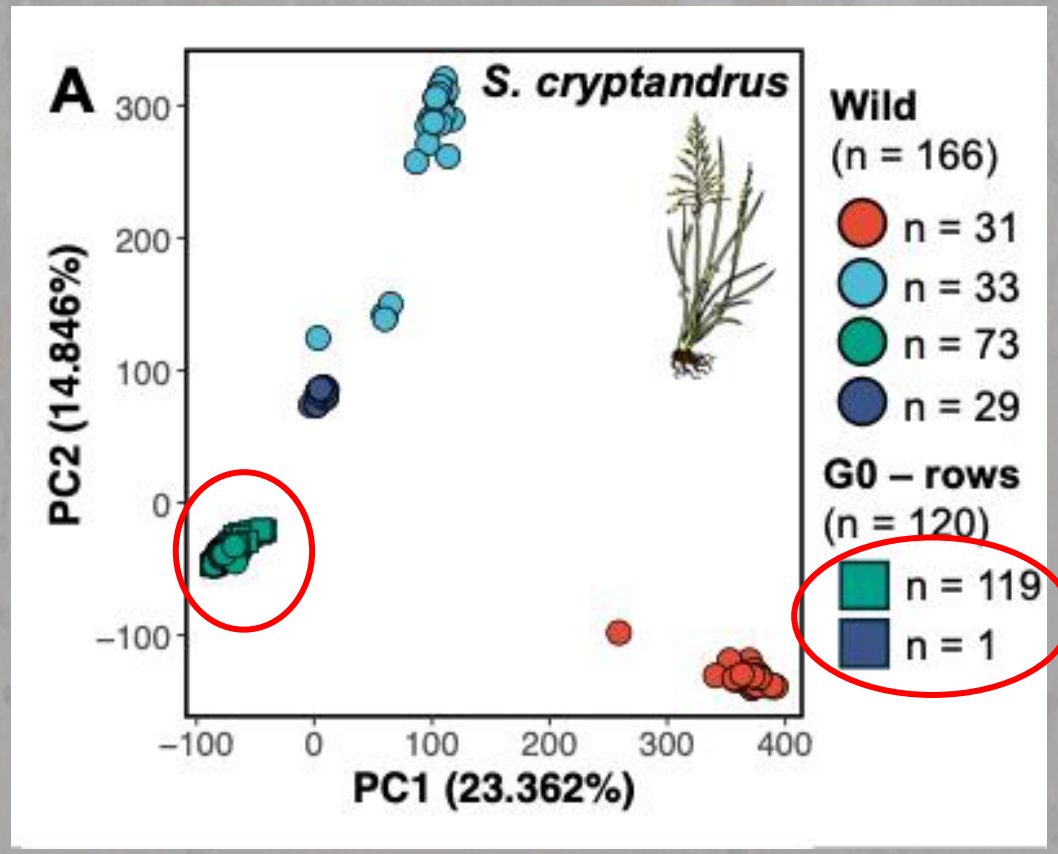
- 4 genetic lineages (Wild)
- All lineages can be present at each wild population

Colors represent assigned genetic cluster

Landscape Stewardship Collective

Results: *Sporobolus cryptandrus*





- 4 genetic lineages (Wild)
- All lineages can be present at each wild population
- Reduced to 2 lineages in production field (G0)

Colors represent assigned genetic cluster

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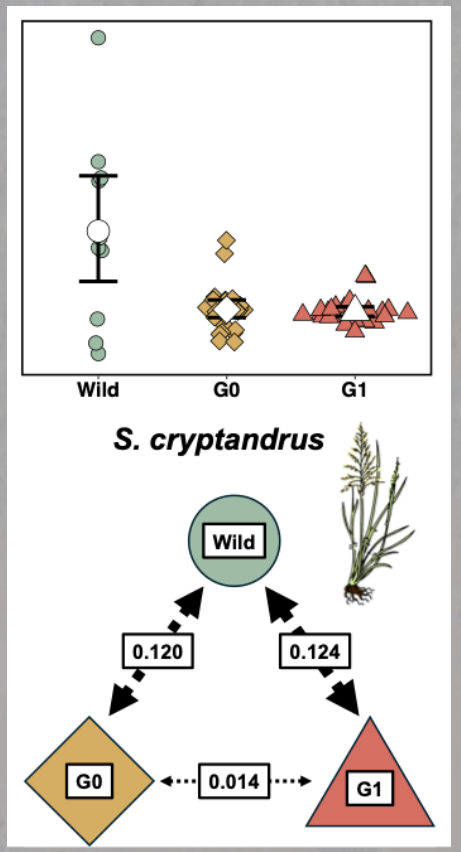
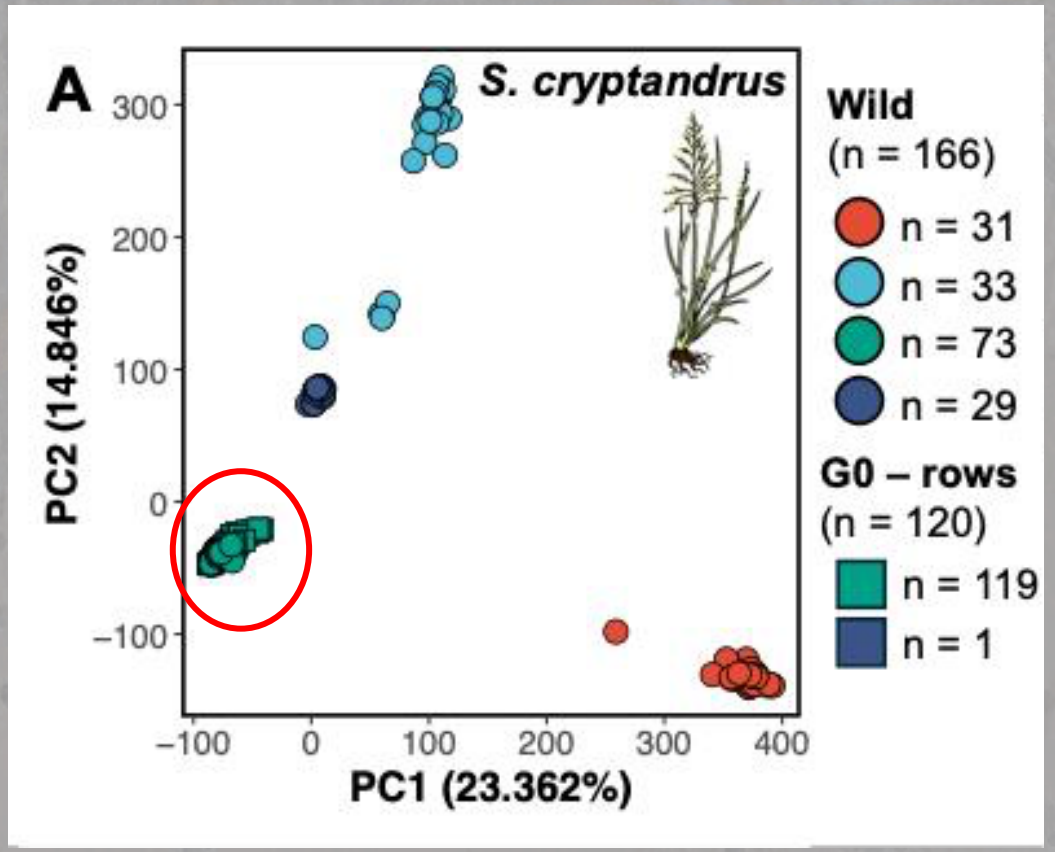
Results: *Sporobolus cryptandrus*





- 4 genetic lineages (Wild)
- All lineages can be present at each wild population
- Reduced to 2 lineages in production field (G0)

One genetic lineage dominates in agricultural fields, hence:

- **lower genetic diversity**
- **higher genetic differentiation**

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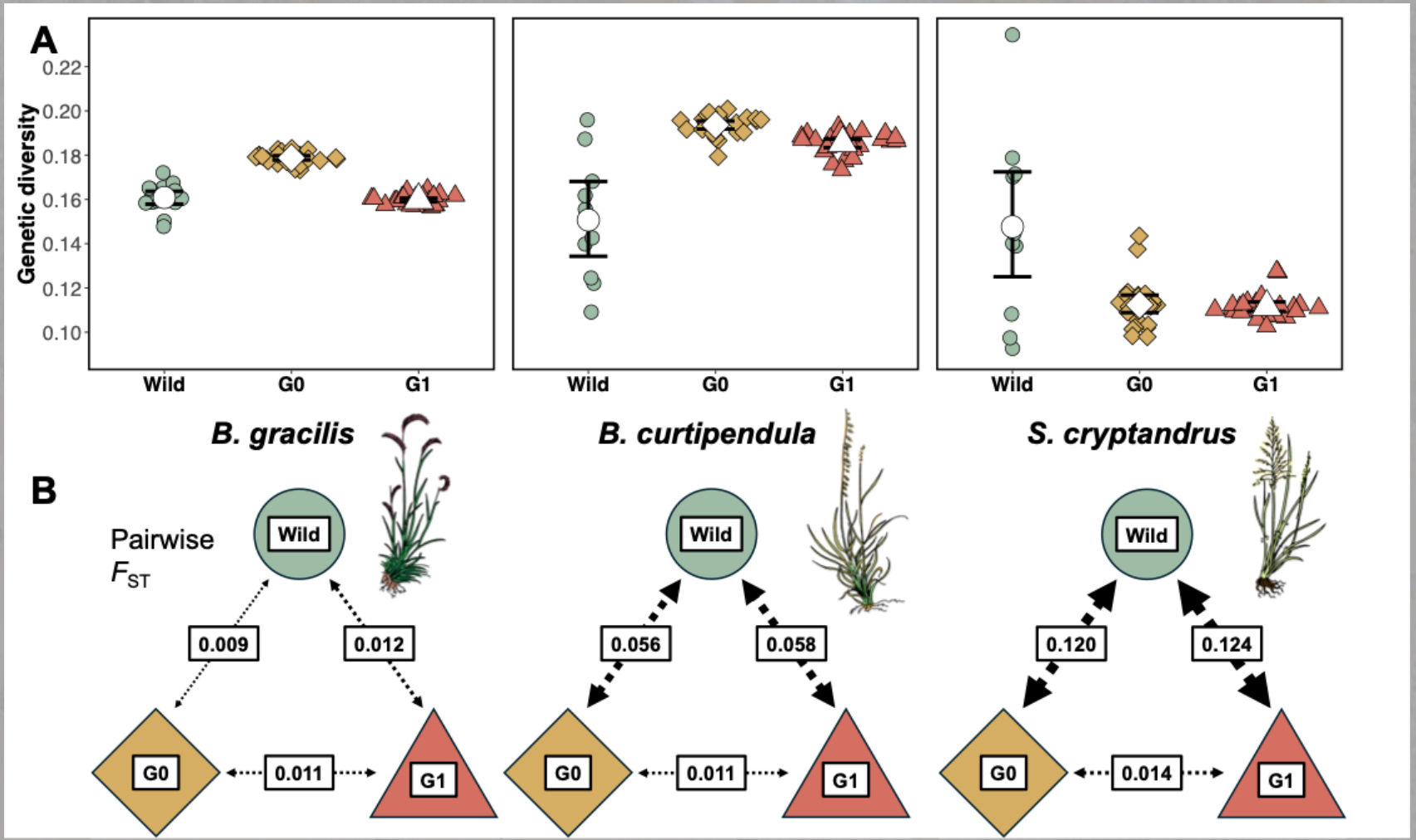
Species-specific biology influences agricultural seed increase



Faske et al., *In review*

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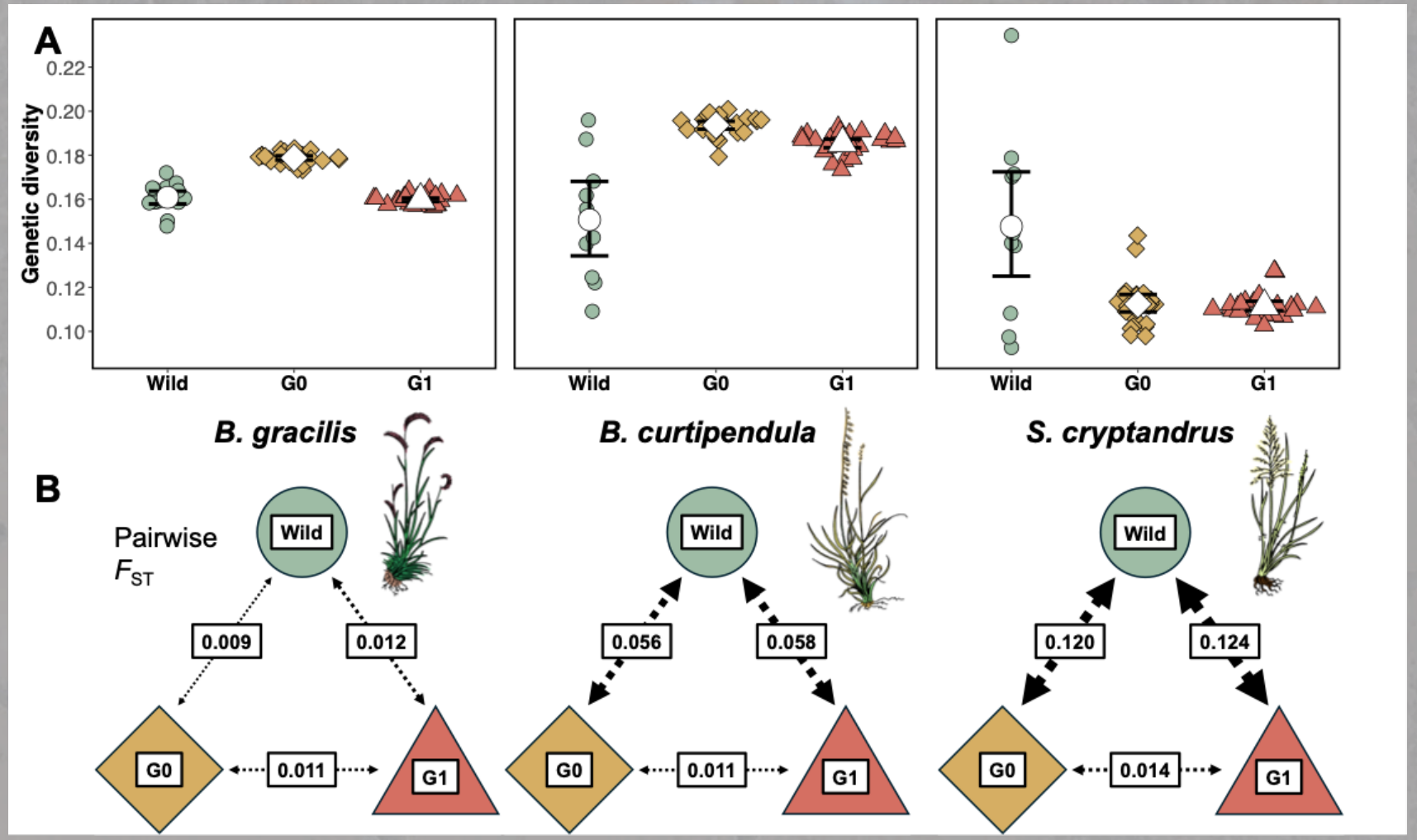

Faske et al., *In review*

Agricultural increase is not the culprit

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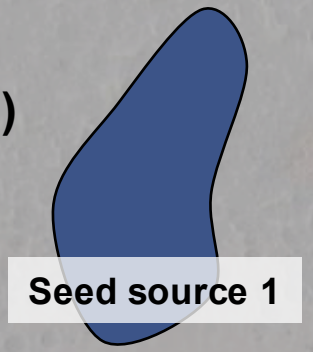
Seed increase hypothesis for *S. cryptandrus*

Wild collected seed source

2N (selfing)

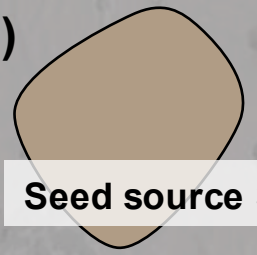


Seed source 1

2N (selfing)

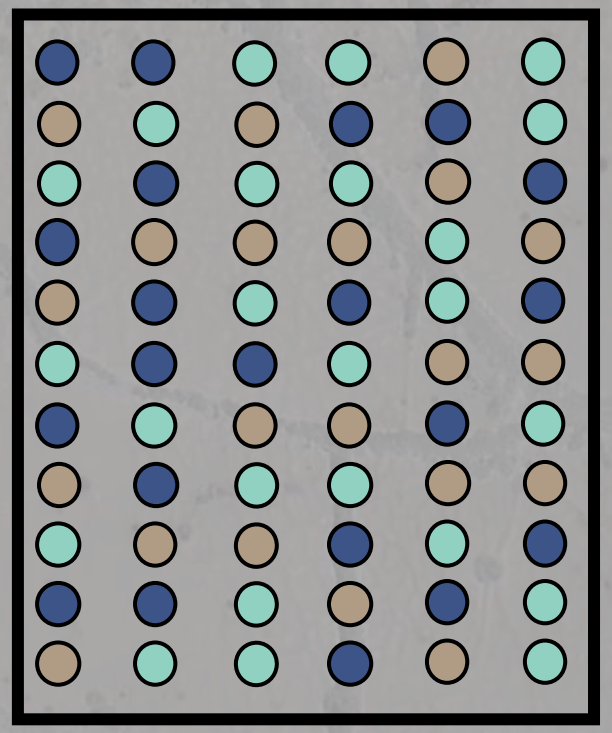
Seed source 2

2N (selfing)



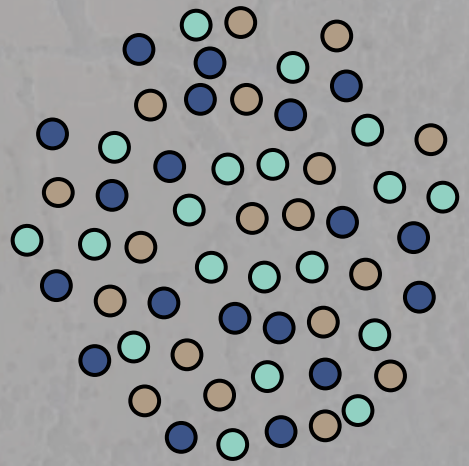
Seed source 3

Production field (Established from G0 seed)



Harvested seed (G1)

Genetics preserved



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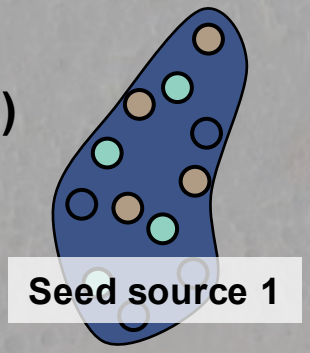
Reality for *S. cryptandrus*

Wild collected seed source

2N (selfing)

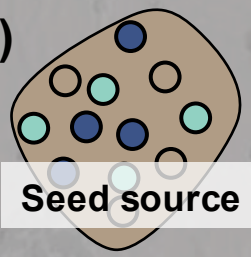


Seed source 1

2N (selfing)

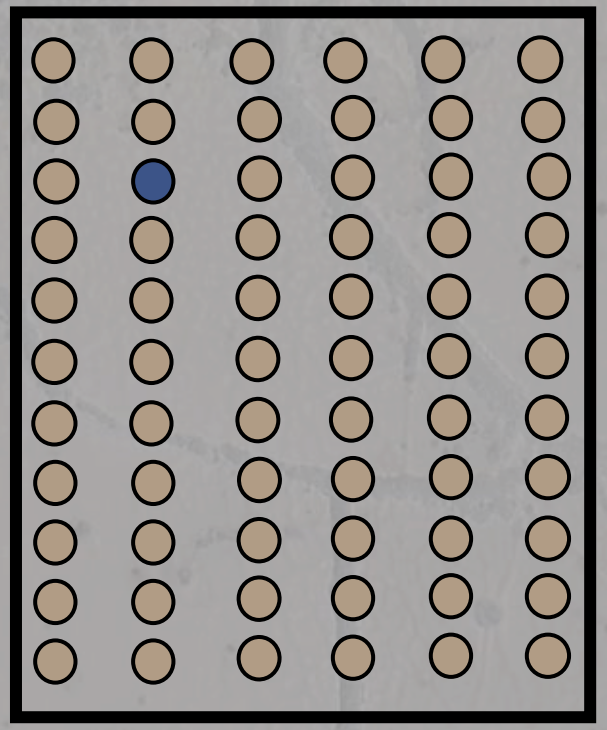
Seed source 2

2N (selfing)

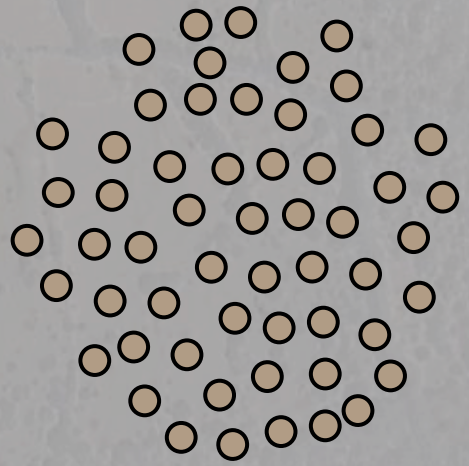


Seed source 3

Production field (Established from G0 seed)



Harvested seed (G1)



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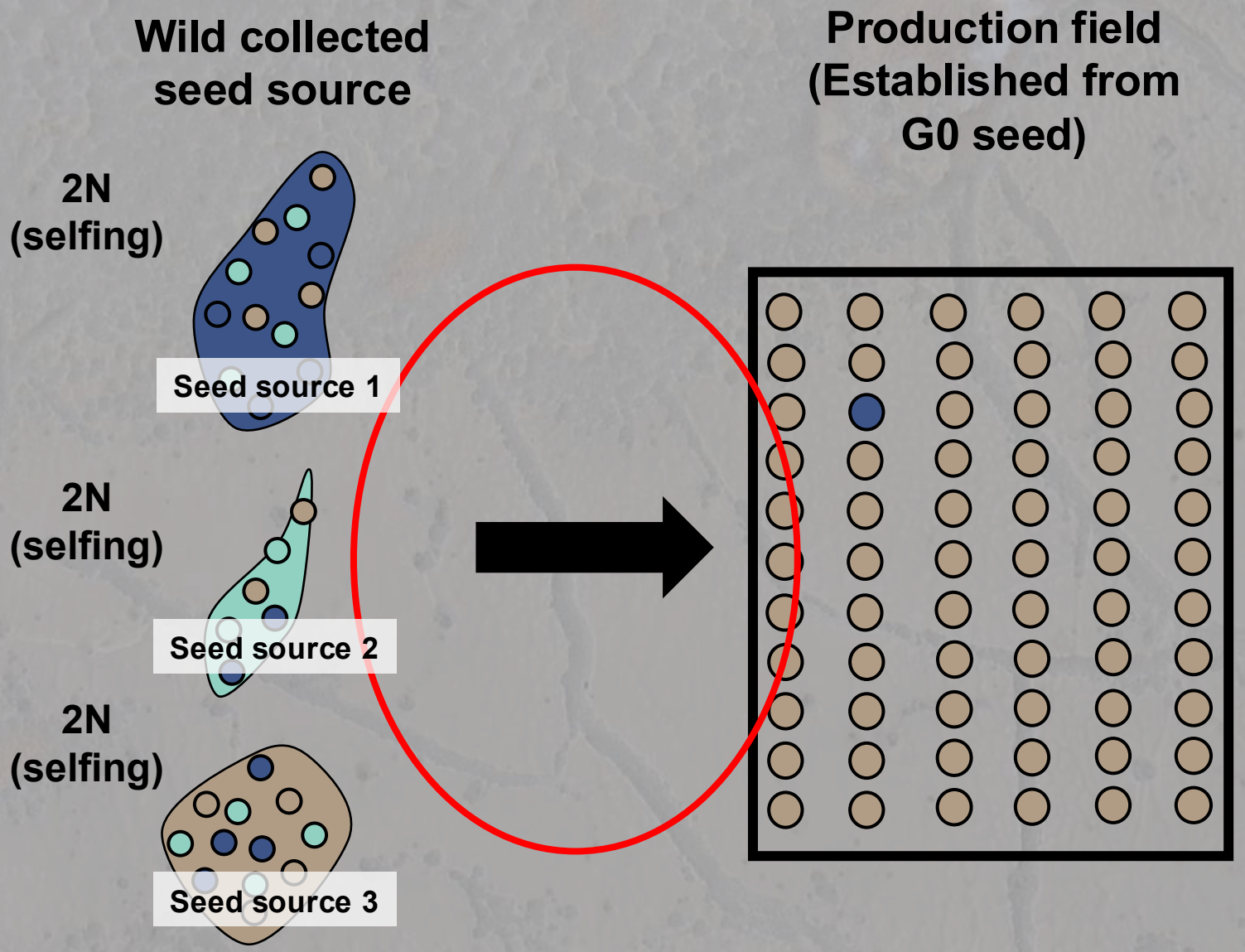
Where do the shifts occur (*Bouteloua curtipendula* and *Sporobolus cryptandrus*)?



Genetic shifts occur between seed collection and field establishment

Factors to consider:

- timing of seed collection
- single vs. multiple collection events
- seed storage
- greenhouse propagation of plugs
- and more…

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Take home messages

In our quest to increase the number of species and sources available to conduct ecologically and genetically appropriate restoration:

- Species biology matters
- We need more information about how seed collection and field establishment practices cause genetic shifts
- Does it matter?
  - Do we need all genetic lineages and ploidy levels present?

Take home messages

In our quest to increase the number of species and sources available to conduct ecologically and genetically appropriate restoration:

- Species biology matters
- We need more information about how seed collection and field establishment practices cause genetic shifts
- Does it matter?
  - Do we need all genetic lineages and ploidy levels present?

Using native seed in a project? Do you want to help understand these patterns and processes better? Contact us!

Landscape Stewardship Collective

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