

Overview

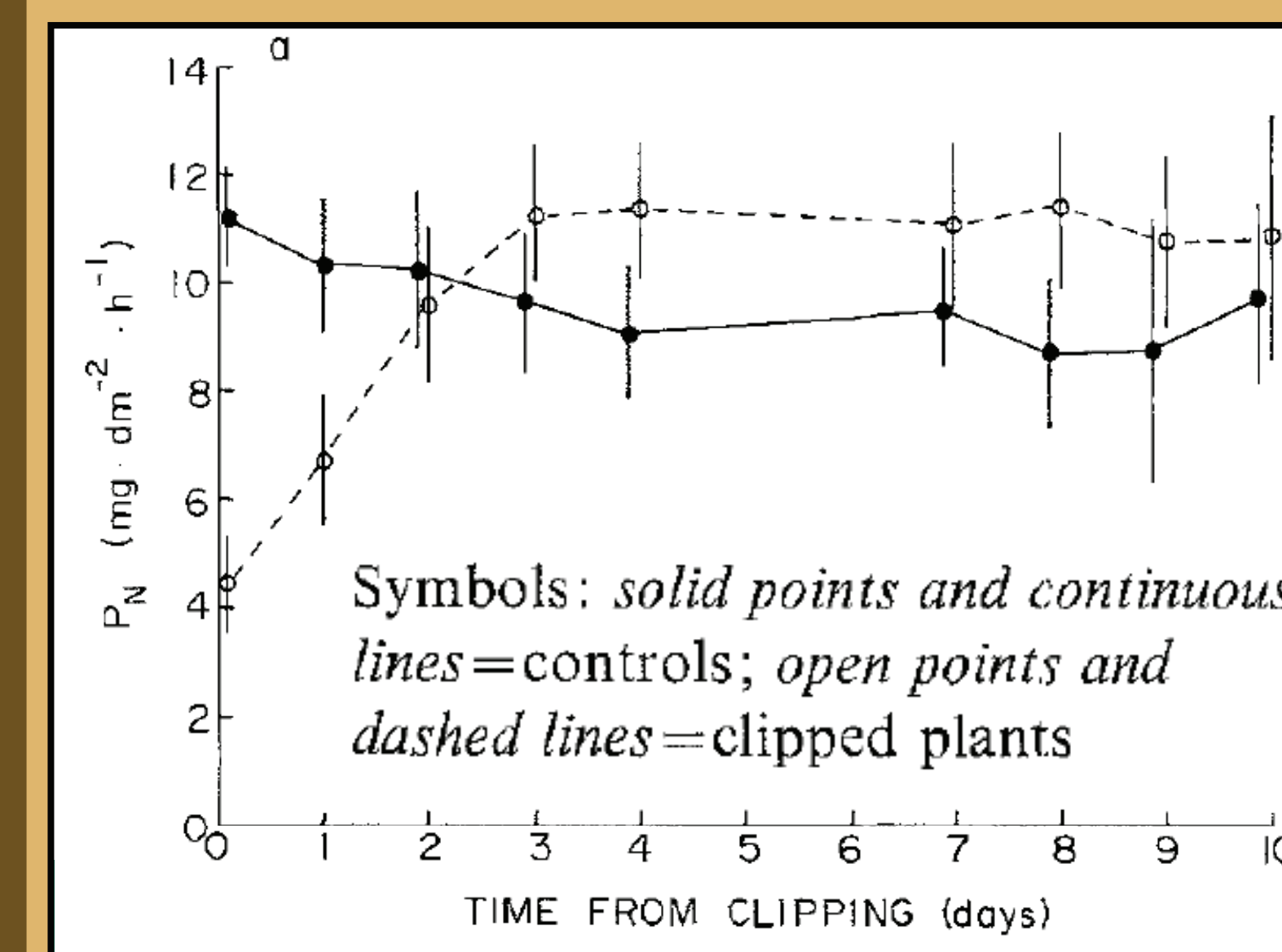
Land managers on the Colorado Plateau contend with significant unknowns when it comes to determining the best practices for restoring public lands and meeting the demands for **marketable native seed**. Here:

- (1) We present a unified research framework to synthesize substantial advances already made in understanding native systems and restoration options.
- (2) We use *Bouteloua gracilis* as a case study and will apply this framework to other species in the future (i.e., *Sporobolus cryptandrus*, *Heliomeris multiflora*, *Ericameria nauseosa*, *Plantago patagonica*).
- (3) We highlight what has been accomplished, identify knowledge gaps, and discuss future options to bring useable science to land managers invested in restoring public lands on the Colorado Plateau.

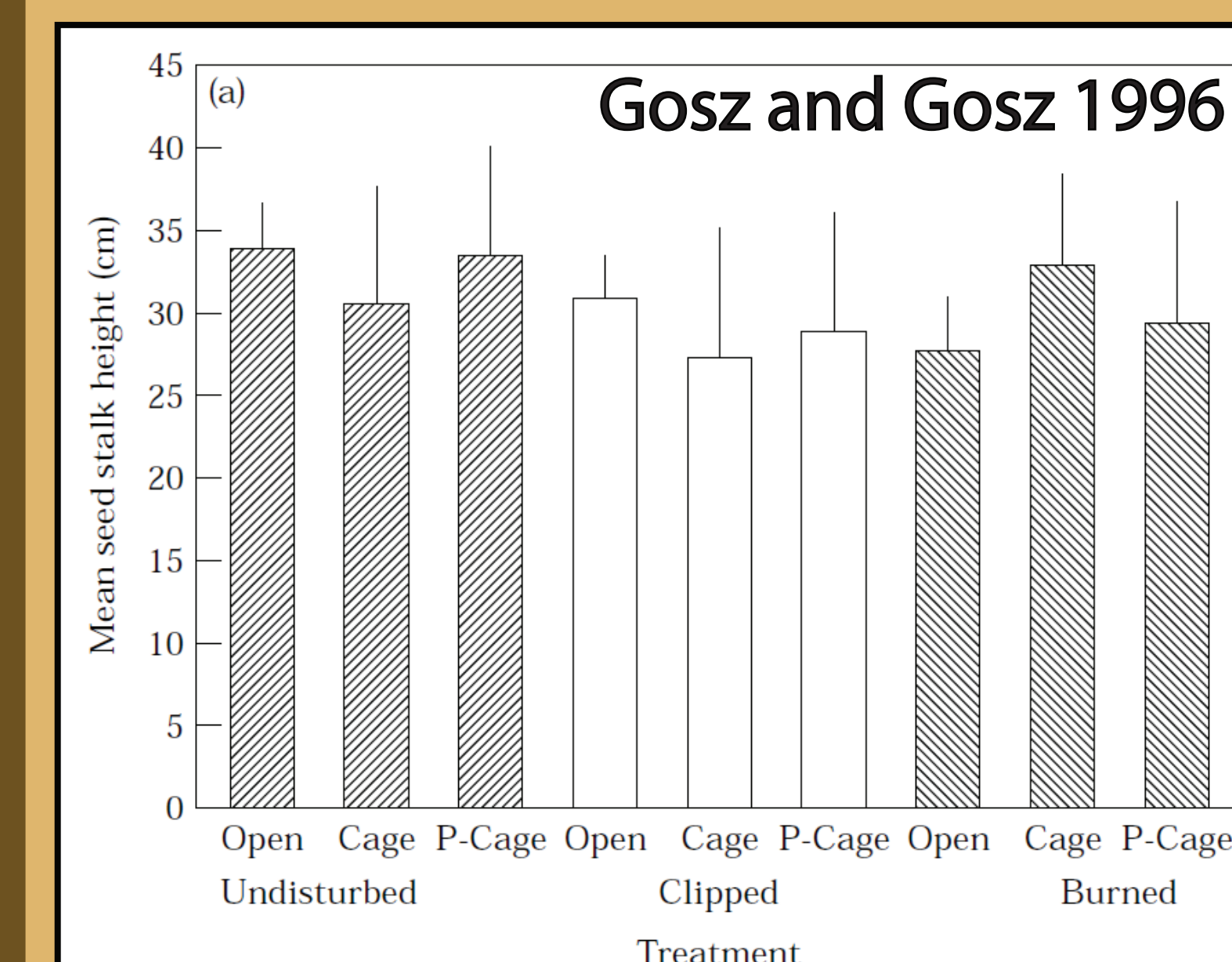
Case study

Bouteloua gracilis (blue grama):

- warm season grass
- high quality forage species for cattle
- used in soil erosion control
- common in mine reclamation
- common in sagebrush systems
- 50+ years of research in grasslands and deserts



Detling et al. 1979



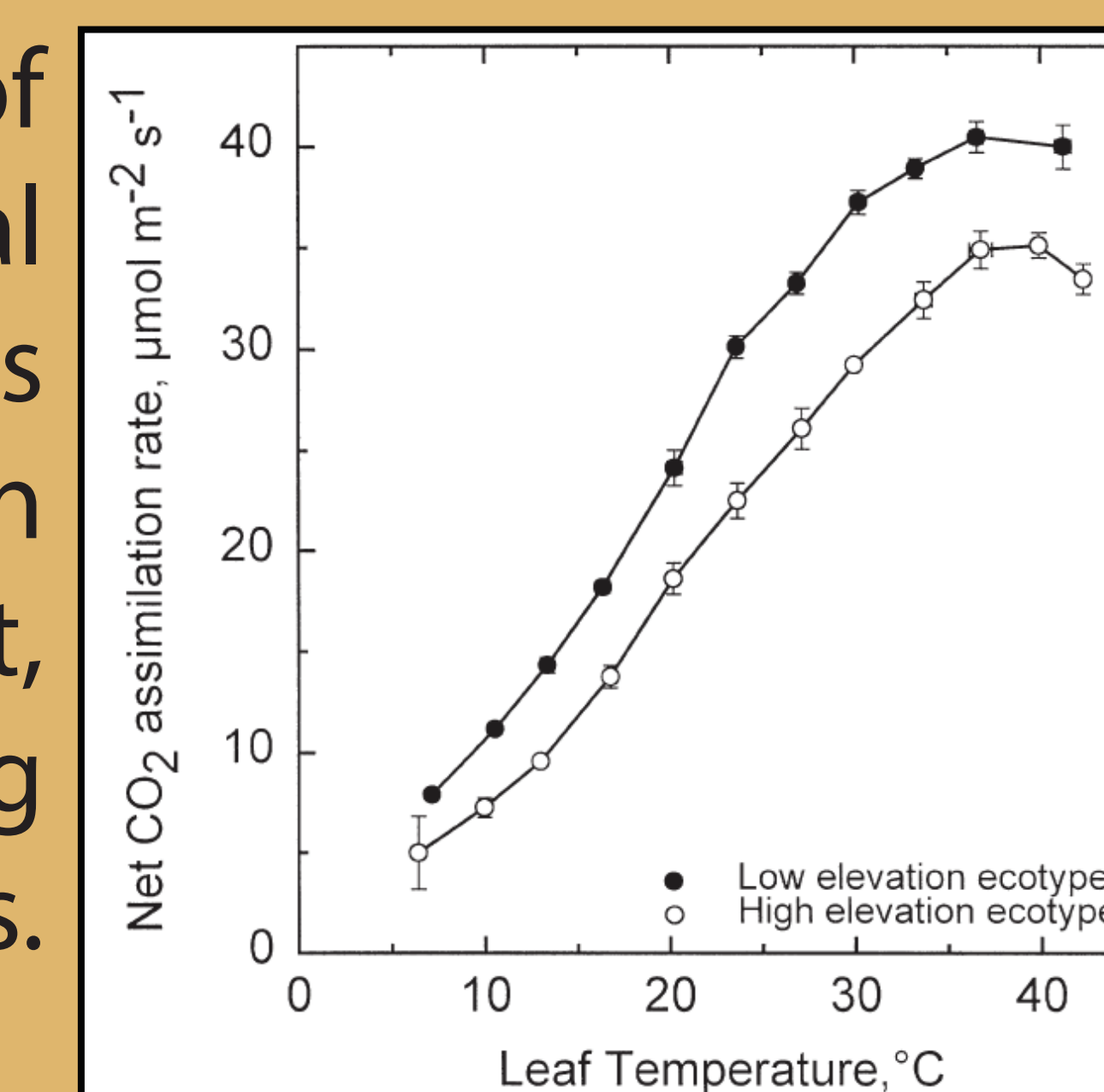
Resilience when *B. gracilis* is experimentally burned or clipped.

Resilience in response to herbivory in clipping experiment.

Experimental Evaluation

Trait heritability
Impacts on fitness
Seed transfer zones
Available seeds

Ecotypic variation of physiological performance is maintained in common garden environment, suggesting genetically-controlled traits.

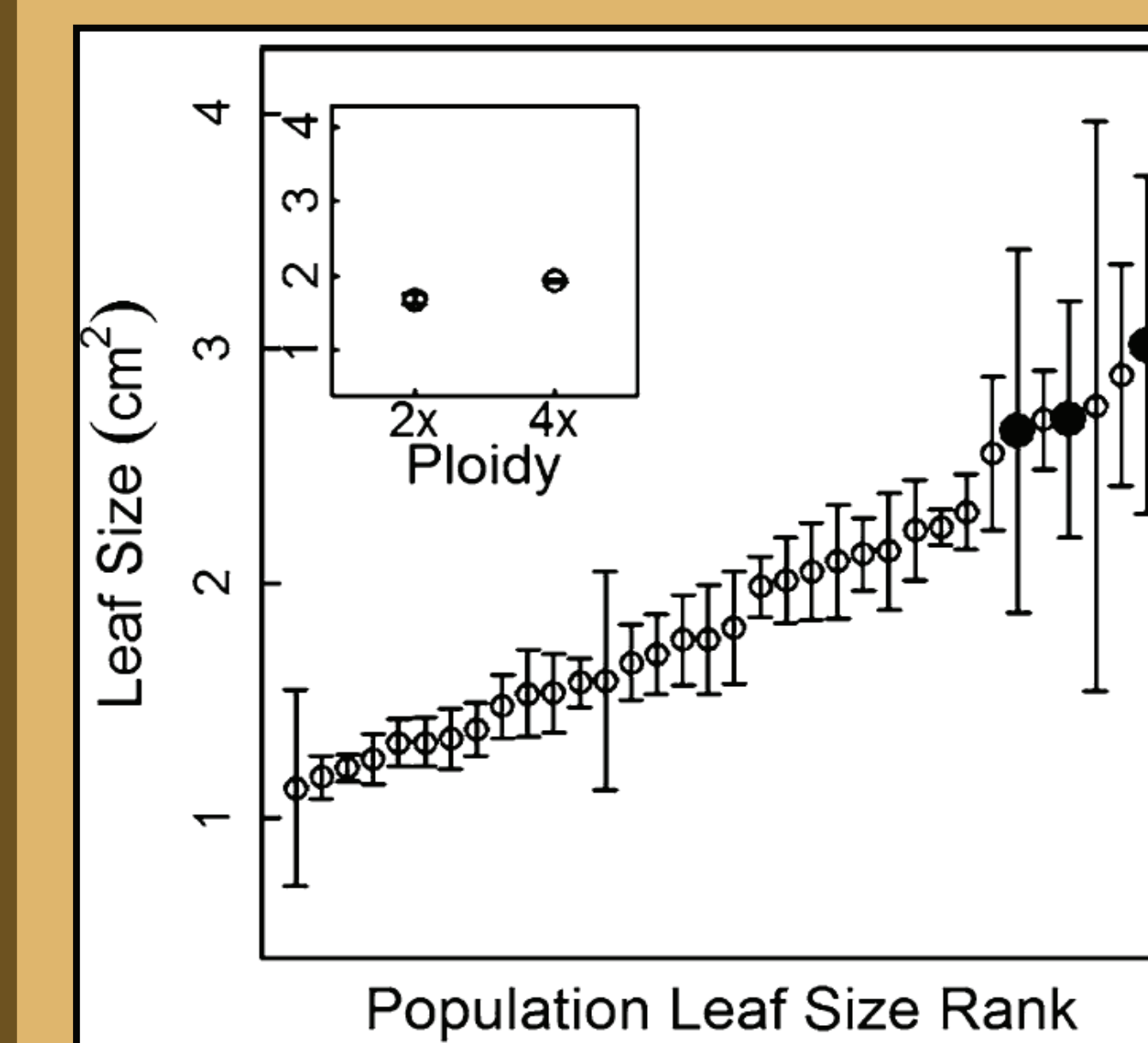


Pittermann and Sage 2000

	Time from seeding (days)								
	82	84	87†	89	91	94	98	114	354
Neighbours present									
no opening (centre)	15	13	6	6	6	6	6	5	5
no opening (interspace)	15	15	9	9	9	9	9	7	6
10-cm-diameter opening	15	13	9	8	8	8	8	6	5
20-cm-diameter opening	15	15	10	10	10	10	10	10	9
30-cm-diameter opening	15	15	14	14	14	14	14	14	13
Neighbours excluded*	15	15	15	15	15	15	15	15	15
Maximum temperature (°C)	35	38	33	33	34	32	37		
Precipitation (mm)	0	0	9	0	6-6	4-1	0-5		

Aguilera and Laurenroth 1993

Belowground competition for resources shows spatial placement limits establishment.



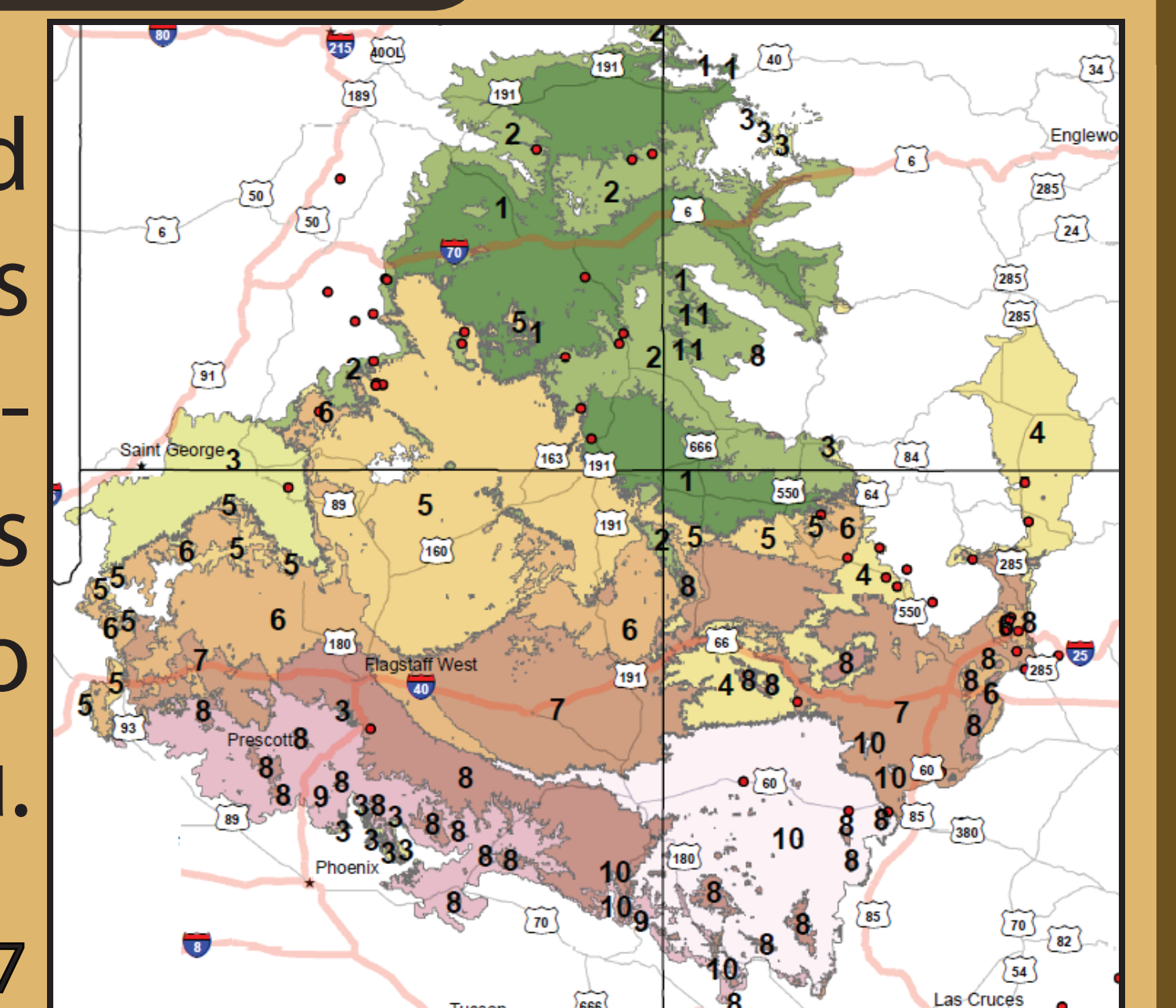
Butterfield and Wood 2015

Trait variation assessed across wild populations, cultivars, and ploidy levels. Traits align with climate.

Landscape Assessment

Genotypes match climate
Population differentiation
Trait variability

Climate zones defined and Seeds of Success collections obtained to capture genetic variation across populations on the Colorado Plateau.



CPNPP map modified from Doherty et al. 2017

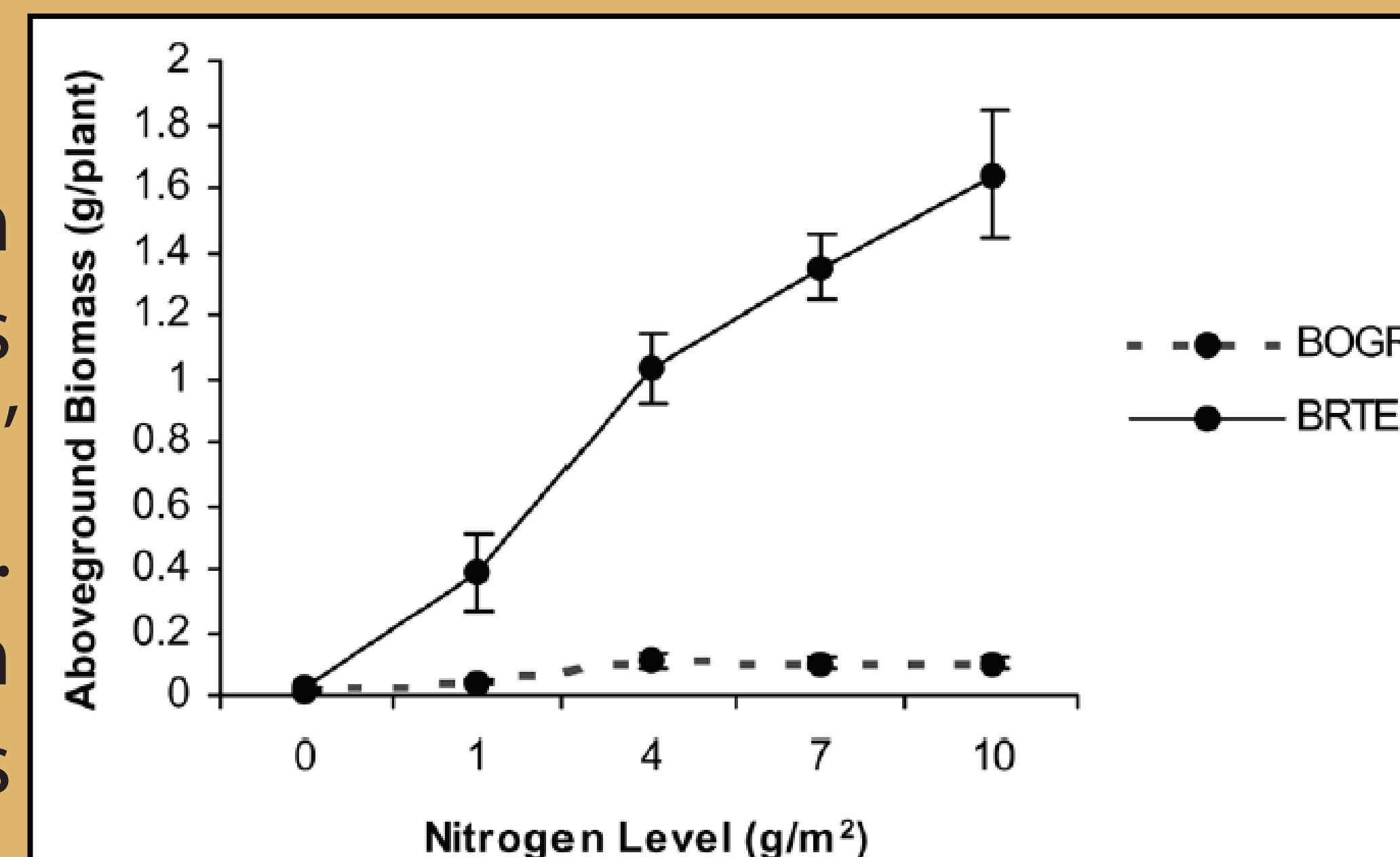
Unknowns & future directions

- How have *B. gracilis* populations performed in previous restoration projects?
- High performing cultivars exist: "Blonde ambition", "Hachita", "Bad River", "Lovington", "Alma"
...but are they always suitable?
- How do cultivars perform alongside natives in common environments?
- How do wild populations perform in multi-generational grow-outs?



Lowe et al. 2003

Competition with invasives limits *B. gracilis* performance. Low nitrogen status reduces competitive advantage of invasives, suggesting soils are key.



Operational Outcomes

Restoration success
Testing grow-outs
Increasing seed