Restoration successional trajectories, seed zones, and seed production

Francis Kilkenny

USDA FS Rocky Mountain Research Station, Boise, ID

The Great Basin and the sagebrush steppe

Great Basin Native Plant Project (GBNPP)

www.greatbasinnpp.org

Native plant material restoration cycle

Native Seed Collection

Evaluation and Development

Initial Seed Increase

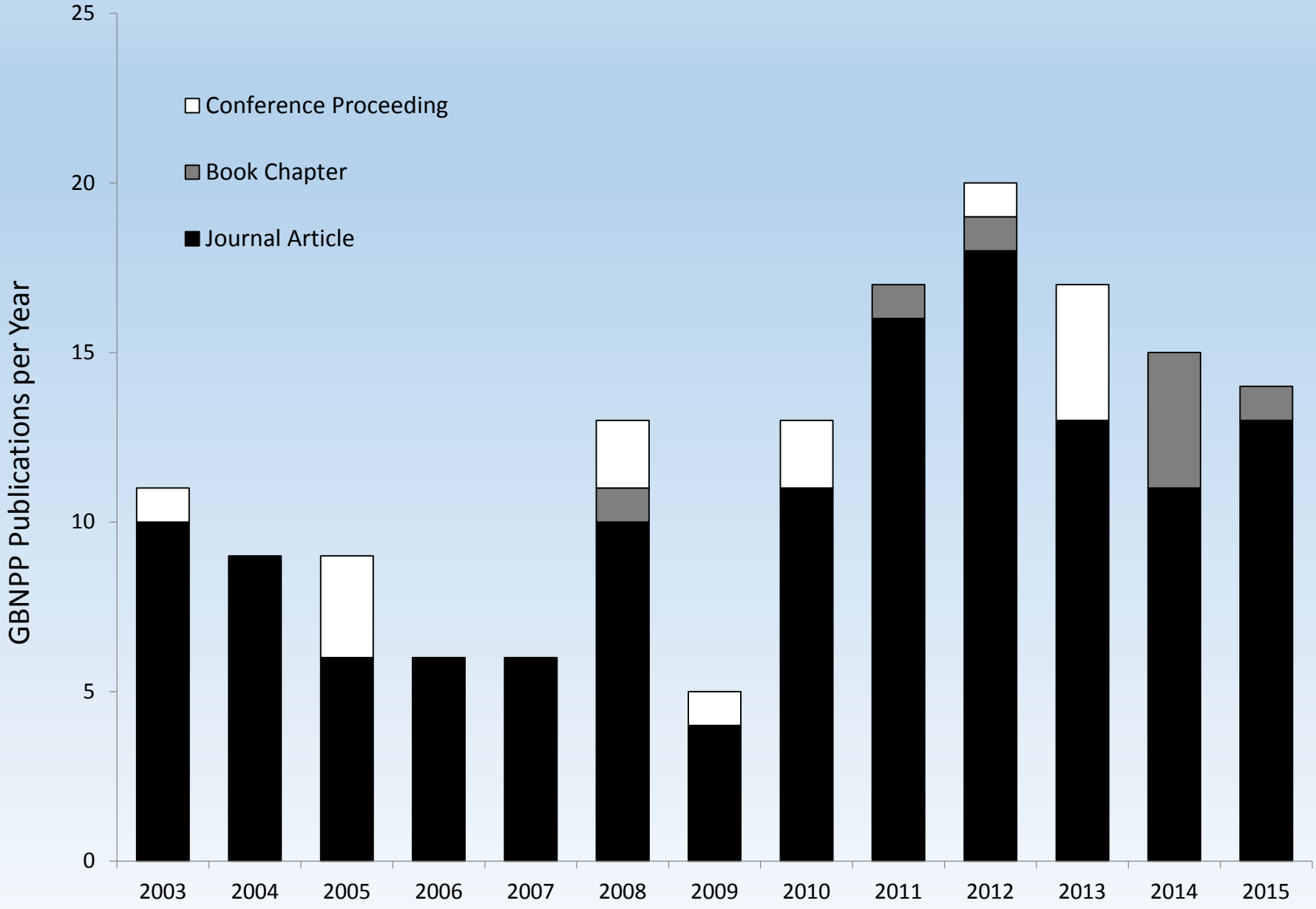
Seed Production

Seed Storage

Restore Native Plant Communities

-Ecological diversity
-Functional diversity
-Genetic diversity

Great Basin Native Plant Project Publications



Genus	Taxa	Type	Genus	Taxa	Type
Achillea L. Asteraceae	2	F	*Heterotheca* Cass. Asteraceae	1	F
Achnatherum P. Beauv. Poaceae	4	G	*Iliamna* Greene Malvaceae	1	F
Agastache Clayton ex Gronov. Lamiaceae	1	F	*Ipomopsis* Michx. Polemoniaceae	2	F
Agoseris Raf. Asteraceae	4	F	*Koeleria* Pers. Poaceae	1	G
Allium L. Liliaceae	1	F	*Krascheninnikovia* Guldenstaedt Chenopodiaceae	1	S
***Amsinckia* Lehm. Boraginaceae**	3	F	***Lappula* Moench Boraginaceae**	1	F
Aquilegia L. Ranunculaceae	1	F	*Lathyrus* L. Fabaceae	1	F
Arenaria L. Caryophyllaceae	1	F	*Lepidium* L. Brassicaceae	1	F
***Argemone* L. Papaveraceae**	1	F	*Leymus* Hochst. Poaceae	3	G
Aristida L. Poaceae	1	G	*Ligusticum* L. Apiaceae	2	F
Artemisia L. Asteraceae	13	S	*Linum* L. Linaceae	5	F
Astragalus L. Fabaceae	5	F	*Lomatium* Raf. Apiaceae	12	F
Atriplex L. Chenopodiaceae	3	S	*Lotus* L. Fabaceae	1	F
Balsamorhiza Nutt. Asteraceae	3	F	***Lupinus* L. Fabaceae**	8	F
***Blepharipappus* Hook. Asteraceae**	1	F	*Machaeranthera* Nees Asteraceae	1	F
Bromus L. Poaceae	2	G	***Mentzelia* L. Loasaceae**	3	F
Castilleja Mutis ex L.f. Scrophulariaceae	1	F	***Microsteris gracilis* (Hook) Greene Polemoniaceae**	1	F
Chaenactis D.C. Asteraceae	3	F	*Muhlenbergia* Schreb. Poaceae	1	G
Chamerion Raf. ex Holub Onagraceae	1	F	***Nemophila* Nutt. Hydrophyllaceae**	1	F
Chenopodium L. Chenopodiaceae	1	F	***Nicotiana* L. Solanaceae**	1	F
Chrysothamnus Nutt. Asteraceae	3	S	*Oenothera* L. Onagraceae	1	F
***Clarkia* Pursh Onagraceae**	1	F	*Packera* Á. Löve & D. Löve Asteraceae	1	F
Cleome L. Capparaceae	2	F	*Pascopyrum* Á. Löve Poaceae	1	G
***Collinsia* Nutt. Scrophulariaceae**	2	F	*Penstemon* Schmidel Scrophulariaceae[2]	26	F
Crepis L. Asteraceae	3	F	*Perideridia* Rchb. Apiaceae	1	F
***Cryptantha* Lehm. ex G. Don Boraginaceae**	2	F	***Phacelia* Juss. Hydrophyllaceae**	7	F
Cymopterus Raf. Apiaceae	2	F	*Phlox* L. Polemoniaceae	1	F
Dalea L. Fabaceae	3	F	***Plagiobothrys* Fisch. & C.A. Mey. Boraginaceae**	1	F
Delphinium L. Ranunculaceae	2	F	*Poa* L. Poaceae	2	G
Descurainia Webb & Bethel. Brassicaceae	1	F	*Potentilla* L. Rosaceae	2	F
Elymus L. Poaceae	8	G	*Pseudoroegneria* (Nevski) Á. Löve Poaceae	1	G
Enceliopsis (A. Gray) A. Nelson Asteraceae	1	F	*Psoralidium* Rydb. Fabaceae	1	F
Epilobium L. Onagraceae	1	F	*Purshia* DC. ex Poir. Rosaceae	4	S
***Eriastrum* Wooton & Standl. Polemoniaceae**	1	F	*Rudbeckia* L. Asteraceae	1	F
Ericameria Nutt. Asteraceae	1	F	*Scrophularia* L. Scrophulariaceae[2]	1	F
Erigeron L. Asteraceae	3	F	*Shepherdia* Nutt. Elaeagnaceae	2	S
***Eriogonum* Michx. Polygonaceae**	9	F	*Sphaeralcea* A. St.-Hil. Malvaceae	5	F
***Eriophyllum* Lag. Asteraceae**	1	F	*Sporobolus* R. Br. Poaceae	1	G
Festuca L. Poaceae	1	G	*Stanleya* Nutt. Brassicaceae	2	F
Frasera Walter Gentianaceae	1	F	*Stenotus* Nutt. Asteraceae	1	F
Gaillardia Foug. Asteraceae	1	F	*Thelypodium* Endl. Brassicaceae	1	F
***Gilia* Ruiz & Pav. Polemoniaceae**	2	F	***Townsendia* Hook. Asteraceae**	1	F
Grayia Hook. & Arn. Chenopodiaceae	1	F	*Veratrum* L. Liliaceae	1	F
Hedysarum L. Fabaceae	2	F	*Vicia* L. Fabaceae	1	F
Helianthella Nutt. Asteraceae	3	F	*Vulpia* C.C. Gmel. Poaceae	1	G
Hesperostipa (Elias) Barkworth Poaceae	1	G	*Wyethia* Nutt. Asteraceae	1	F

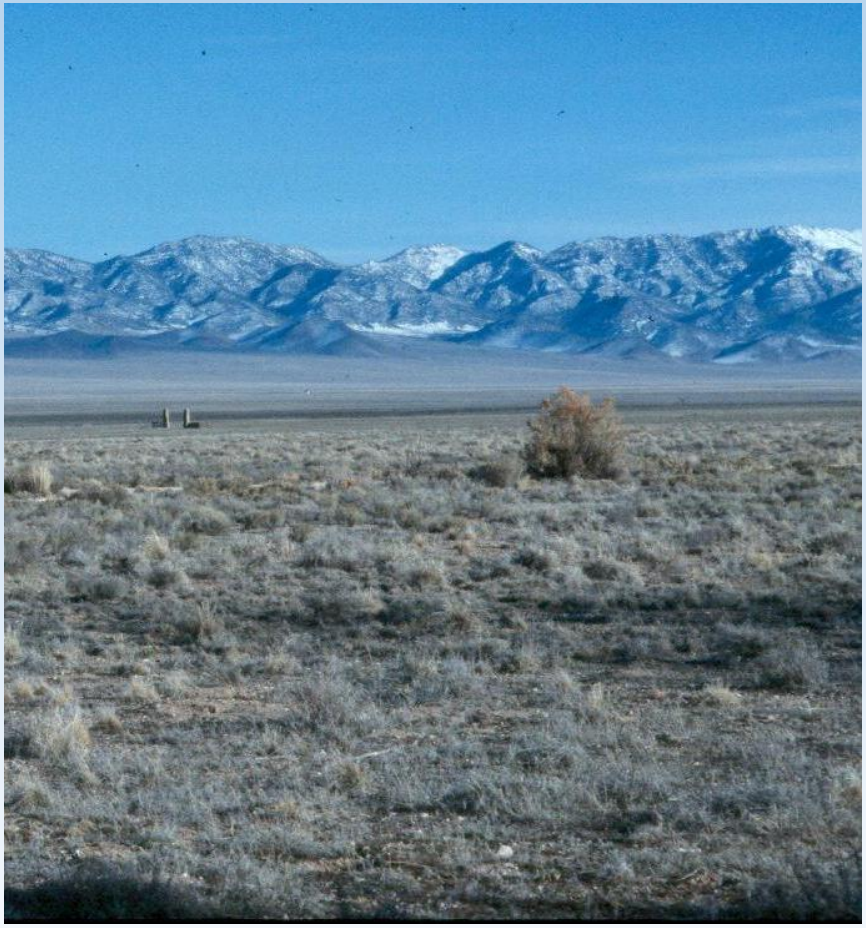
2001-2014, the **Great Basin Native Plant Project** evaluated:

- 92 genera of native plant
- 225 taxa
- 80% are forbs

The Great Basin

Total Area: 550,000 km^2

Public Lands: 410,000 km^2

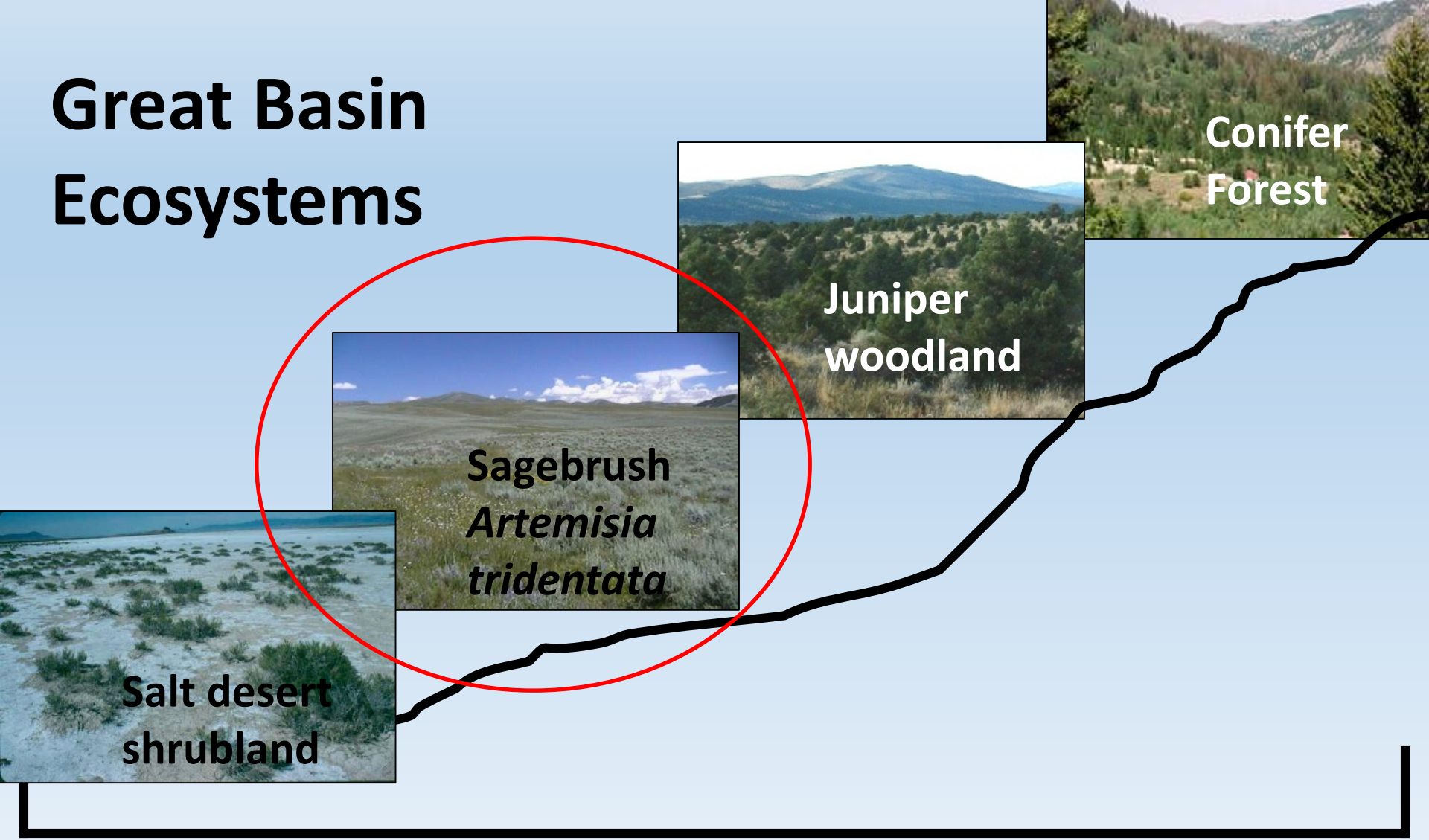


Great Basin Ecosystems

50 mm — Annual Precipitation — 600 mm

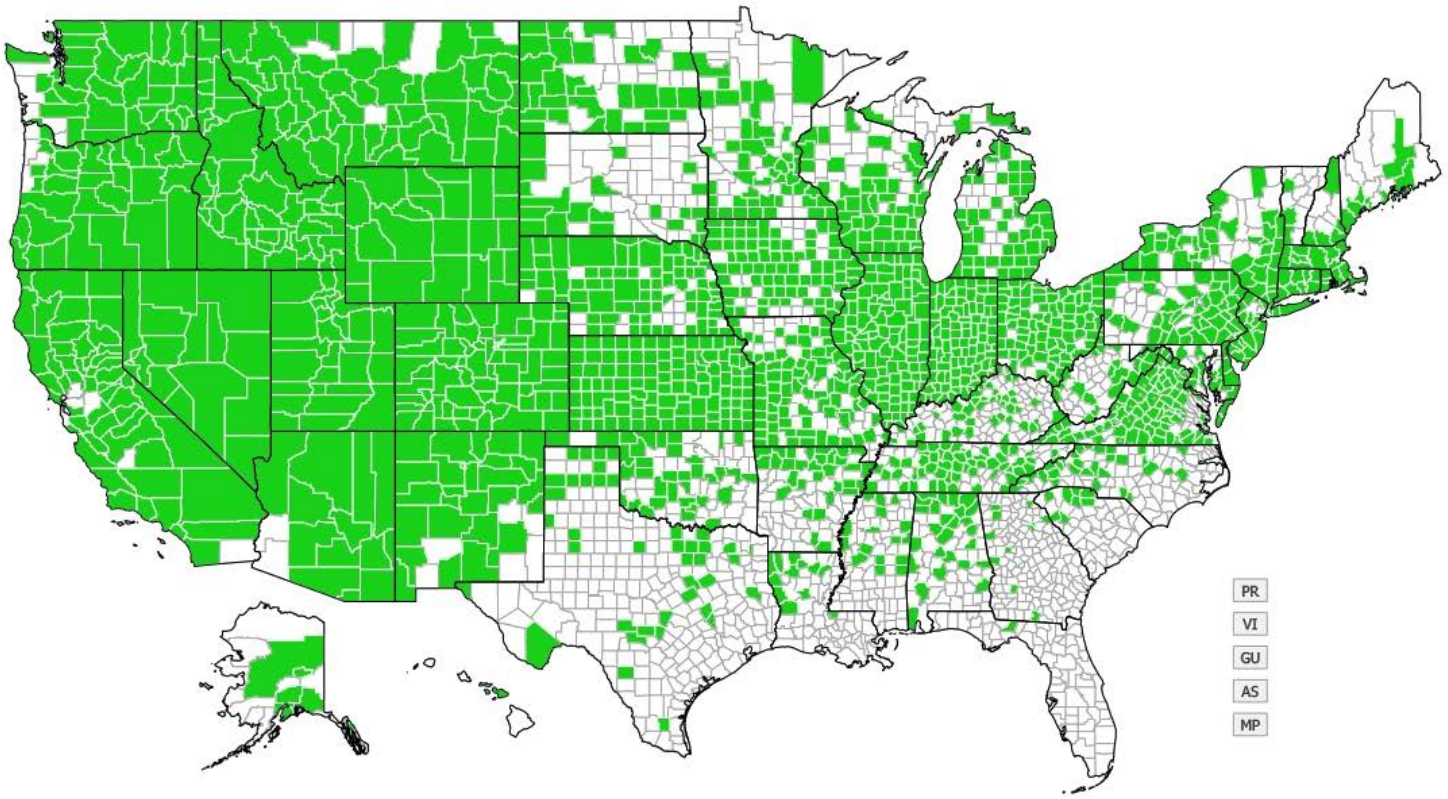
750 m — Elevation — 4000 m

Great Basin Ecosystems



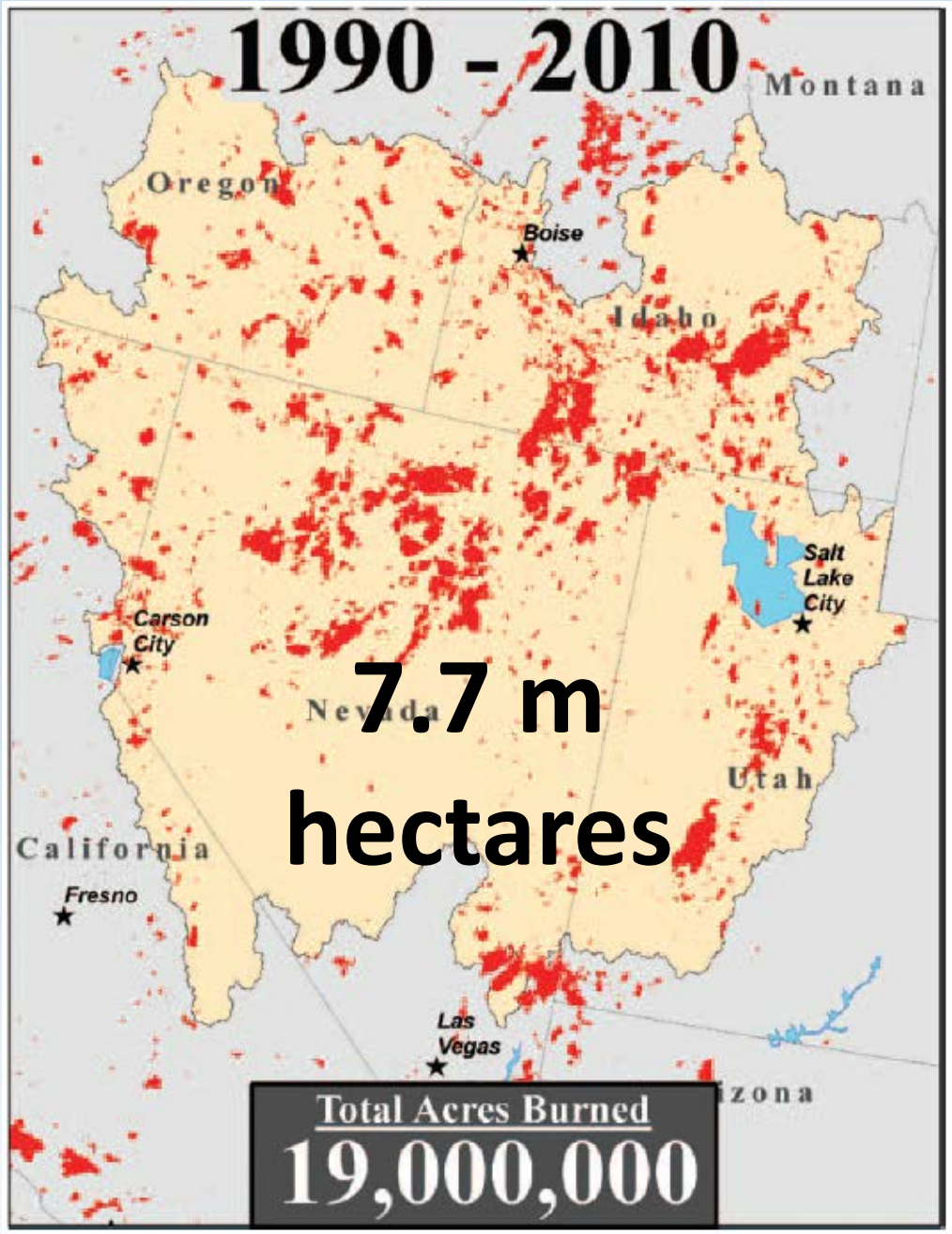
50 mm — Annual Precipitation — 600 mm

750 m — Elevation — 4000 m



Invasive and non-native species
Cheatgrass!

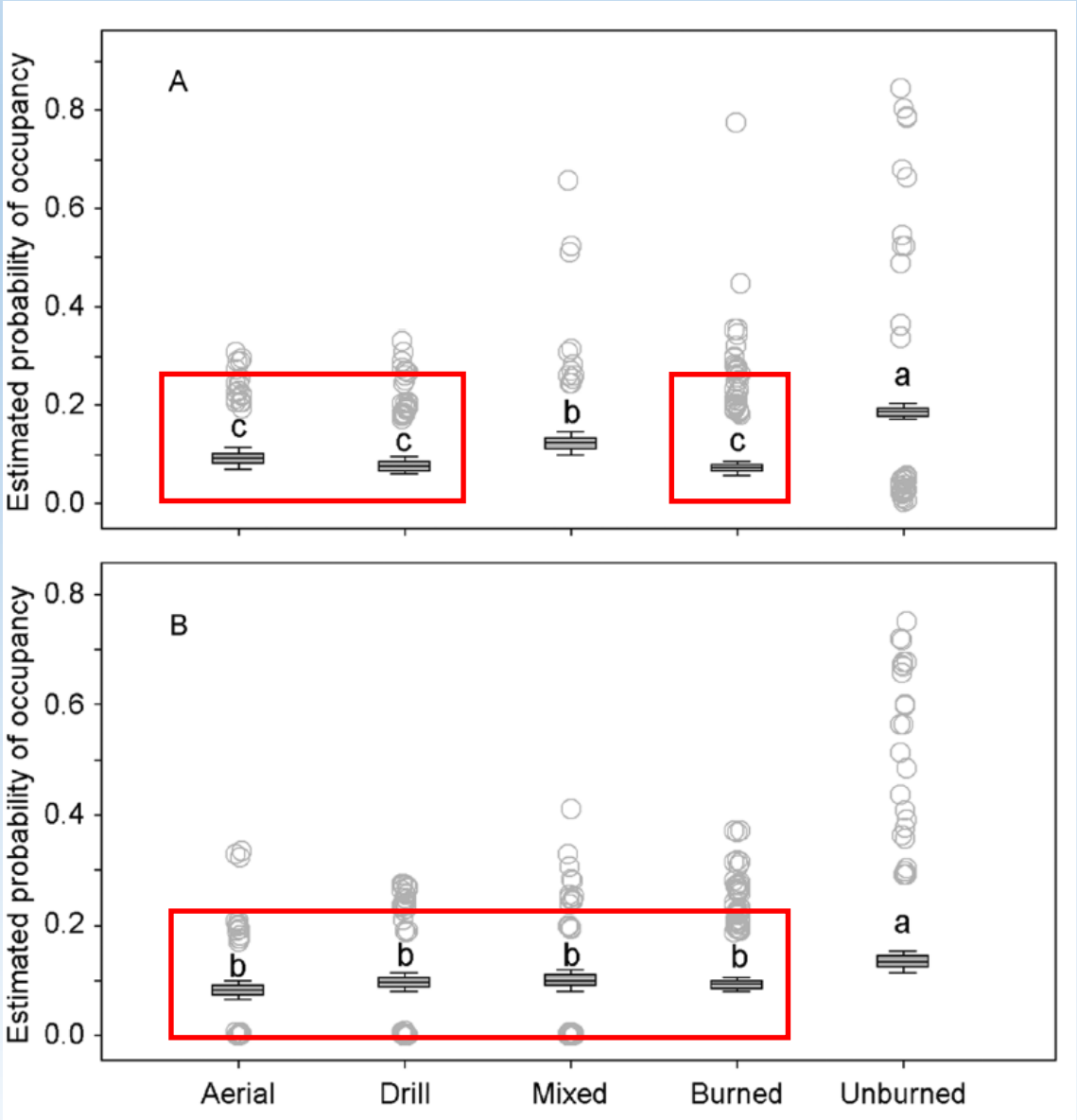
Photo by: Famartin



7.7 m hectares

Shaw *et al.* 2012, Rangelands

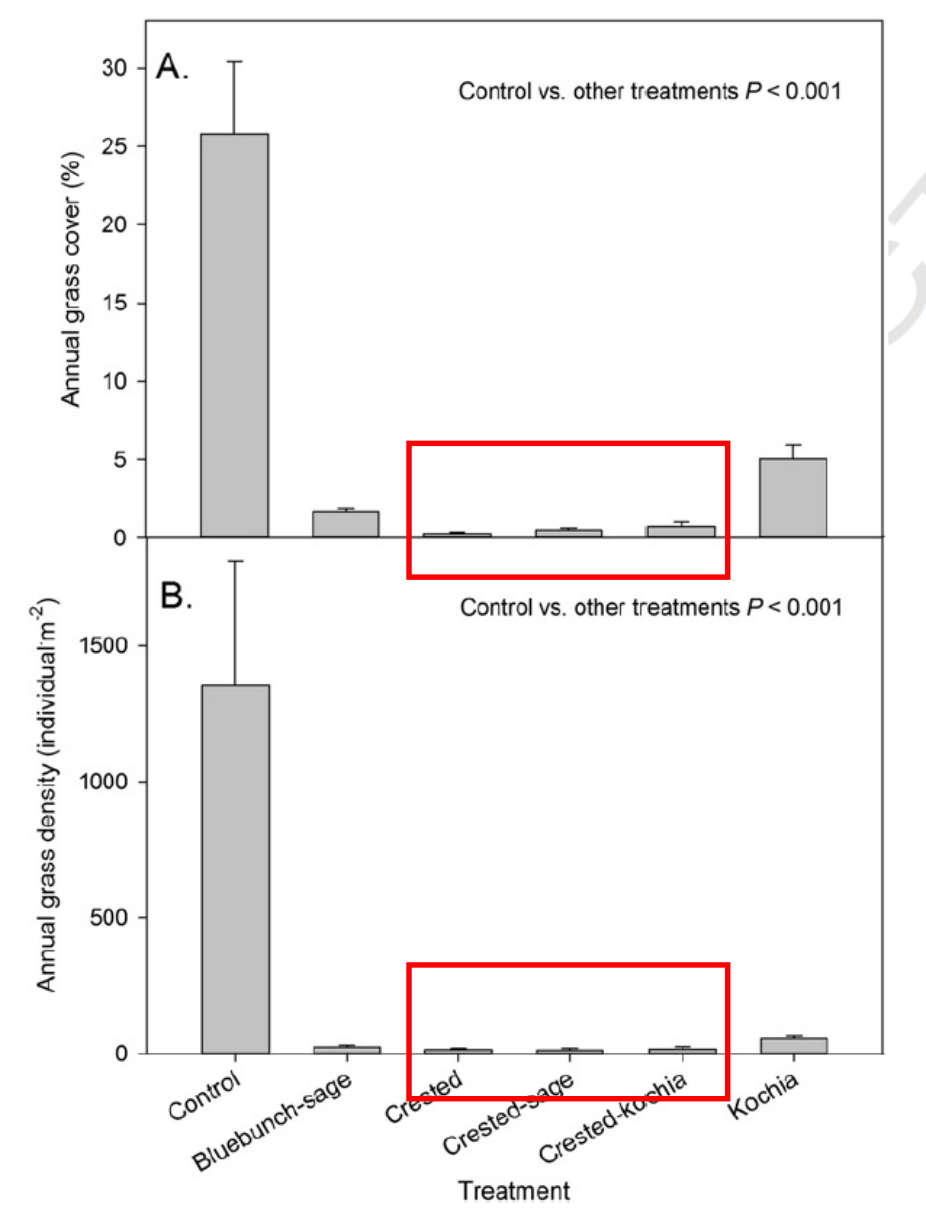
Habitat restoration is lagging



Arkle et al. 2014, Ecosphere

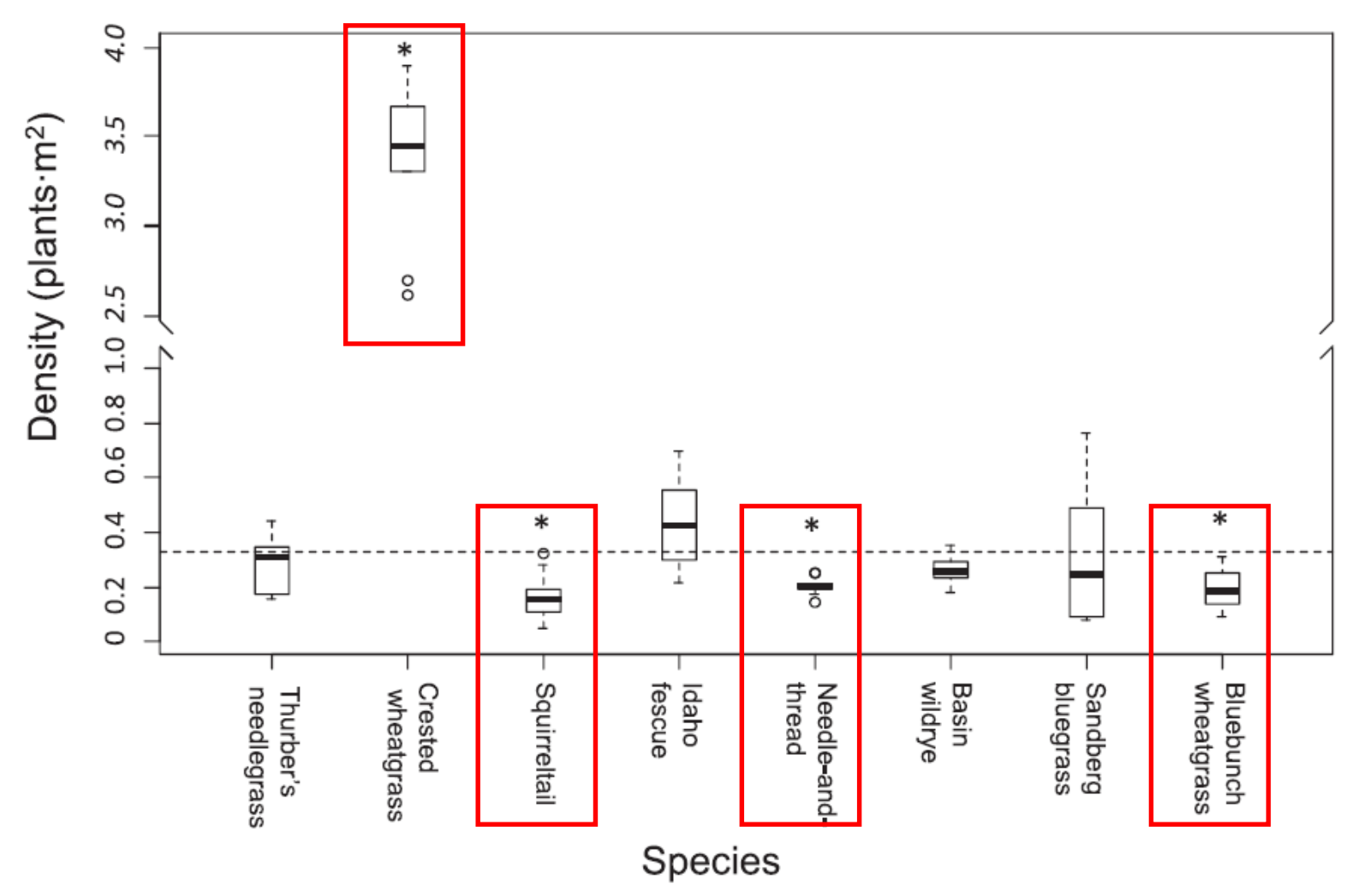
Successional trajectories in restoration

Introduced perennial bunchgrasses suppresses annual exotics…



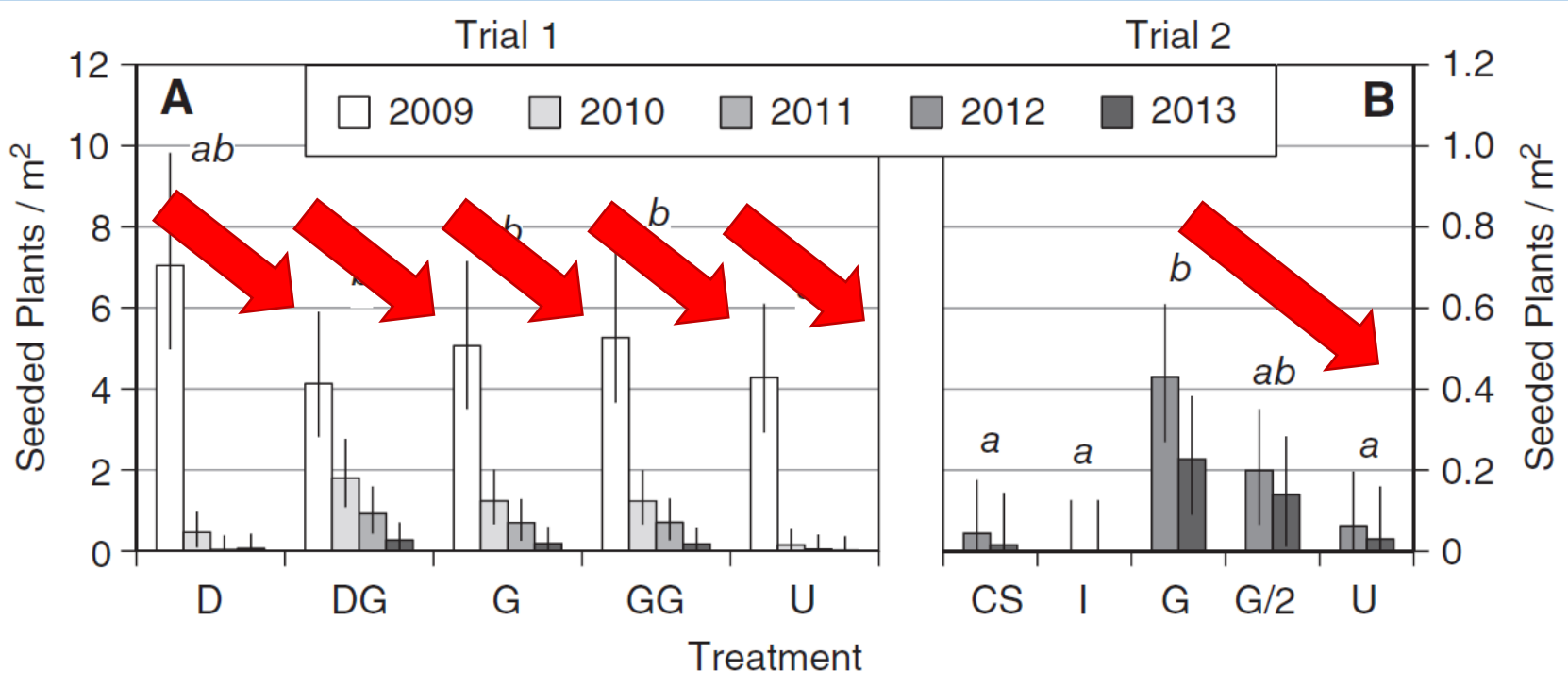
Davies et al. 2017, Rangeland Ecology and Management

…But introduced perennial bunchgrasses can suppress desirable native grasses…



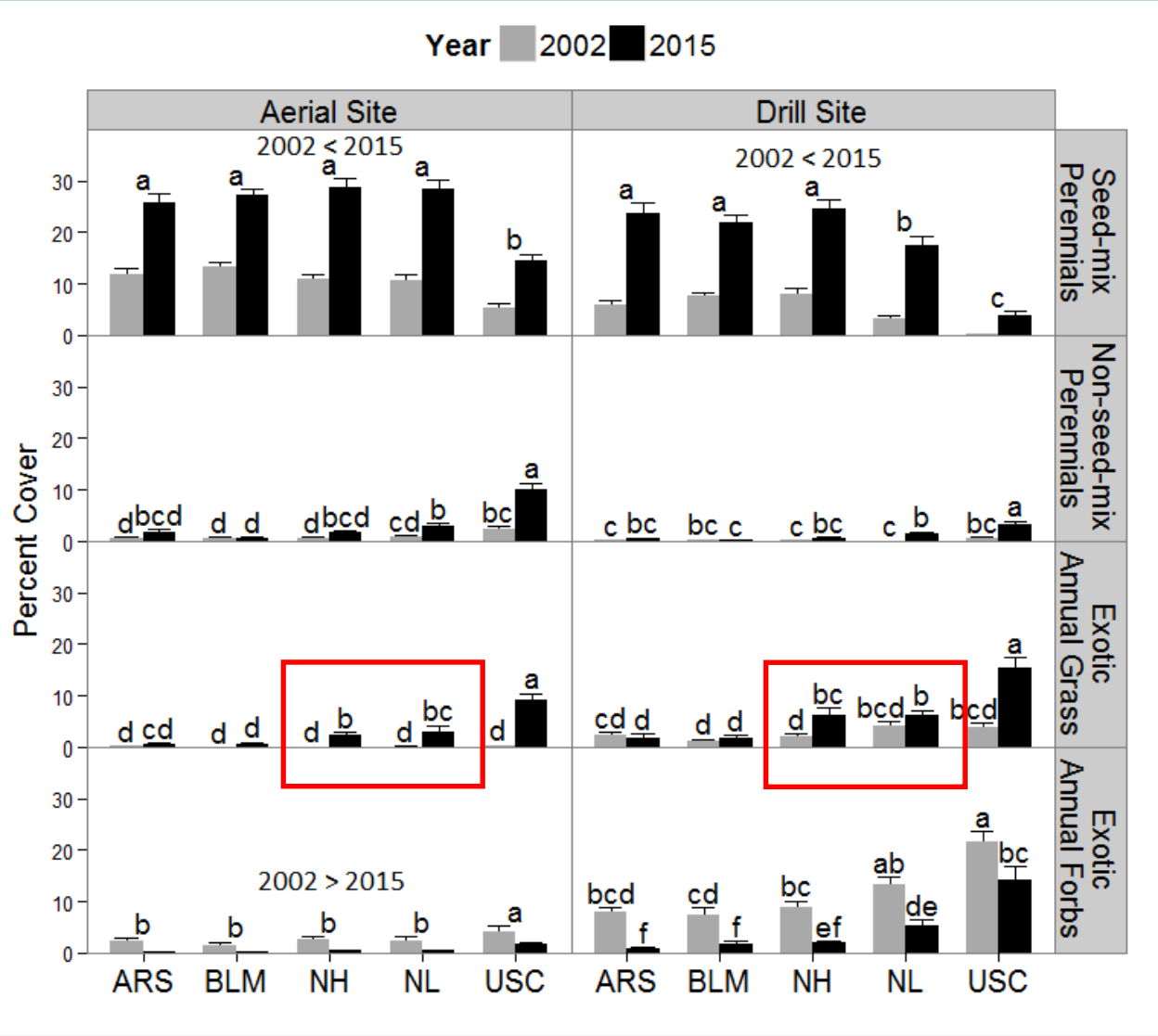
Nafus et al. 2015, Rangeland Ecology and Management

…And introduced perennial bunchgrass stands are hard to diversify after the fact…



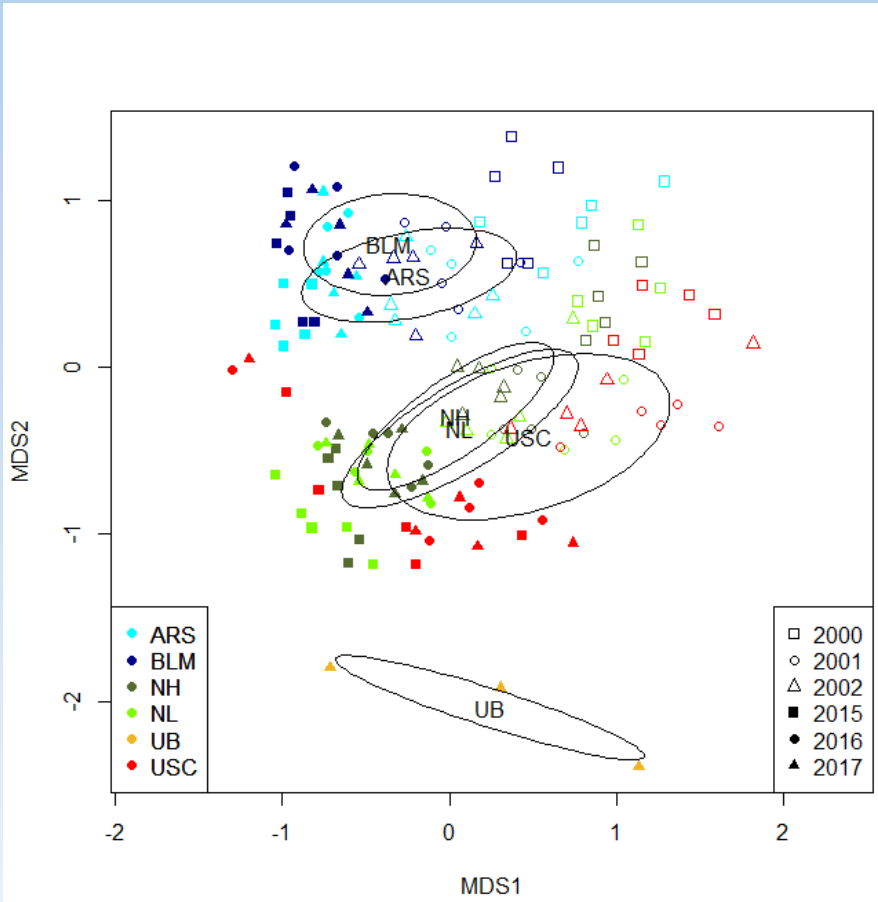
McAdoo et al. 2017, Restoration Ecology

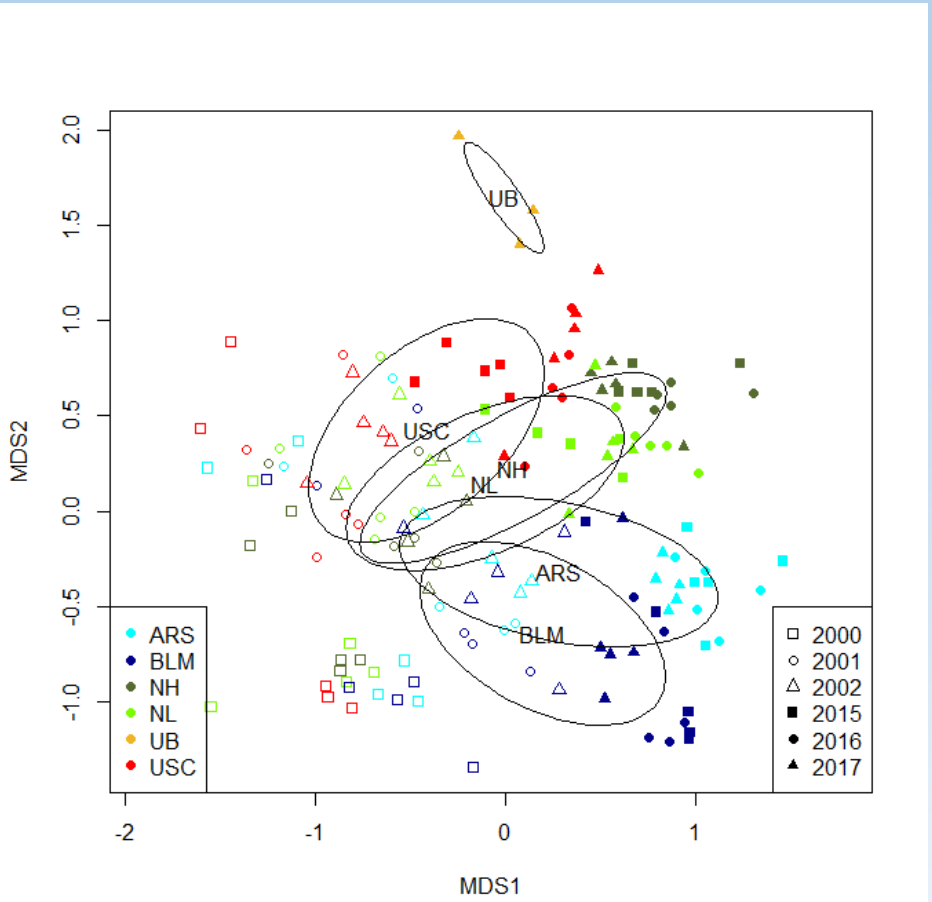
…But native perennials can also suppress annual exotic grasses…



Ott et al., in review for Rangeland Ecology and Management

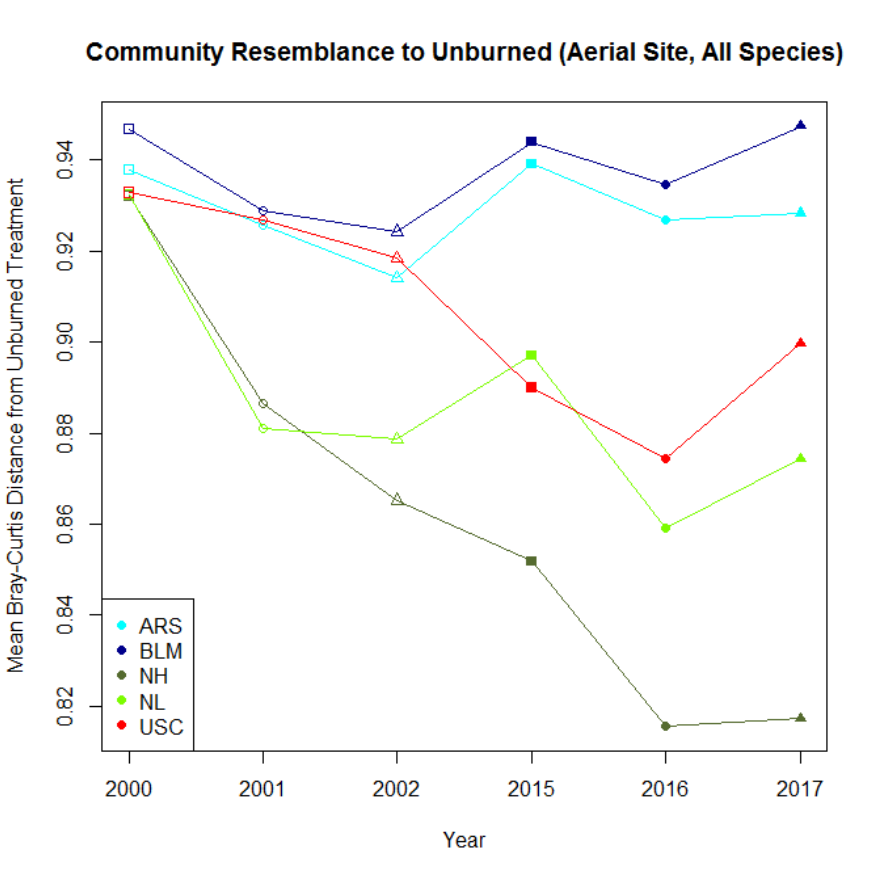
…And native seedings are more likely to approach desired habitat conditions…

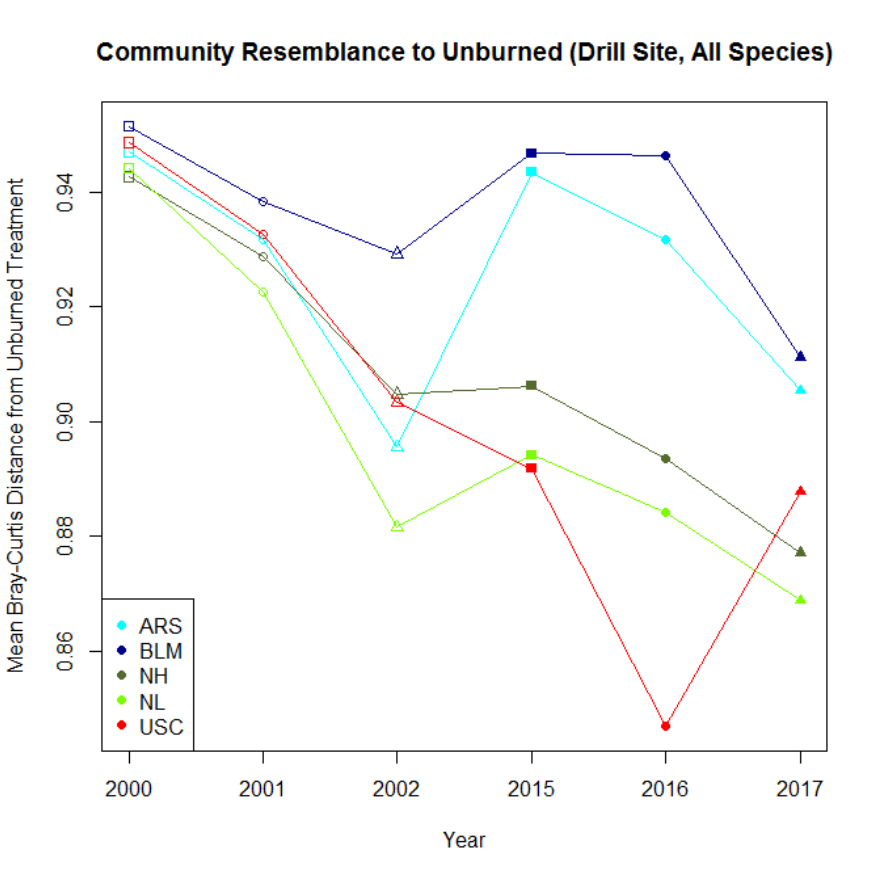




Ott and Kilkenny, unpublished data

…And native seedings are more likely to approach desired habitat conditions…

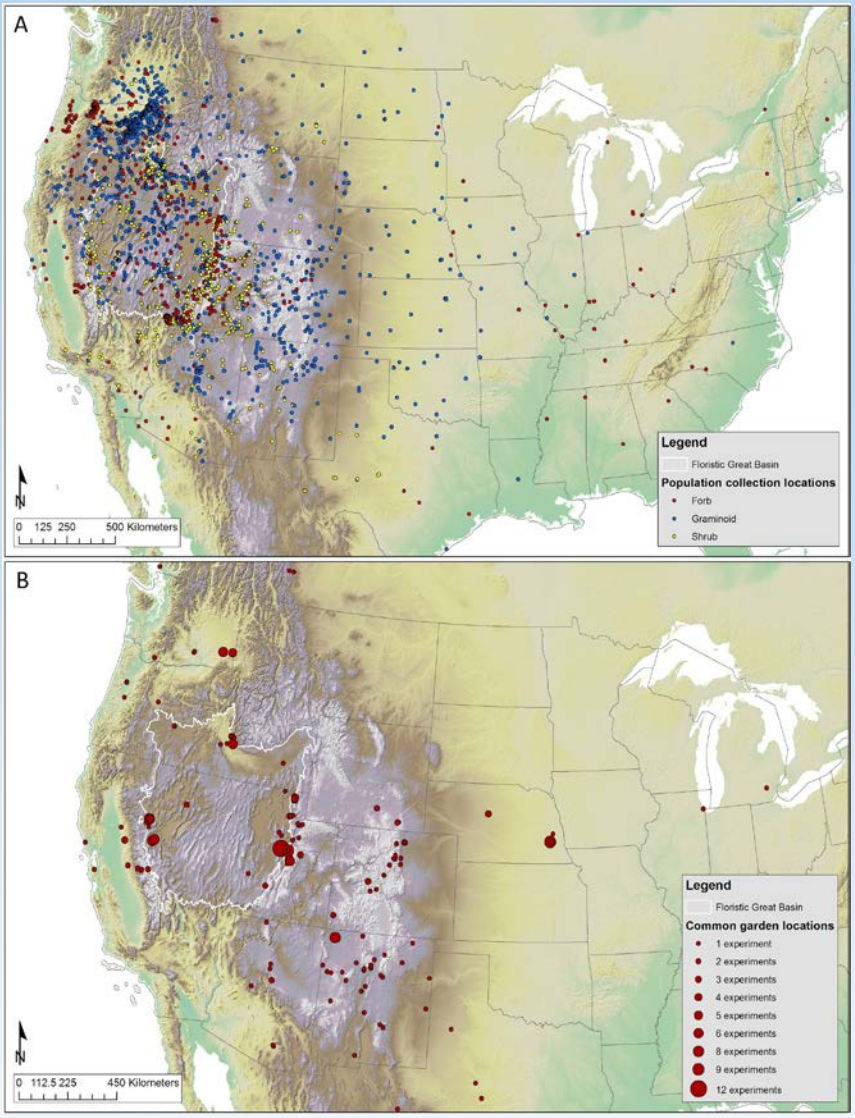


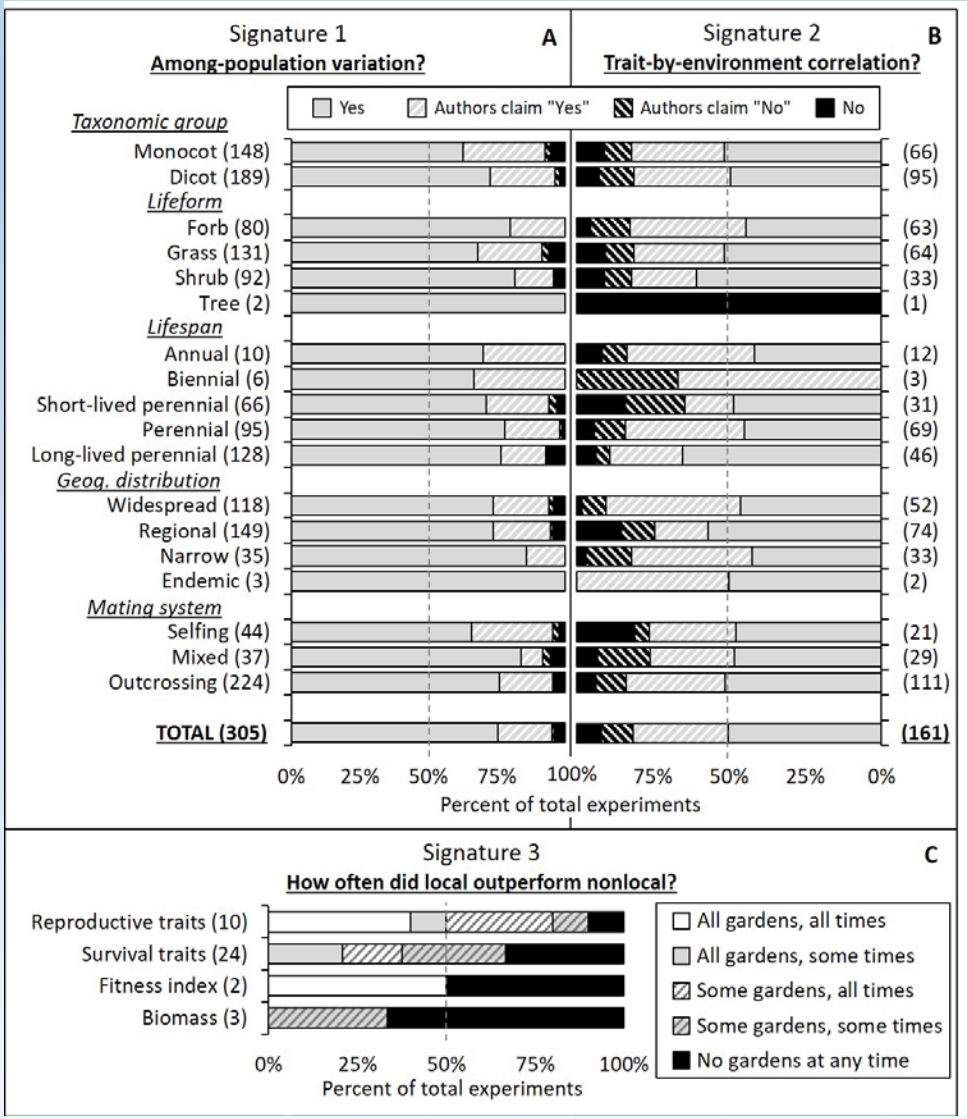


Ott and Kilkenny, unpublished data

Seed zones

Local adaptation is common in the Great Basin





Baughman et al., in review

Seed transfer guidelines

Species-specific

Generalized

Ecological niche modeling

Provisional

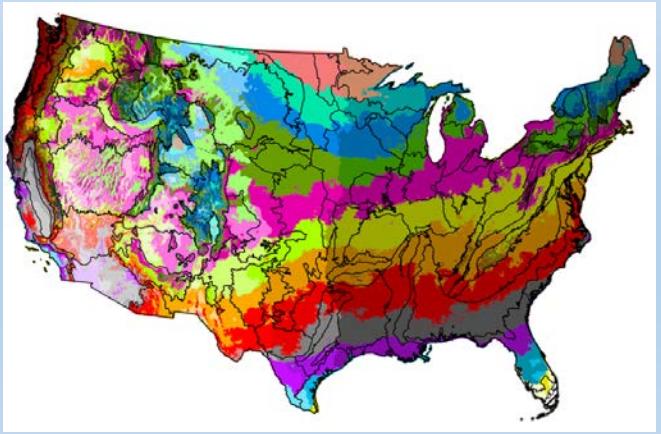
Empirical (genetic)

Quantitative variation

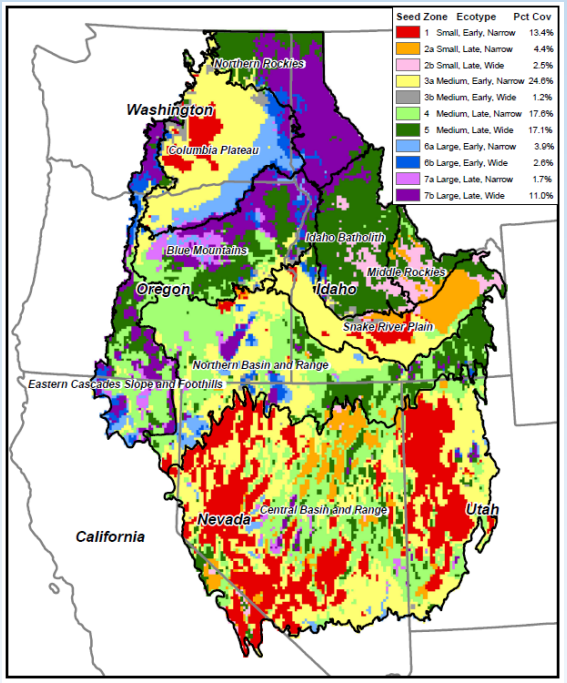
Neutral variation

Genecological/ provenance common garden

Reciprocal transplant



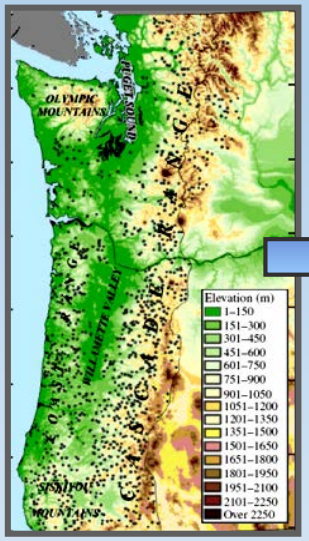
Bower et al. 2014. *Ecological Applications*, 24: 913–919



St. Clair et al. 2013. *Evolutionary Applications*, 6: 933–948

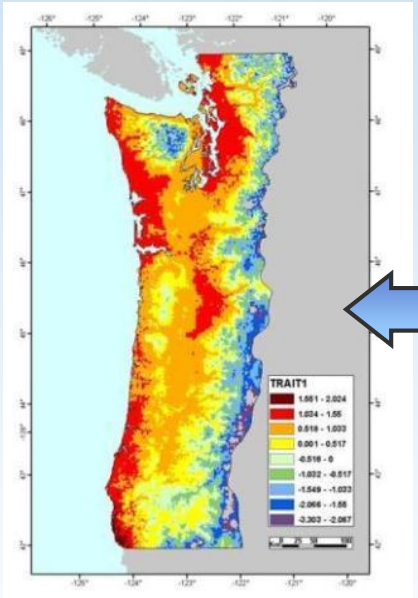
Empirical seed zones are constructed using data from common garden studies

Collect seed from many sources

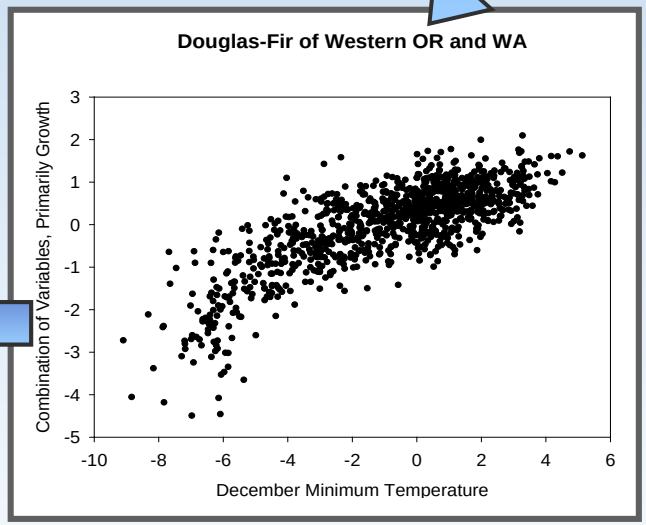


Grow families in a common environment

Measure many adaptive traits

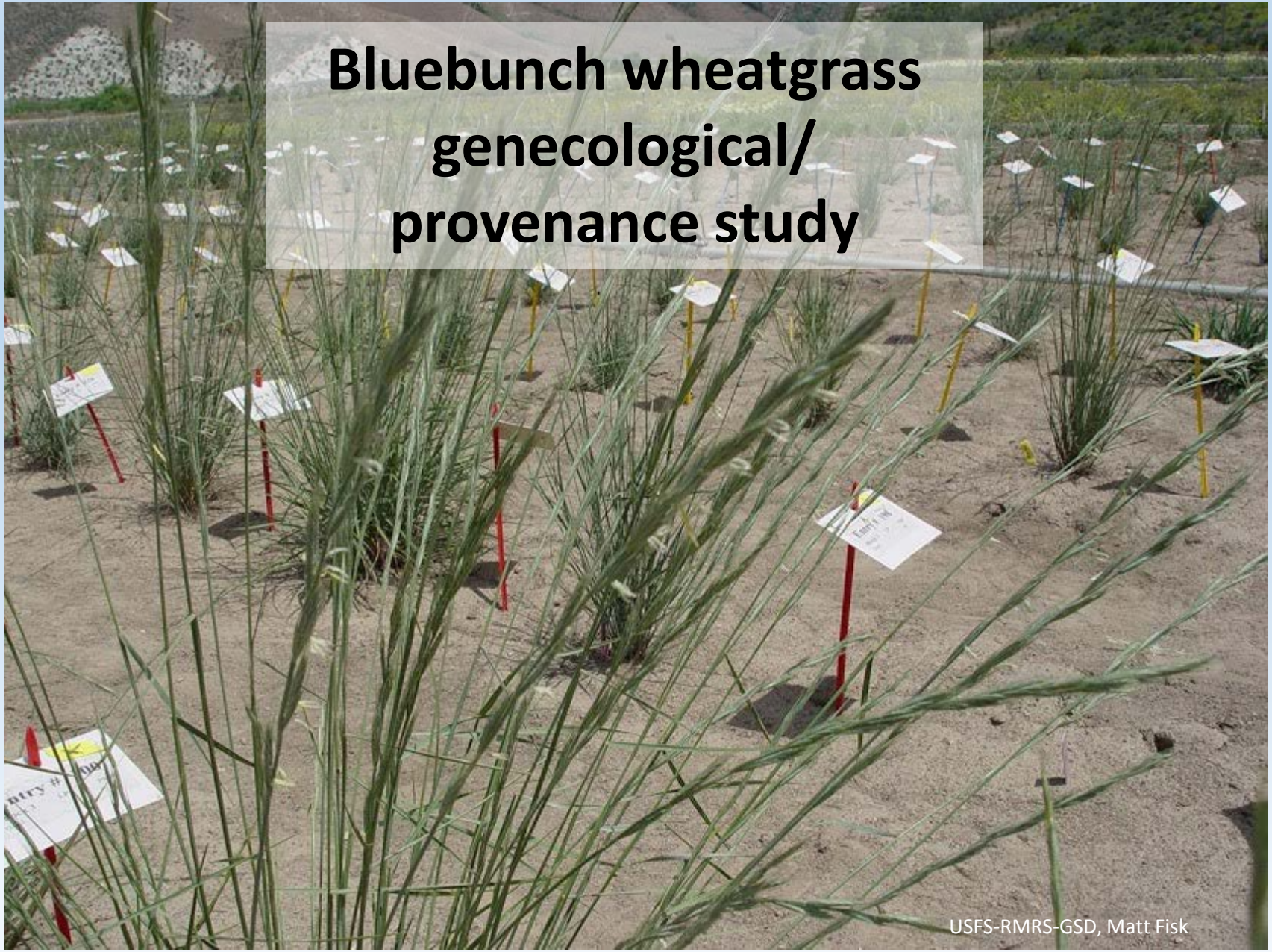


GIS

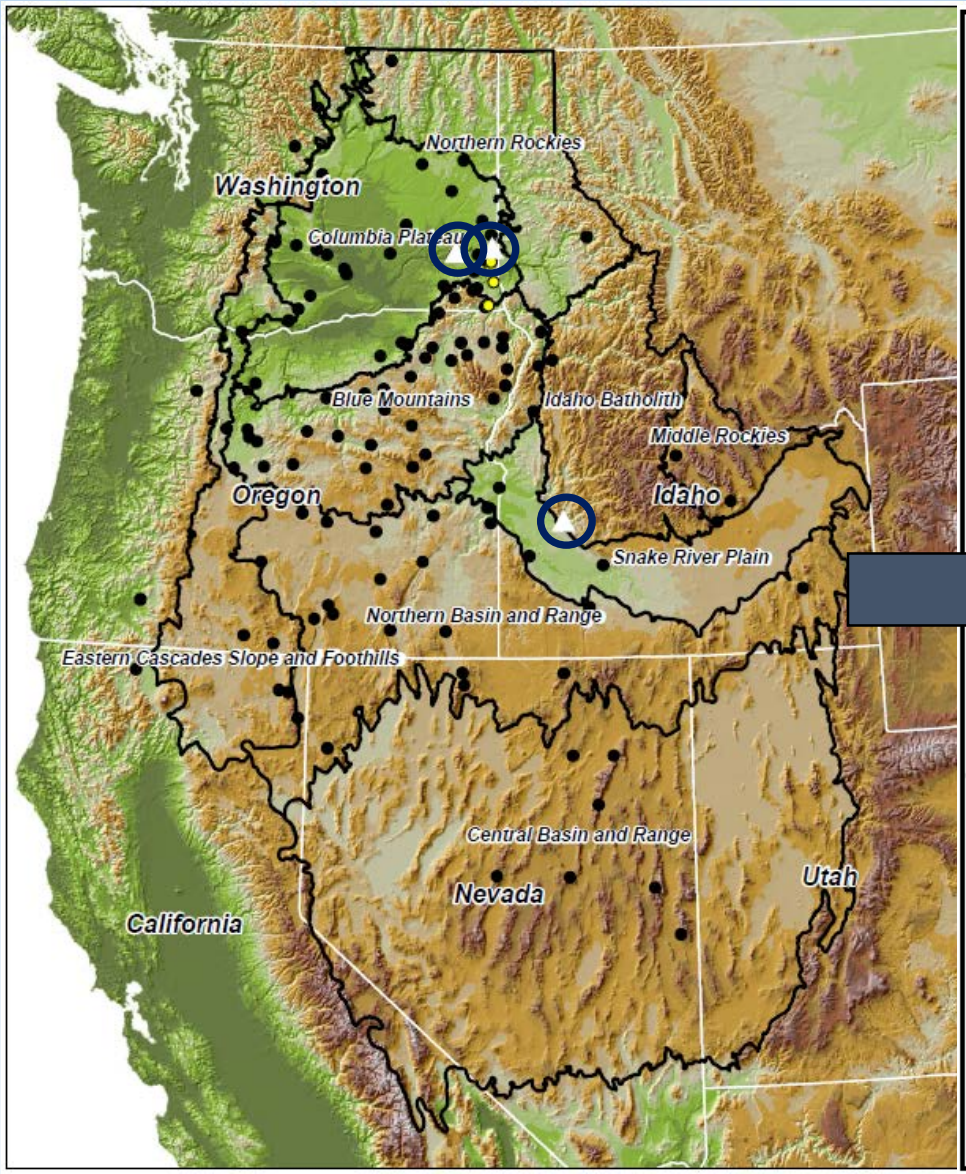


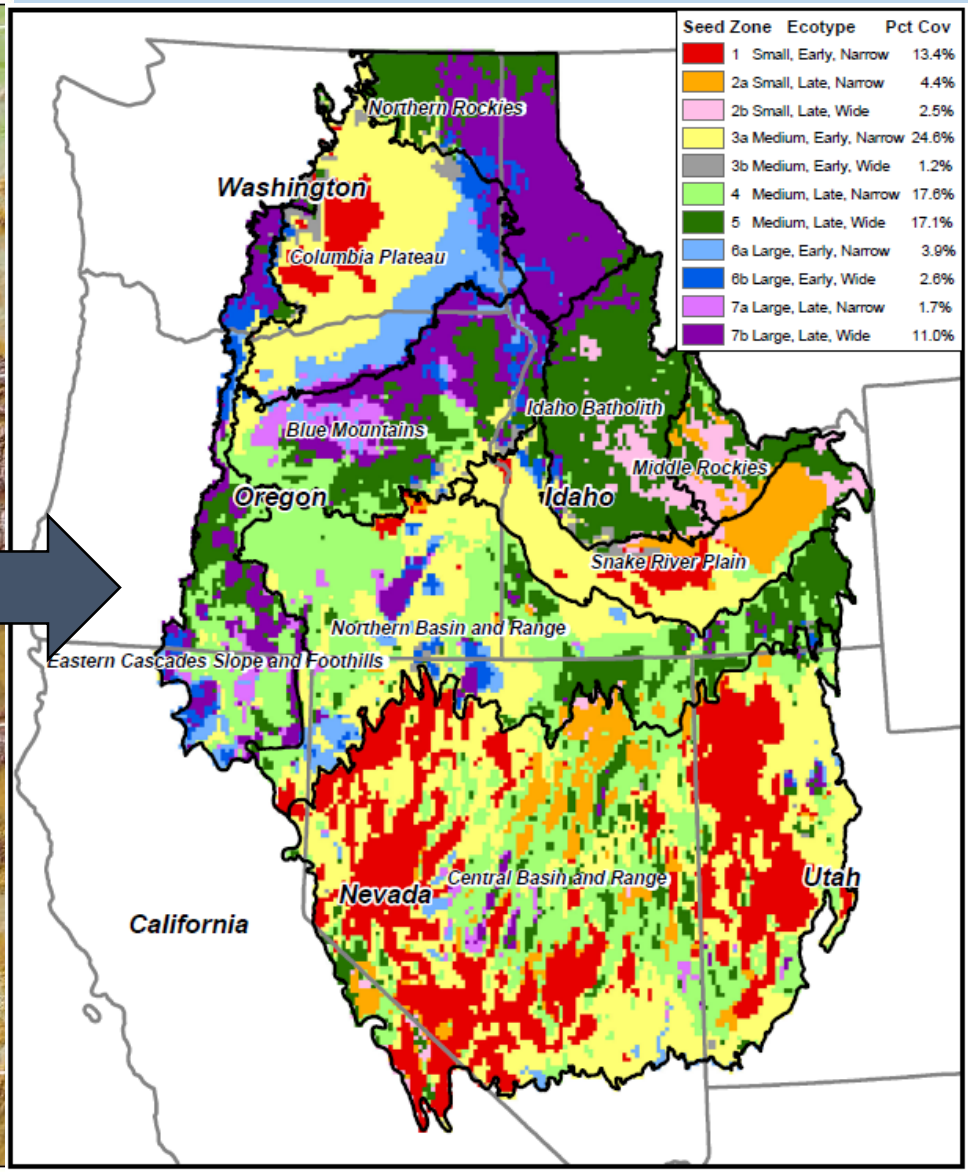
Traits vs source environment

St. Clair et al. 2005 Annals of Botany


Bluebunch wheatgrass genecological/ provenance study
USFS-RMRS-GSD, Matt Fisk

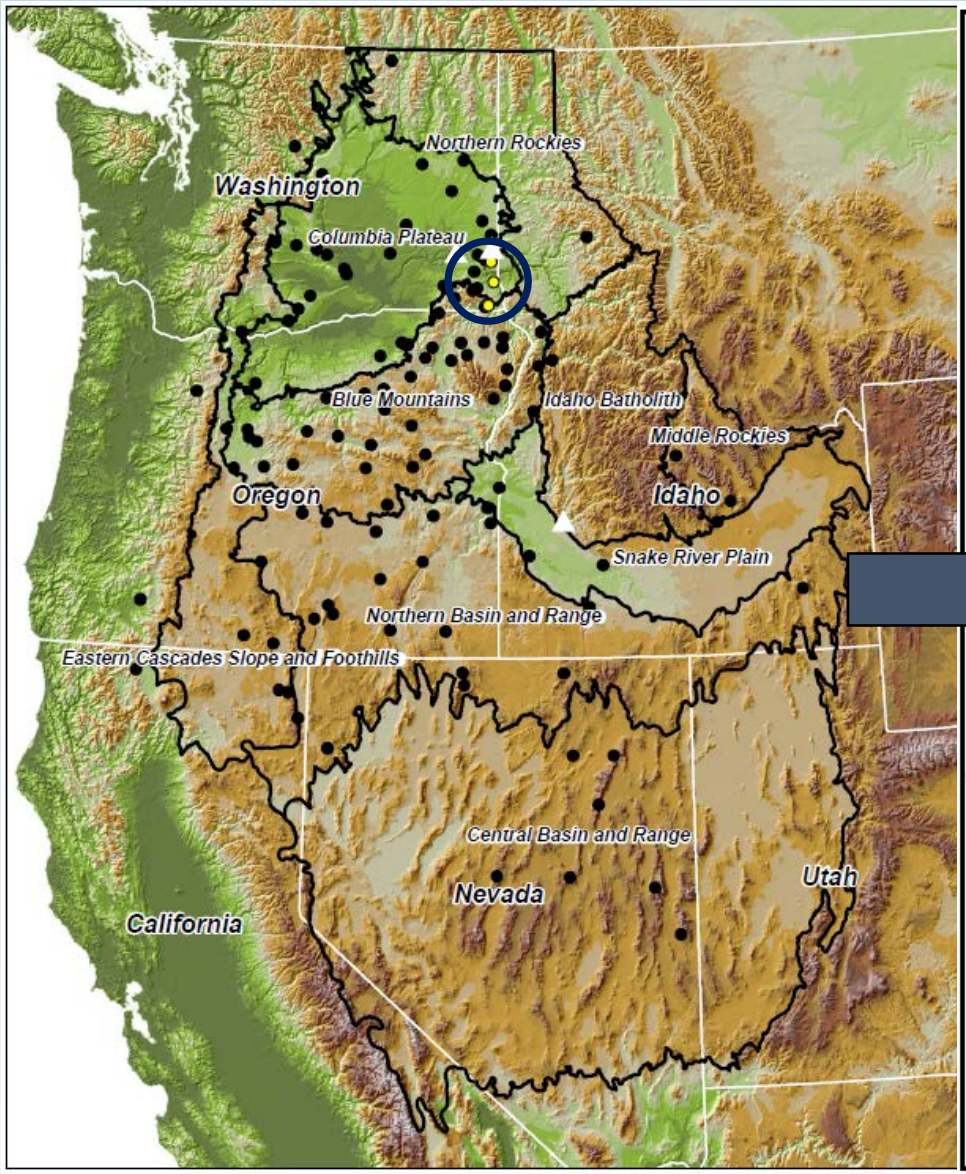
Bluebunch wheatgrass genecology/provenance study

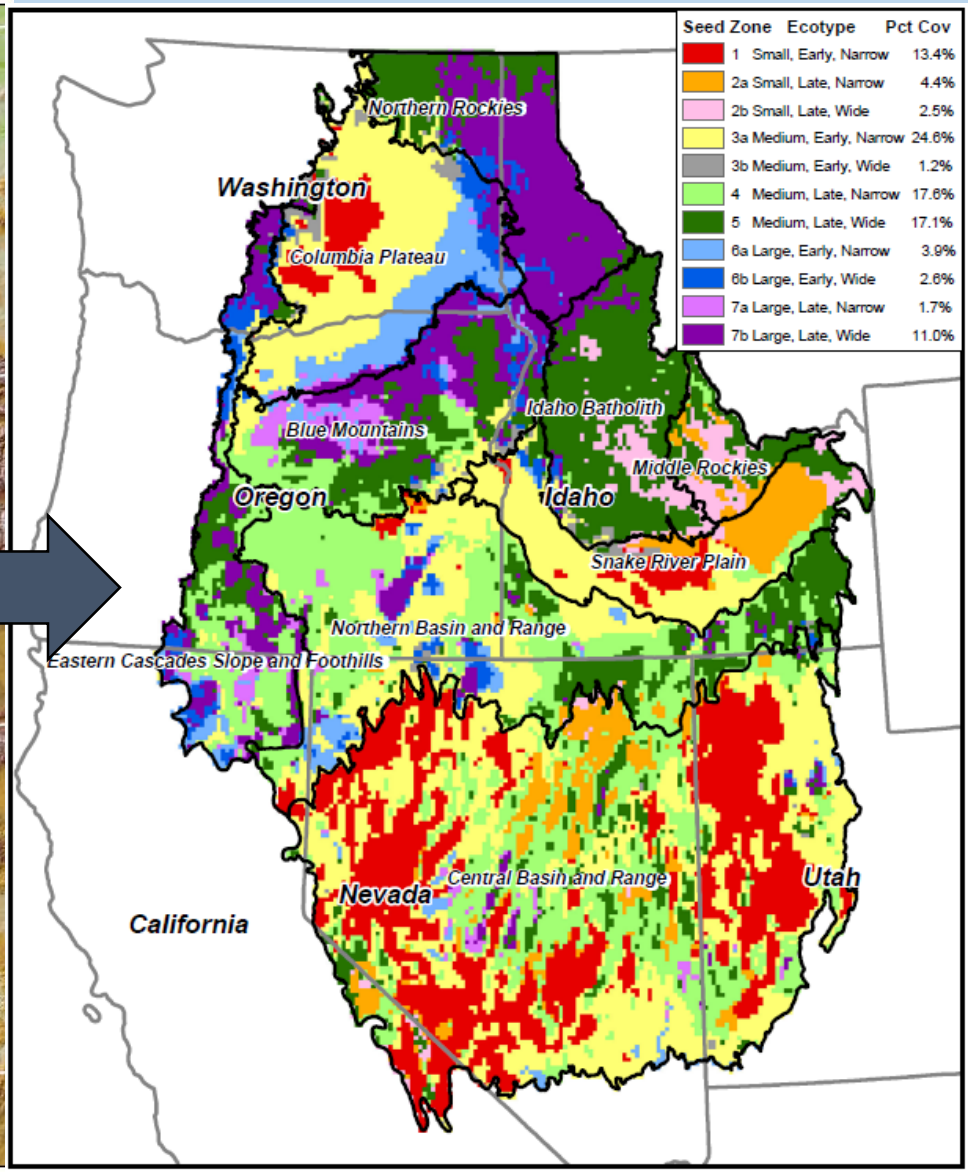




St. Clair et al. 2013. *Evolutionary Applications*, 6: 933–948

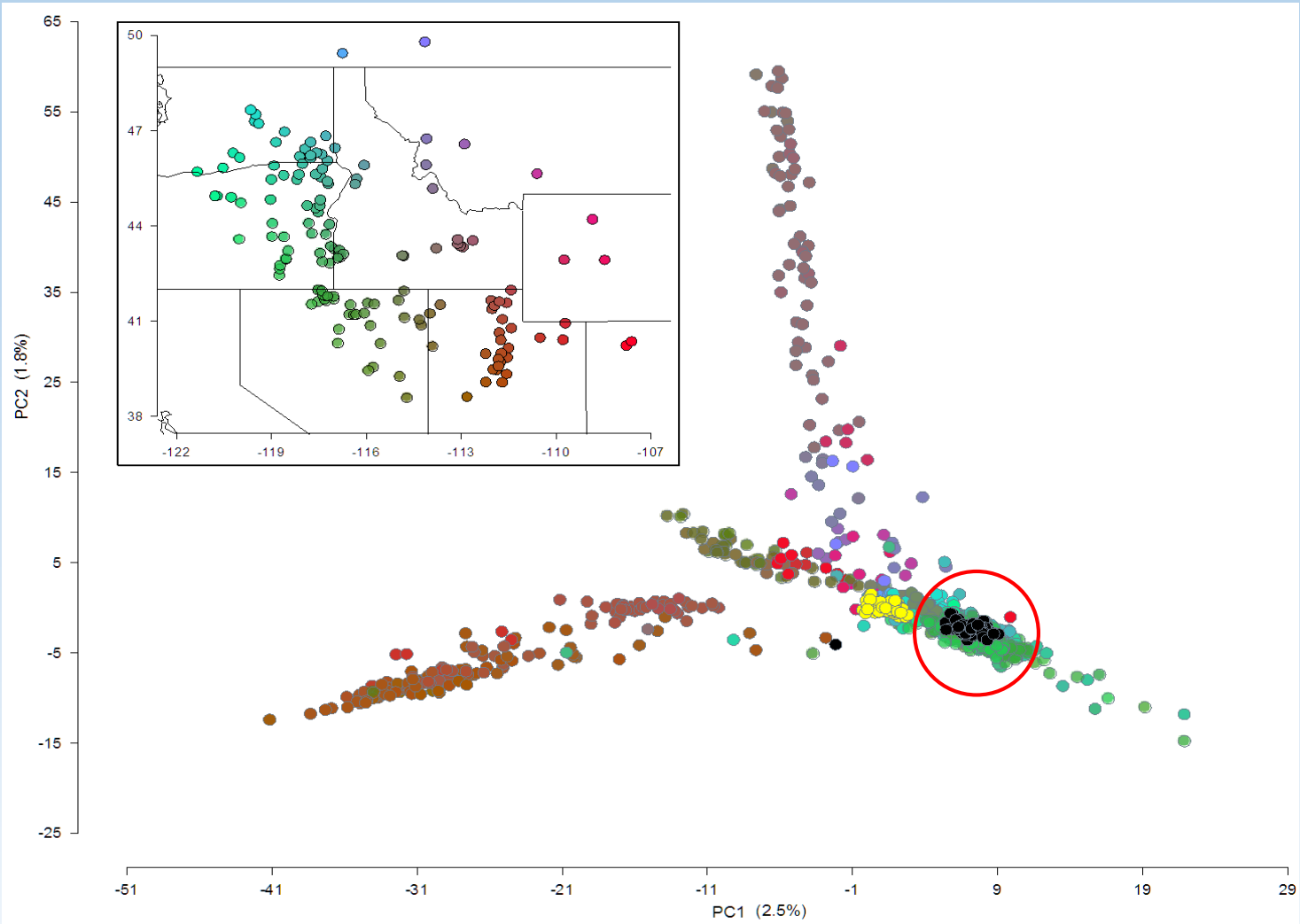
Bluebunch wheatgrass genecology/provenance study





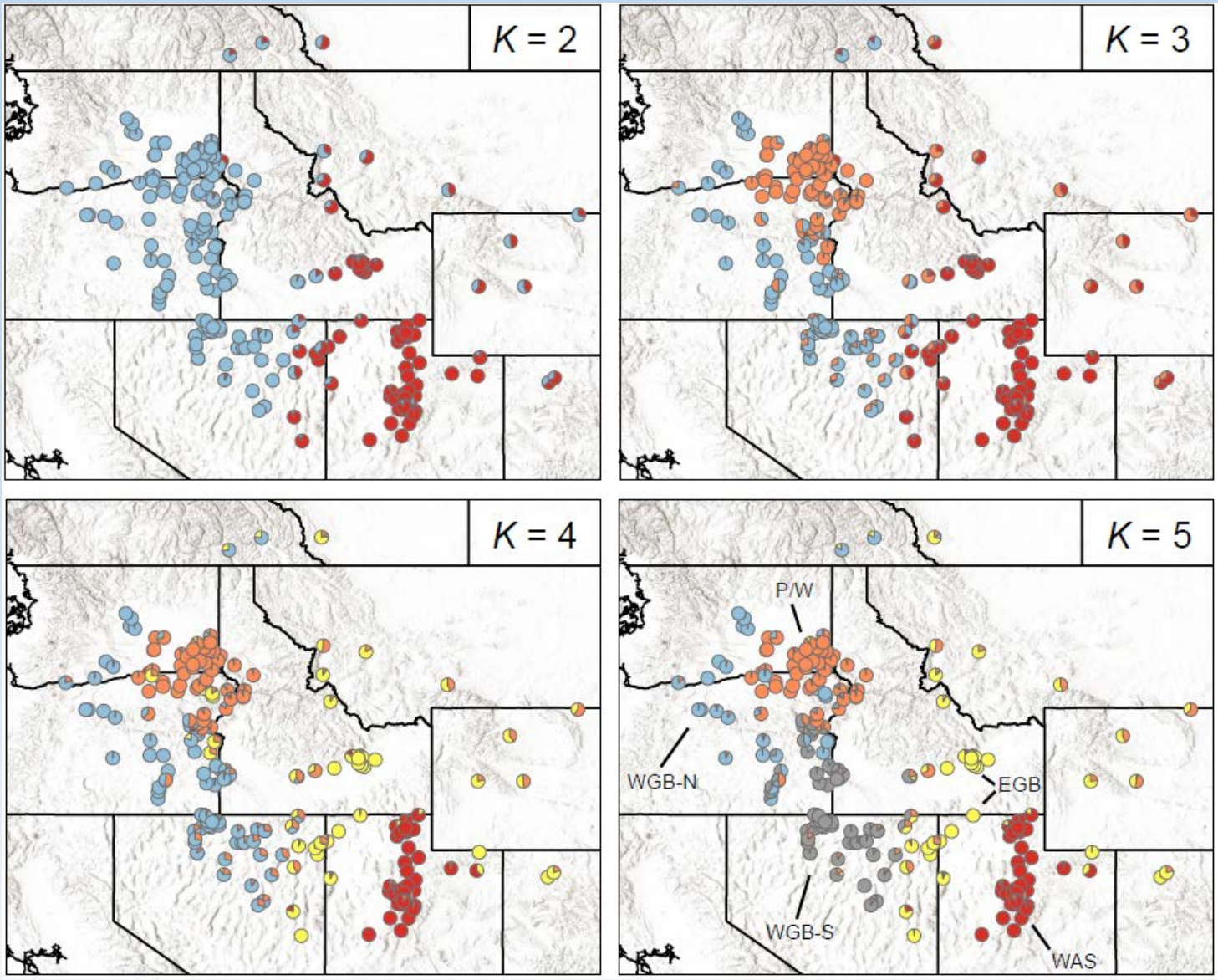
St. Clair et al. 2013. *Evolutionary Applications*, 6: 933–948

Genetic diversity of native and source-identified populations



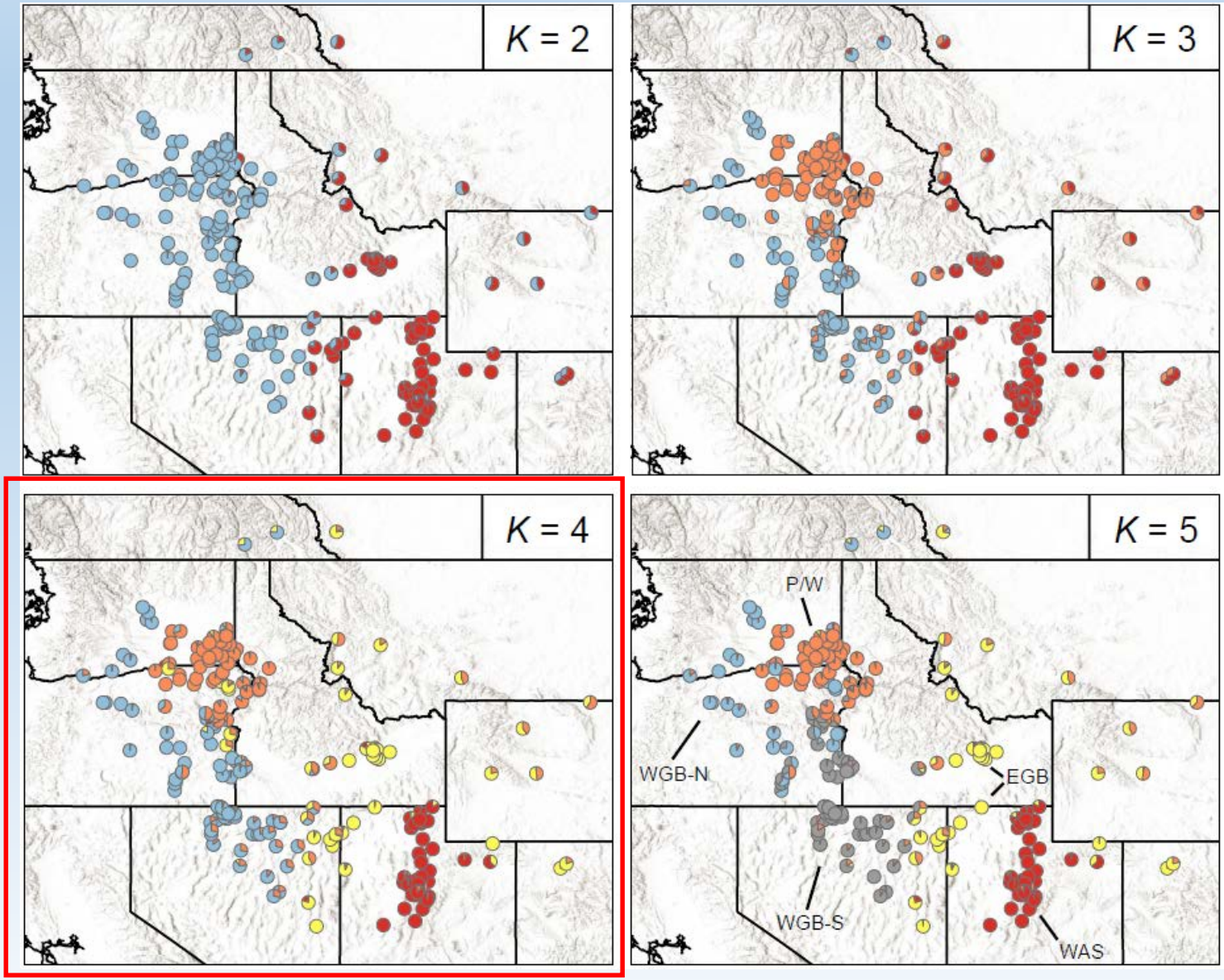
Massatti et al., in review for Evolutionary Applications

Genetic structure of native populations



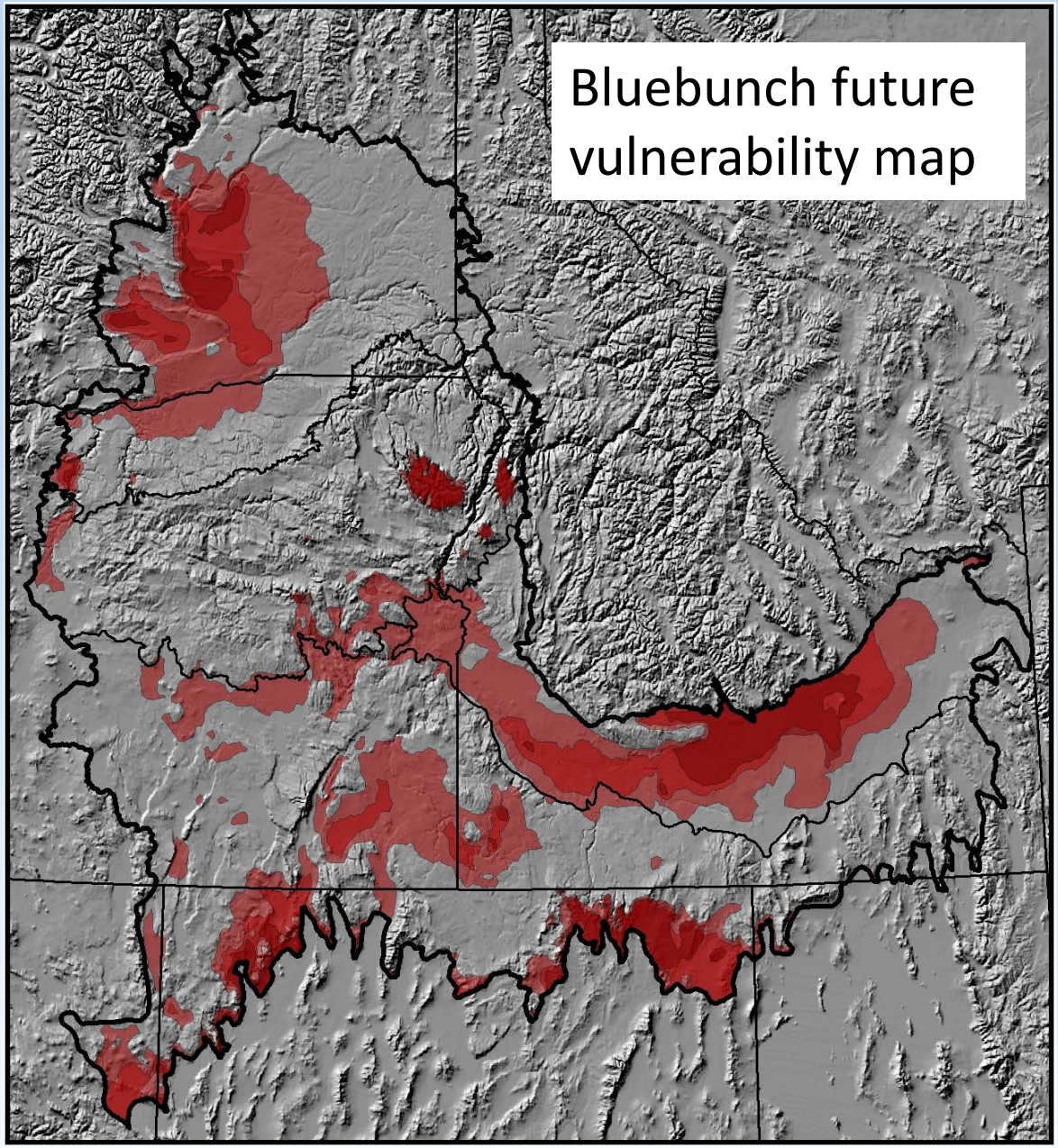
Massatti et al., in review for Evolutionary Applications

Genetic structure of native populations



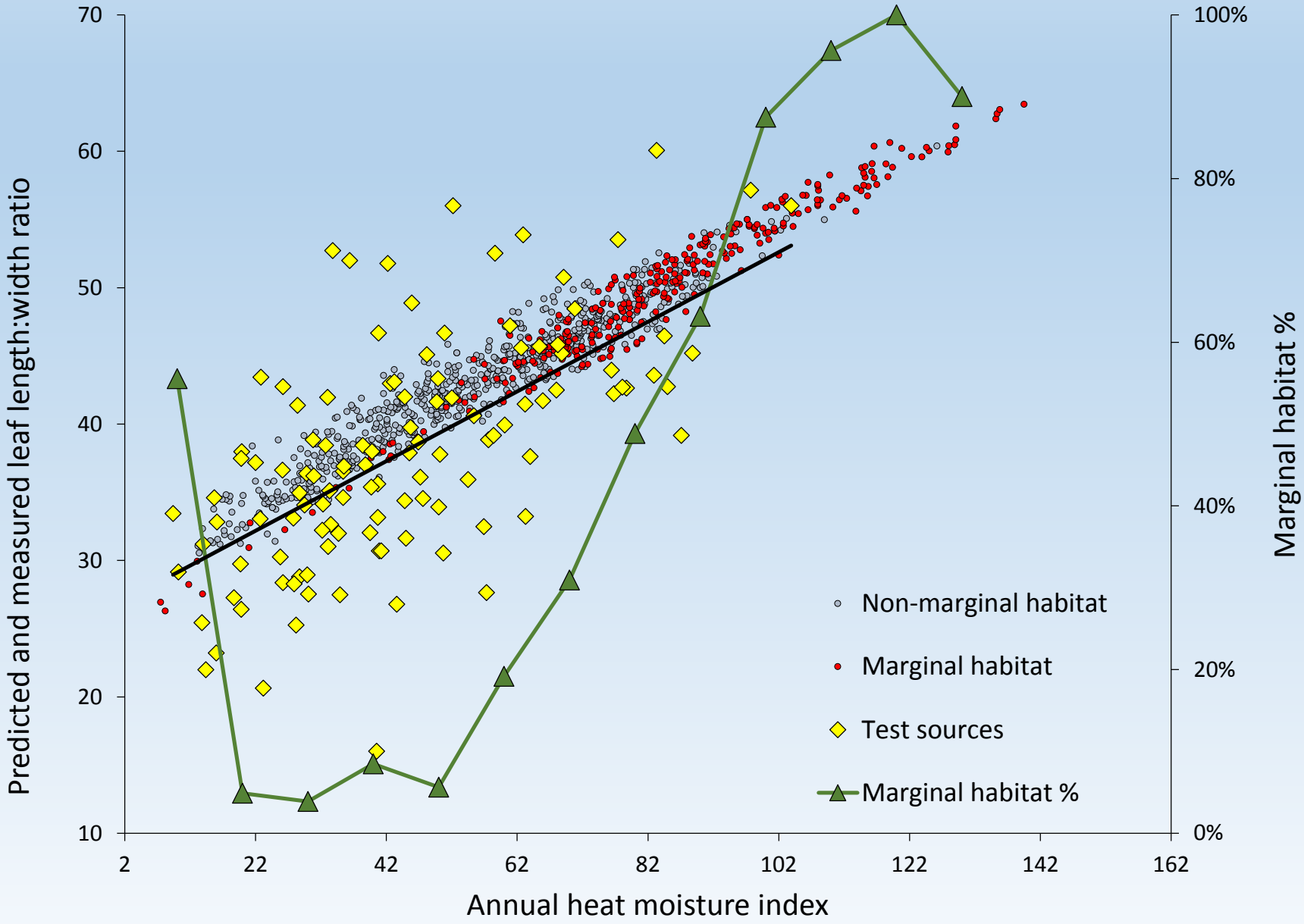
Massatti et al., in review for Evolutionary Applications

Predict future pressures on existing and restored populations



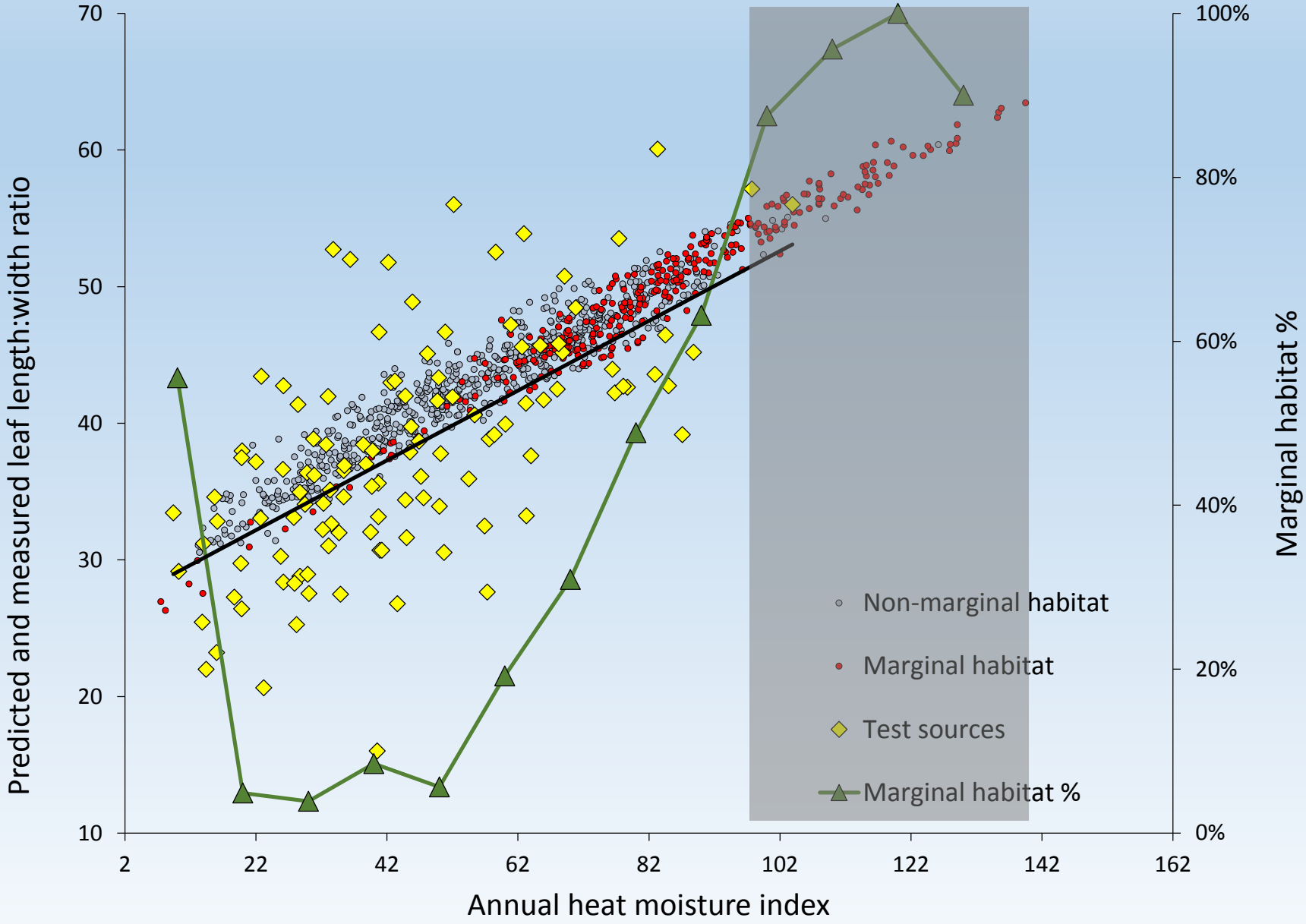
Kilkenny NAJ 2015

Select appropriate sources for adaptation to future climates



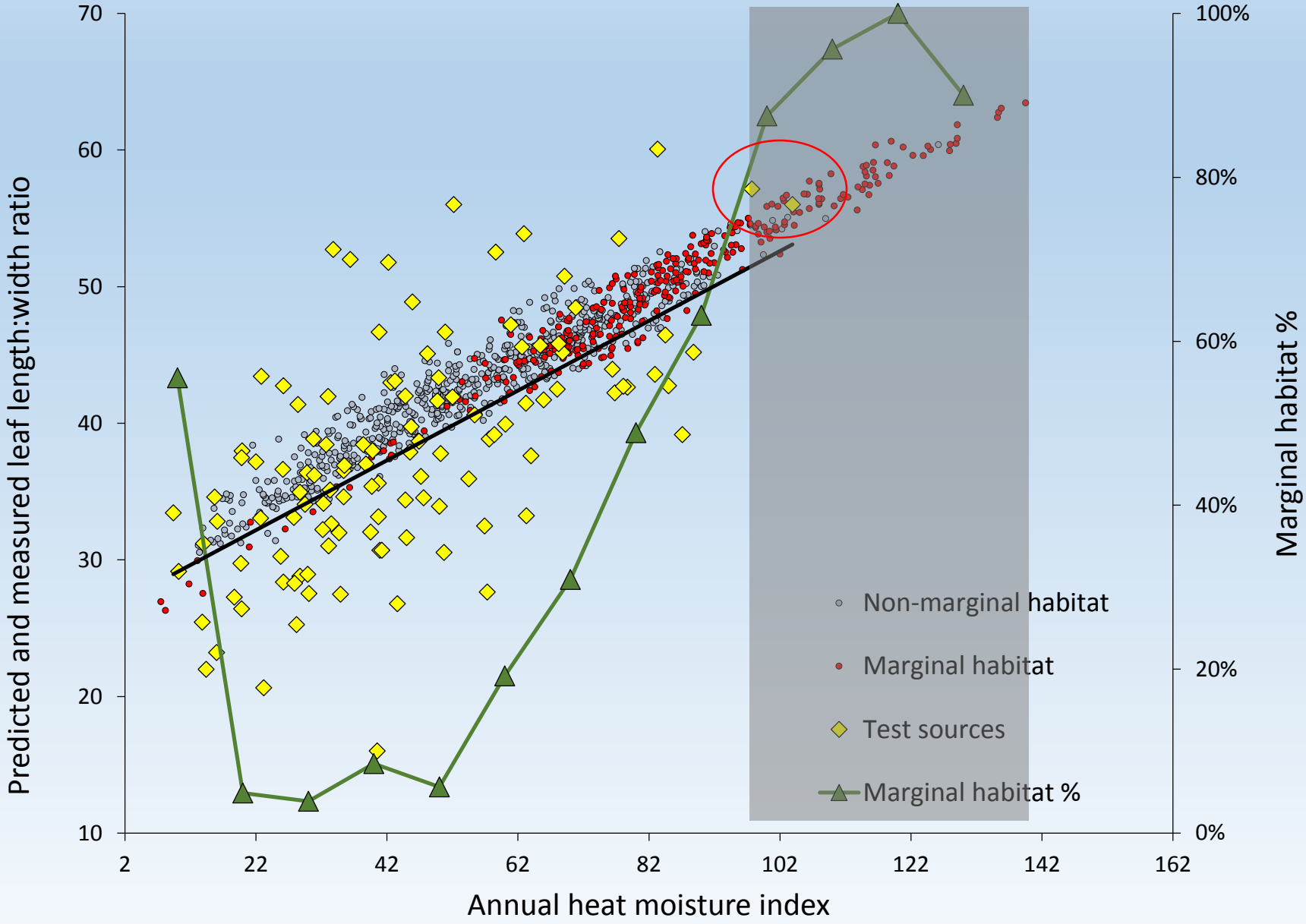
Kilkenny NAJ 2015

Select appropriate sources for adaptation to future climates



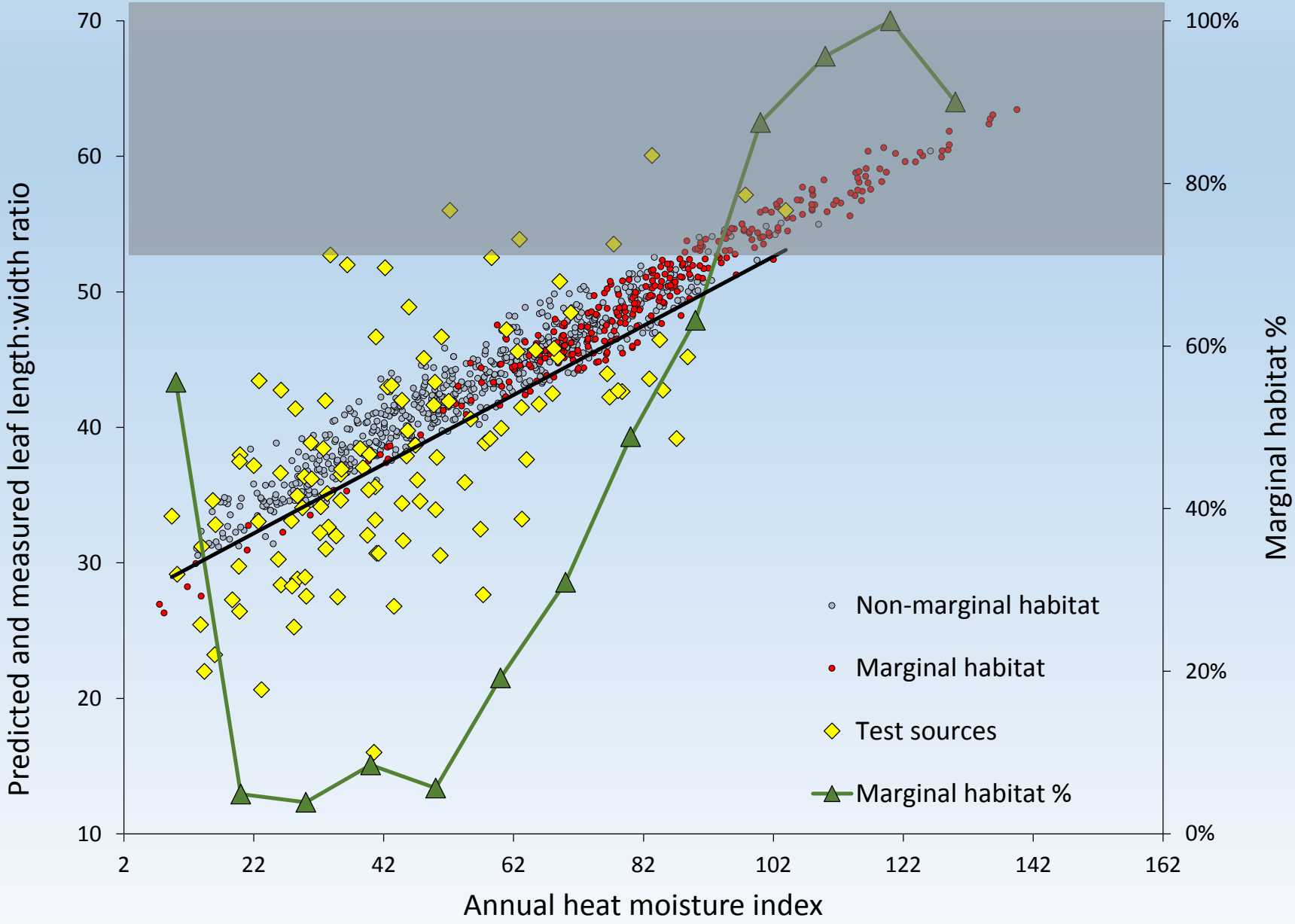
Kilkenny NAJ 2015

Select appropriate sources for adaptation to future climates



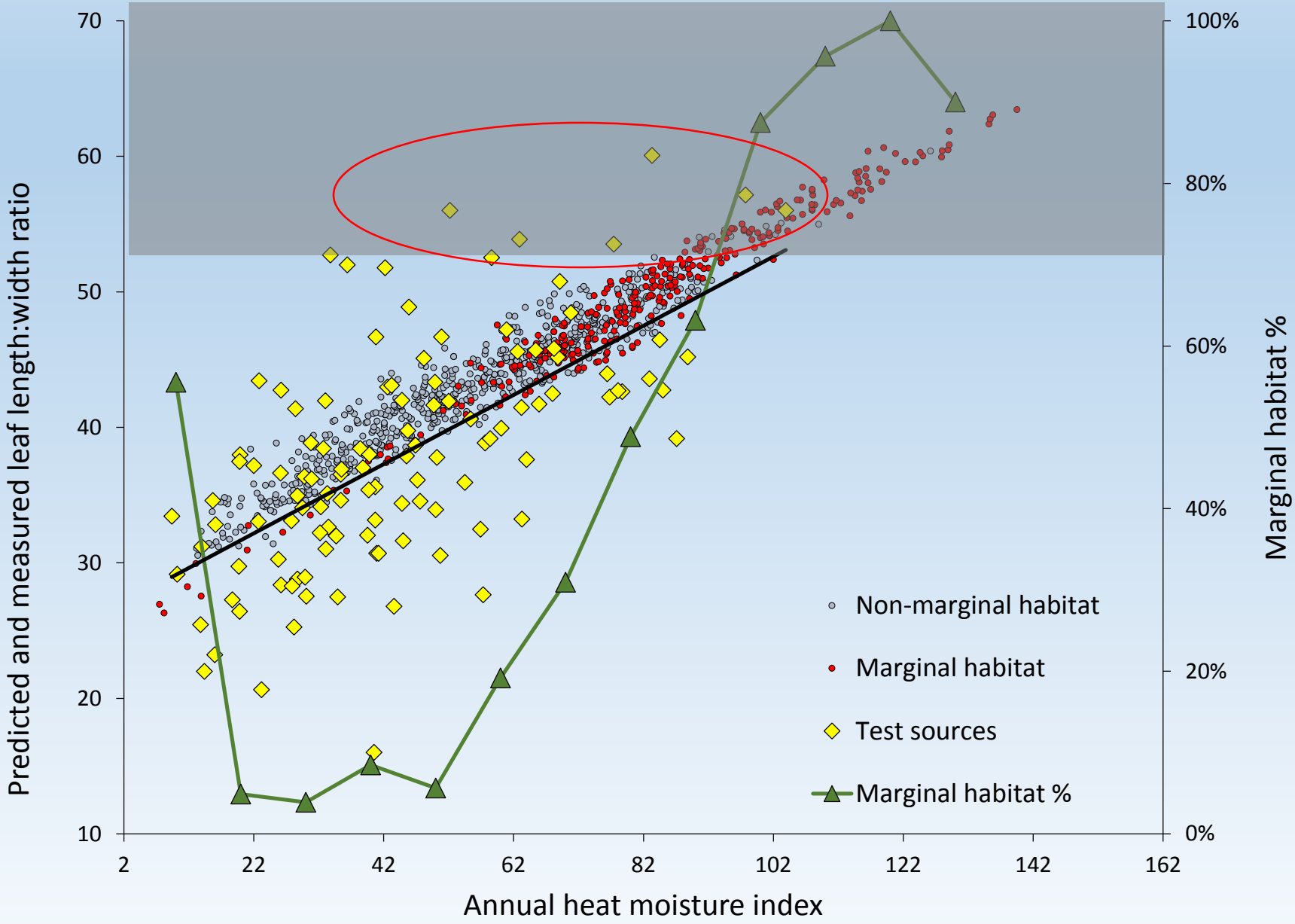
Kilkenny NAJ 2015

Select appropriate sources for adaptation to future climates



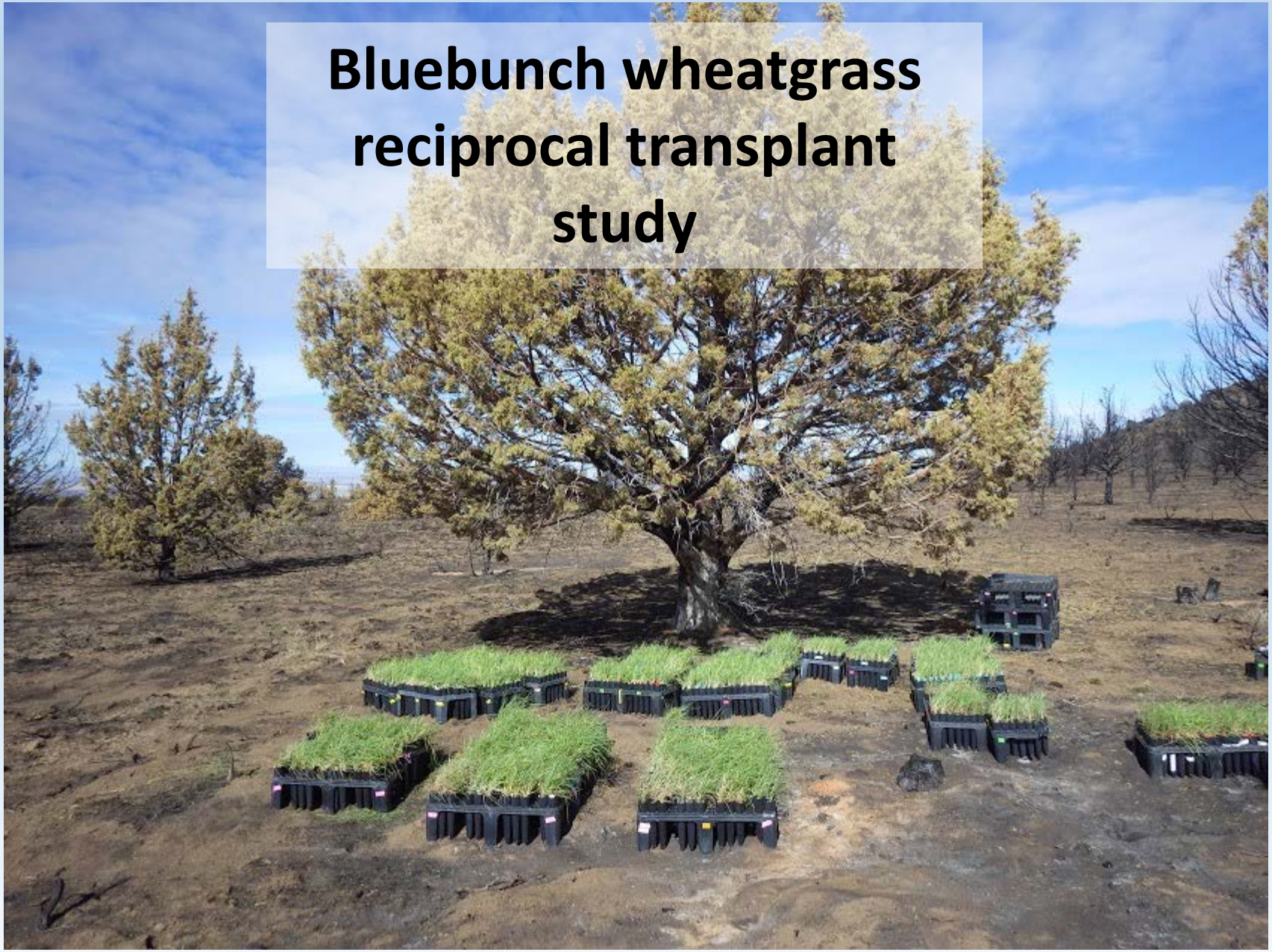
Kilkenny NAJ 2015

Select appropriate sources for adaptation to future climates

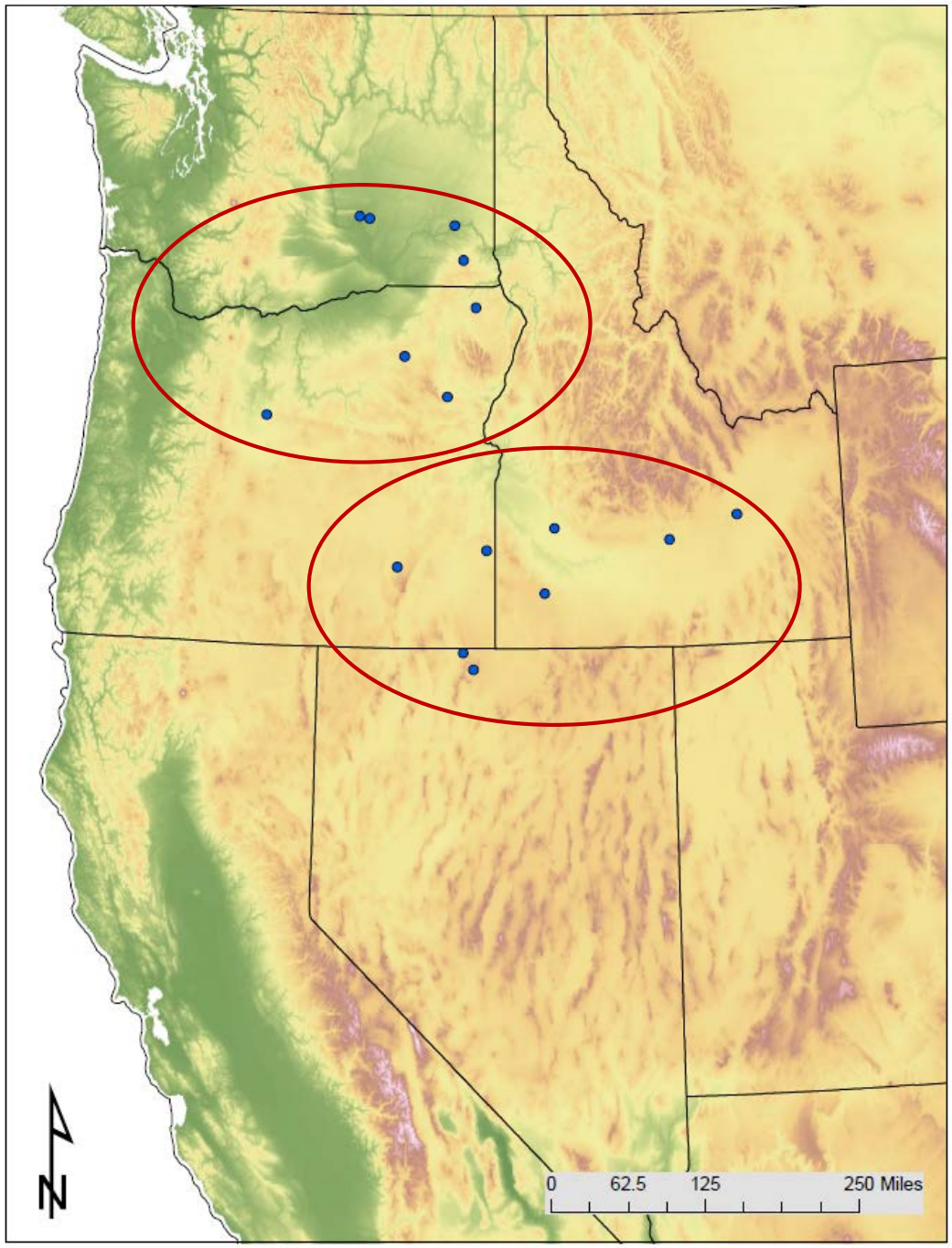


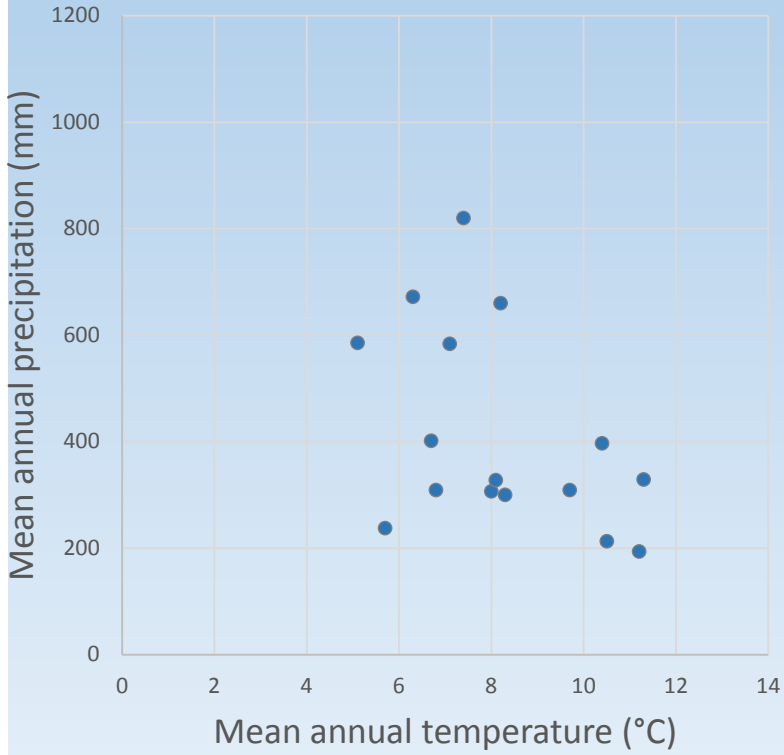
Kilkenny NAJ 2015

Bluebunch wheatgrass reciprocal transplant study



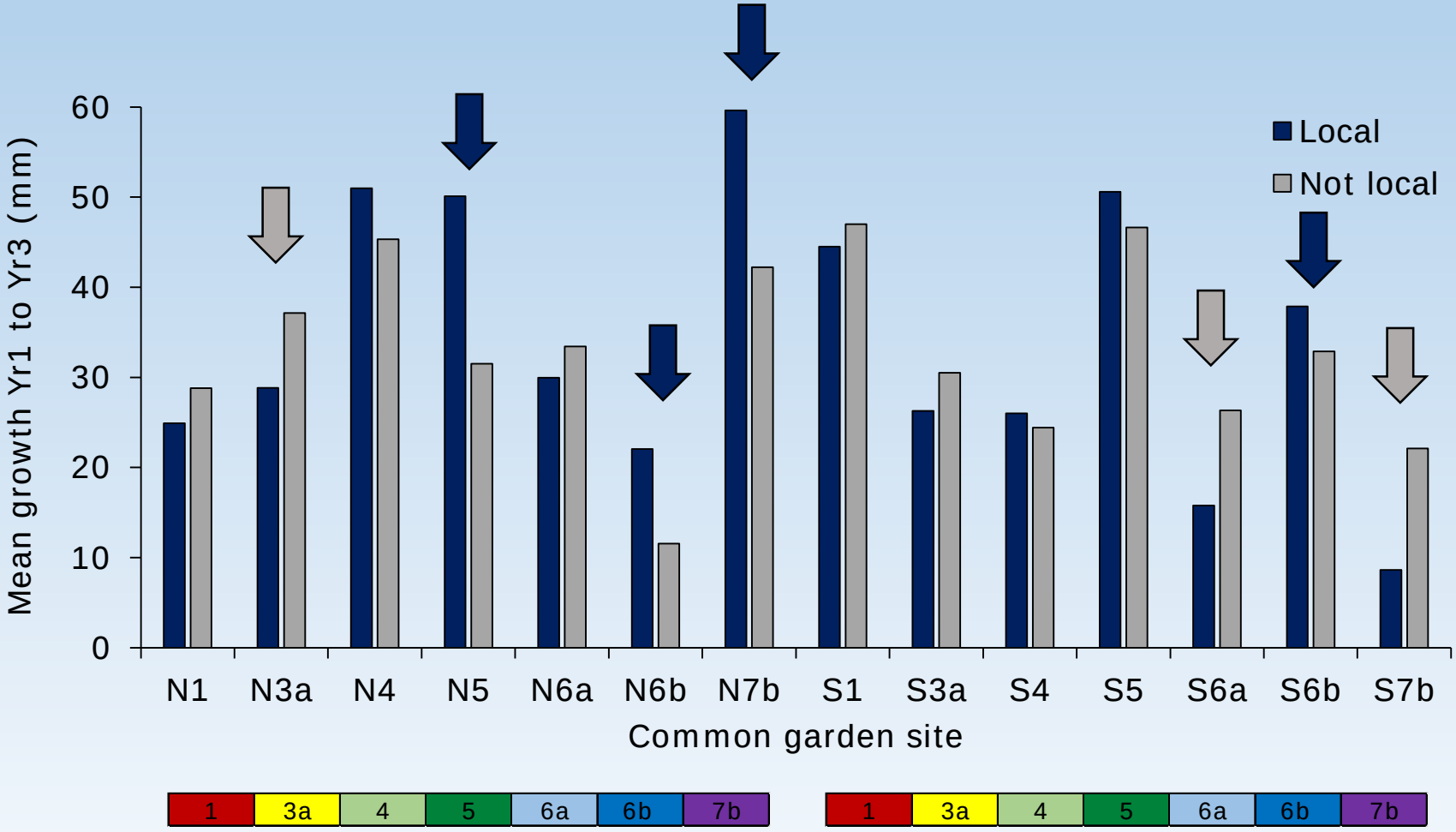
Bluebunch reciprocal transplant study sites





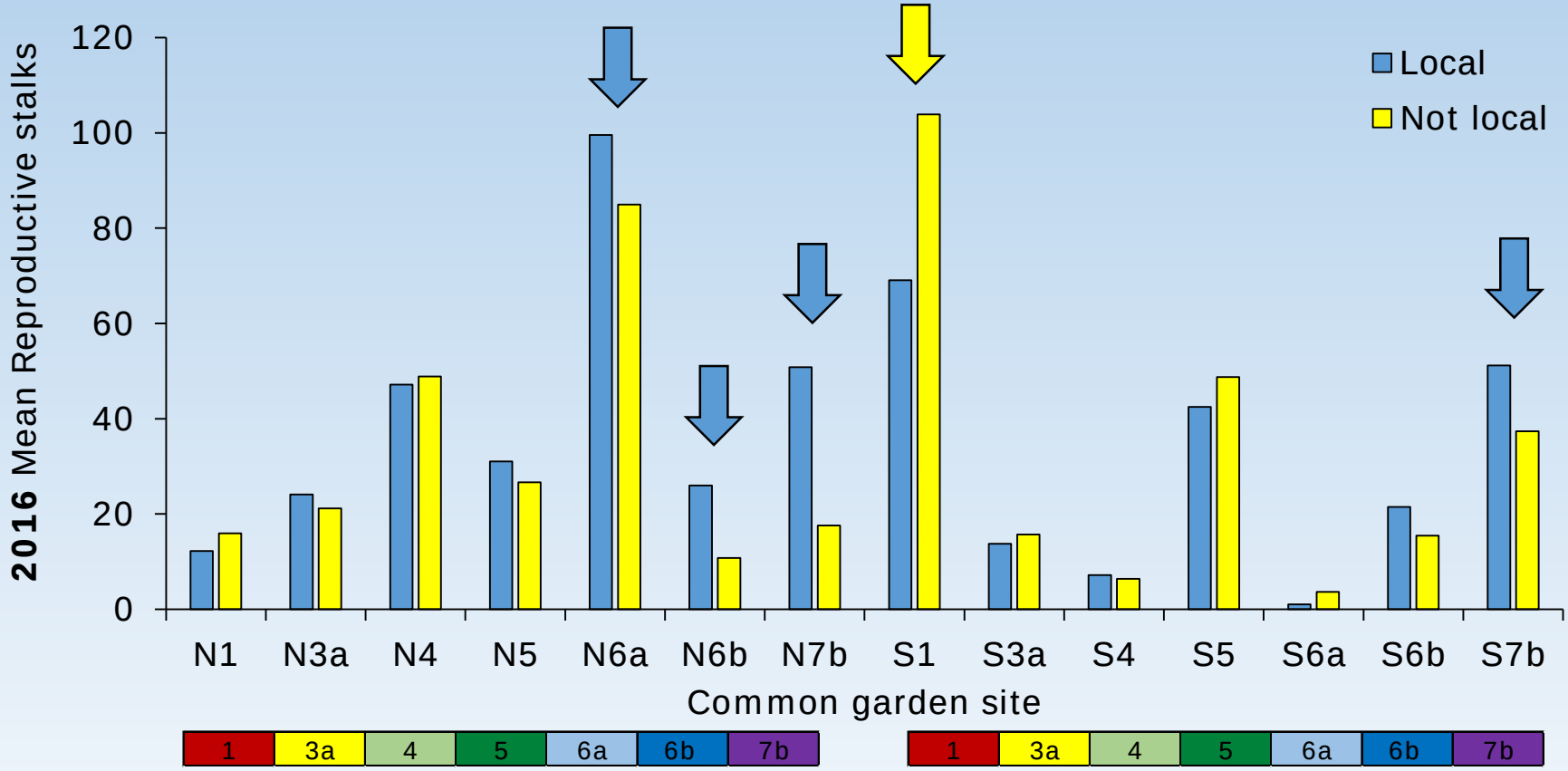
Prendeville et al. unpublished

Growth shows evidence of local adaptation



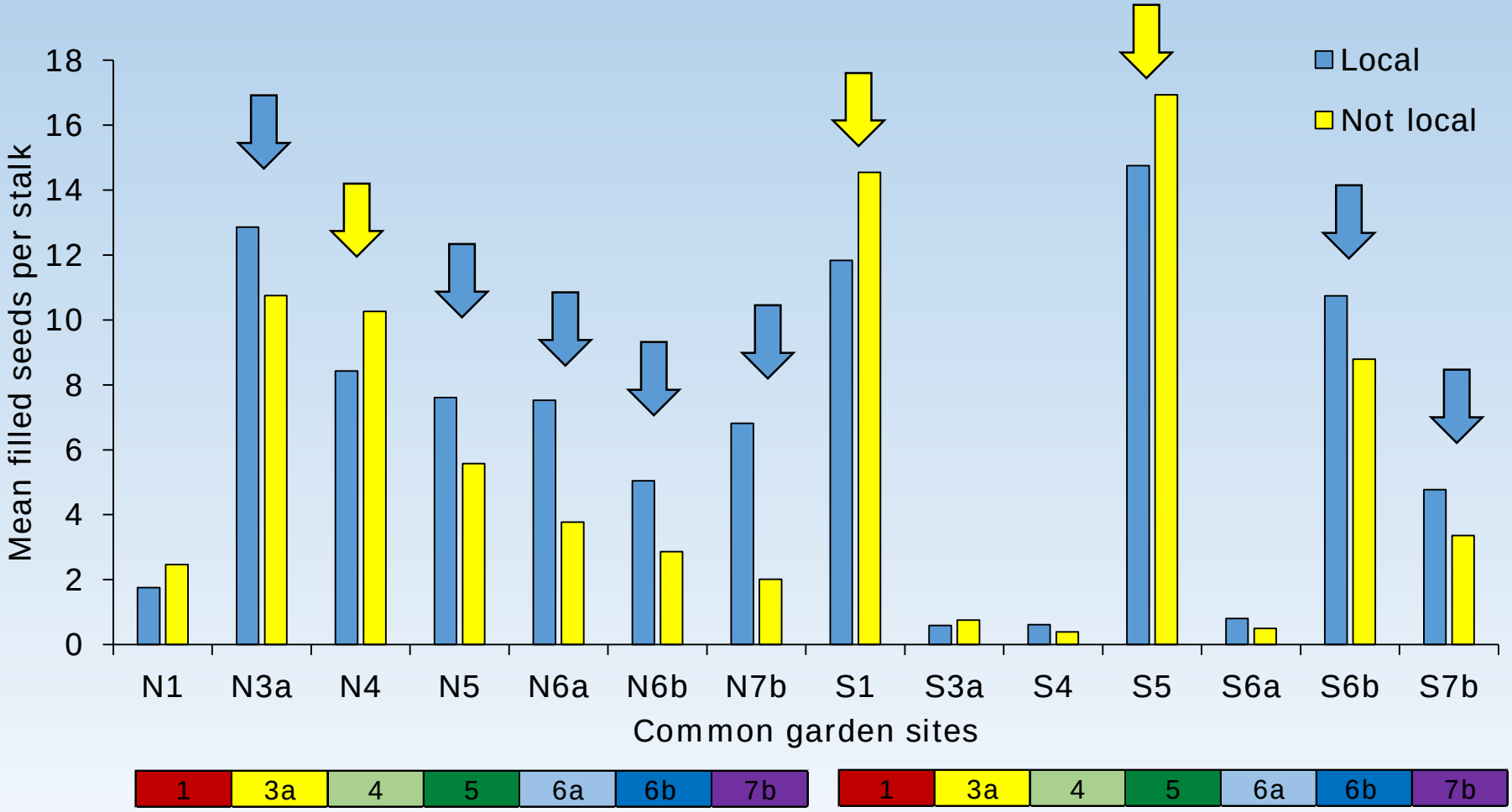
Prendeville et al. unpublished

Reproductive stalks shows evidence of local adaptation



Prendeville et al. unpublished

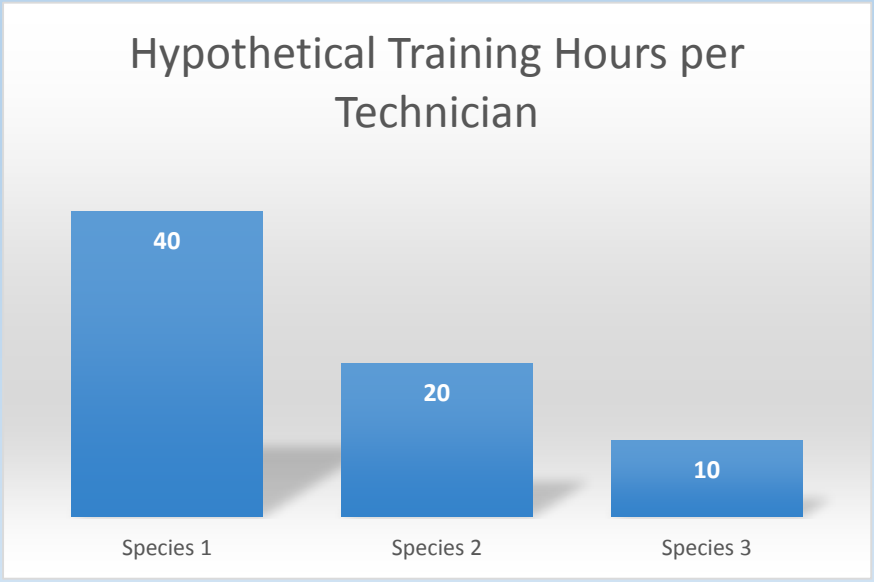
Seed production shows evidence of local adaptation

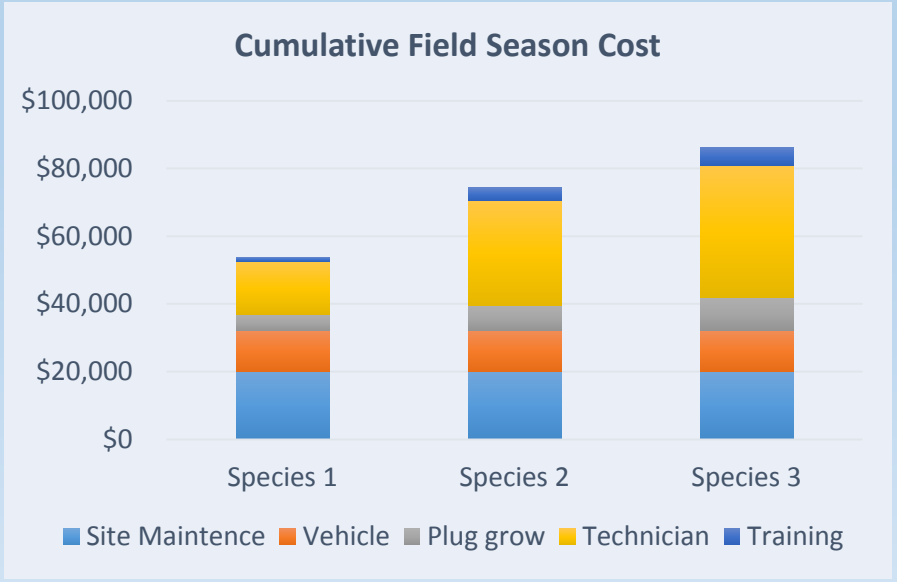


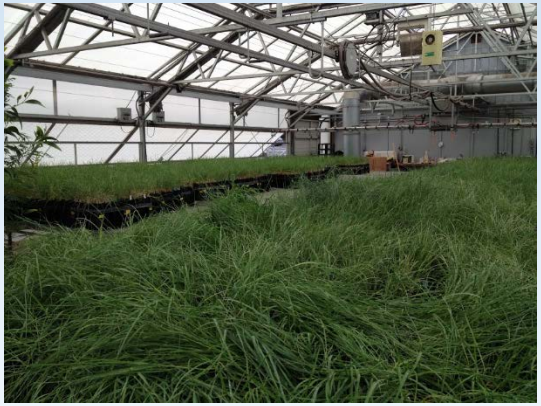
Prendeville et al. unpublished


Intermountain Common
Garden Network

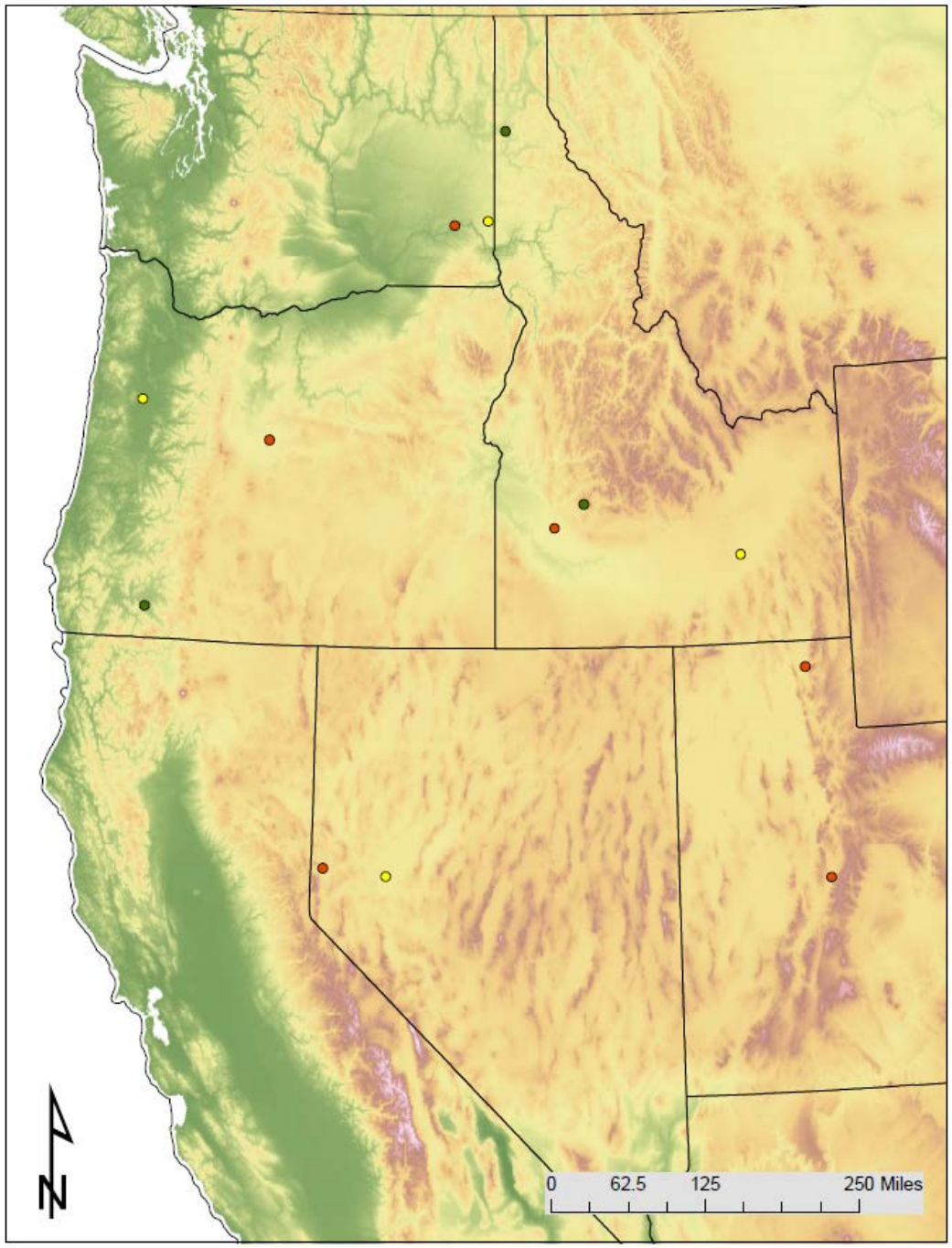
Costs of common garden studies

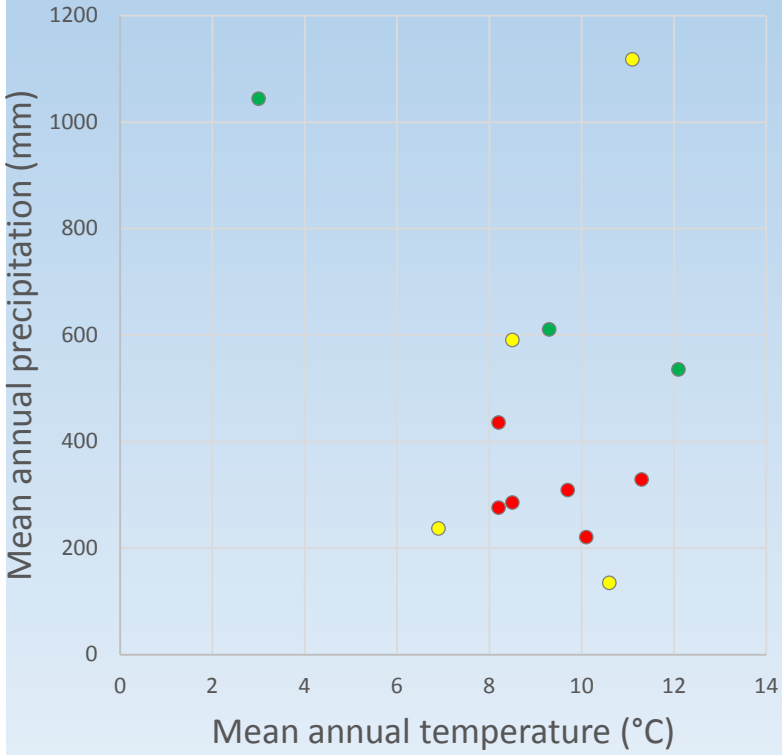




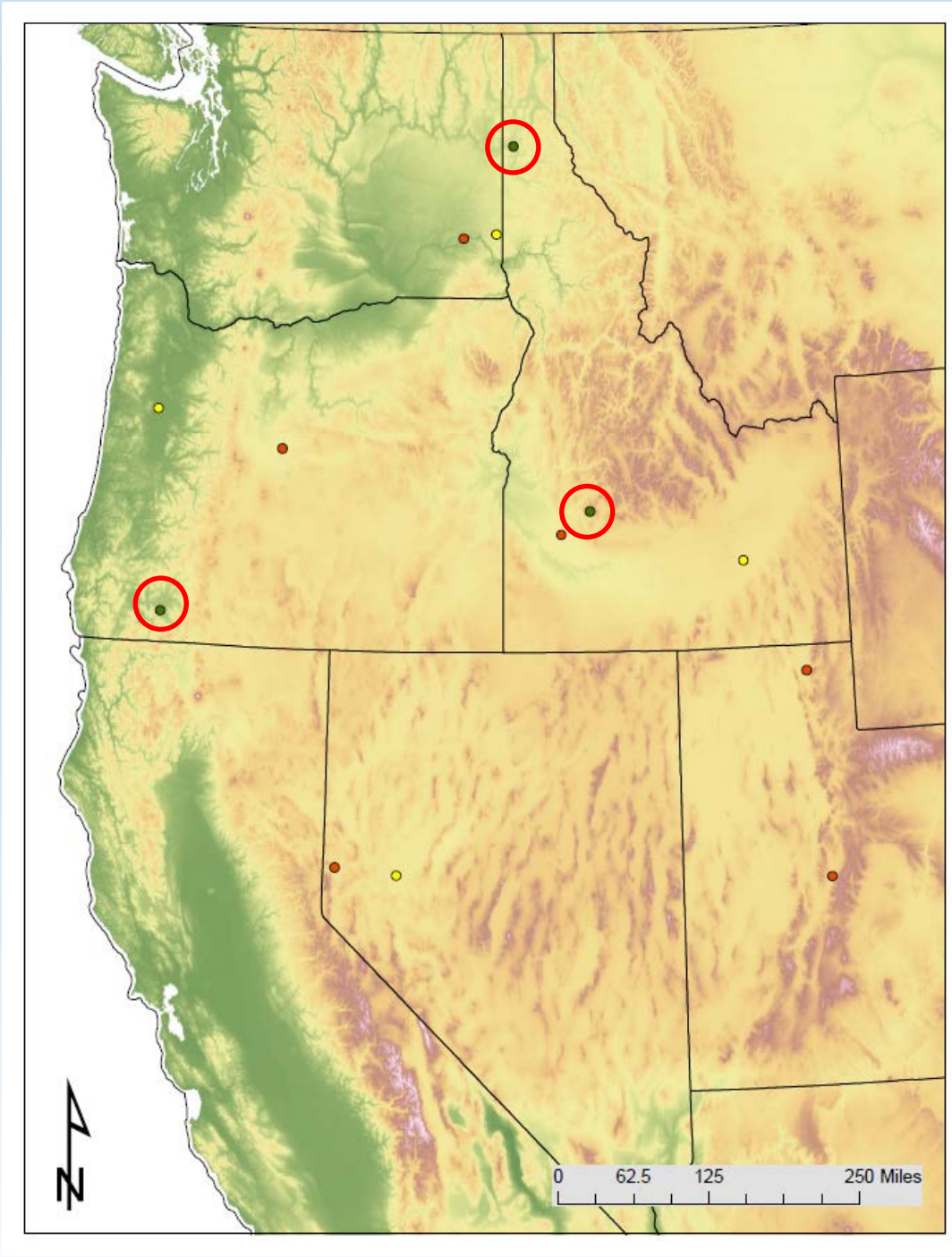


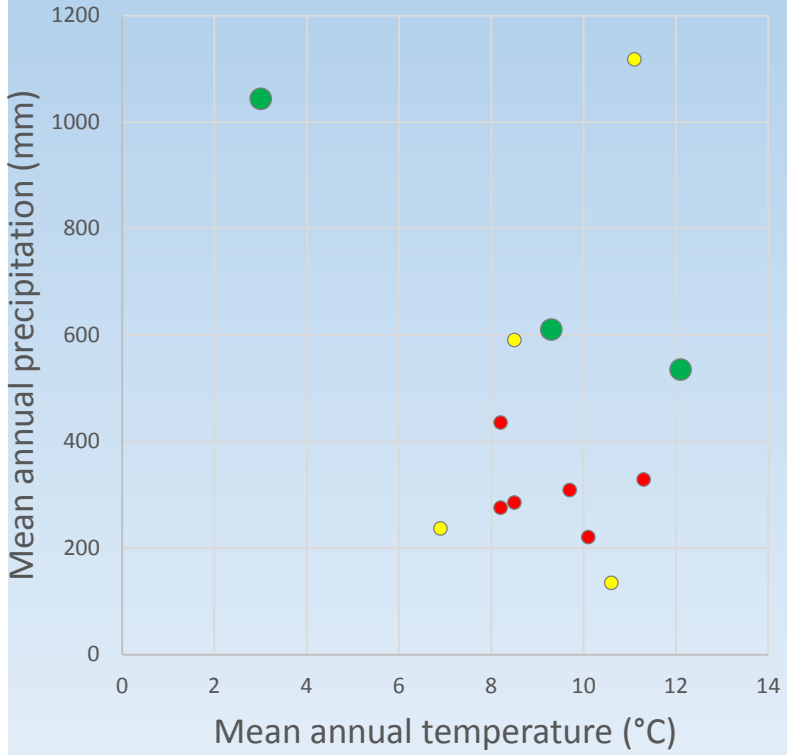
Sites with staff/personnel



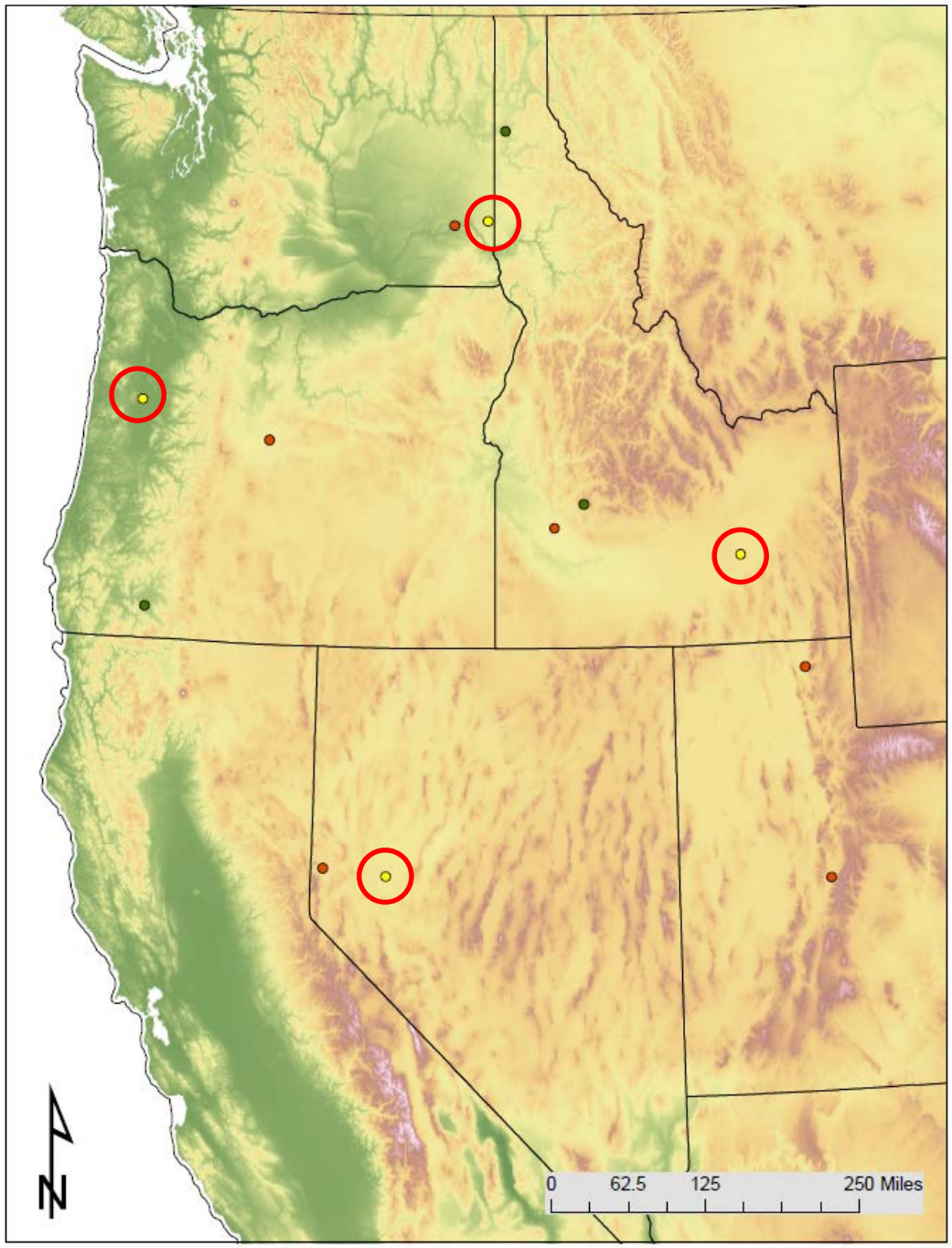


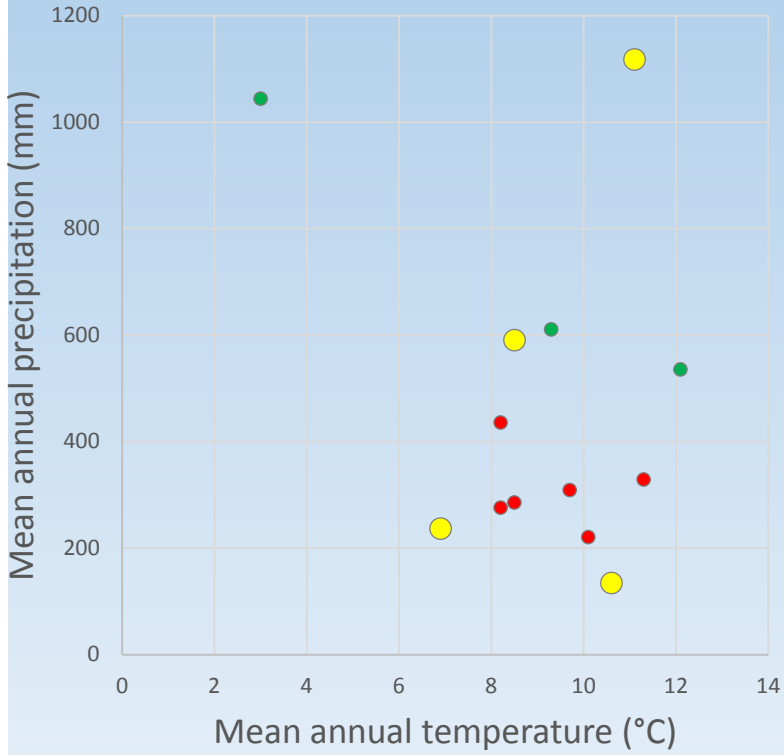
Forest Service nurseries



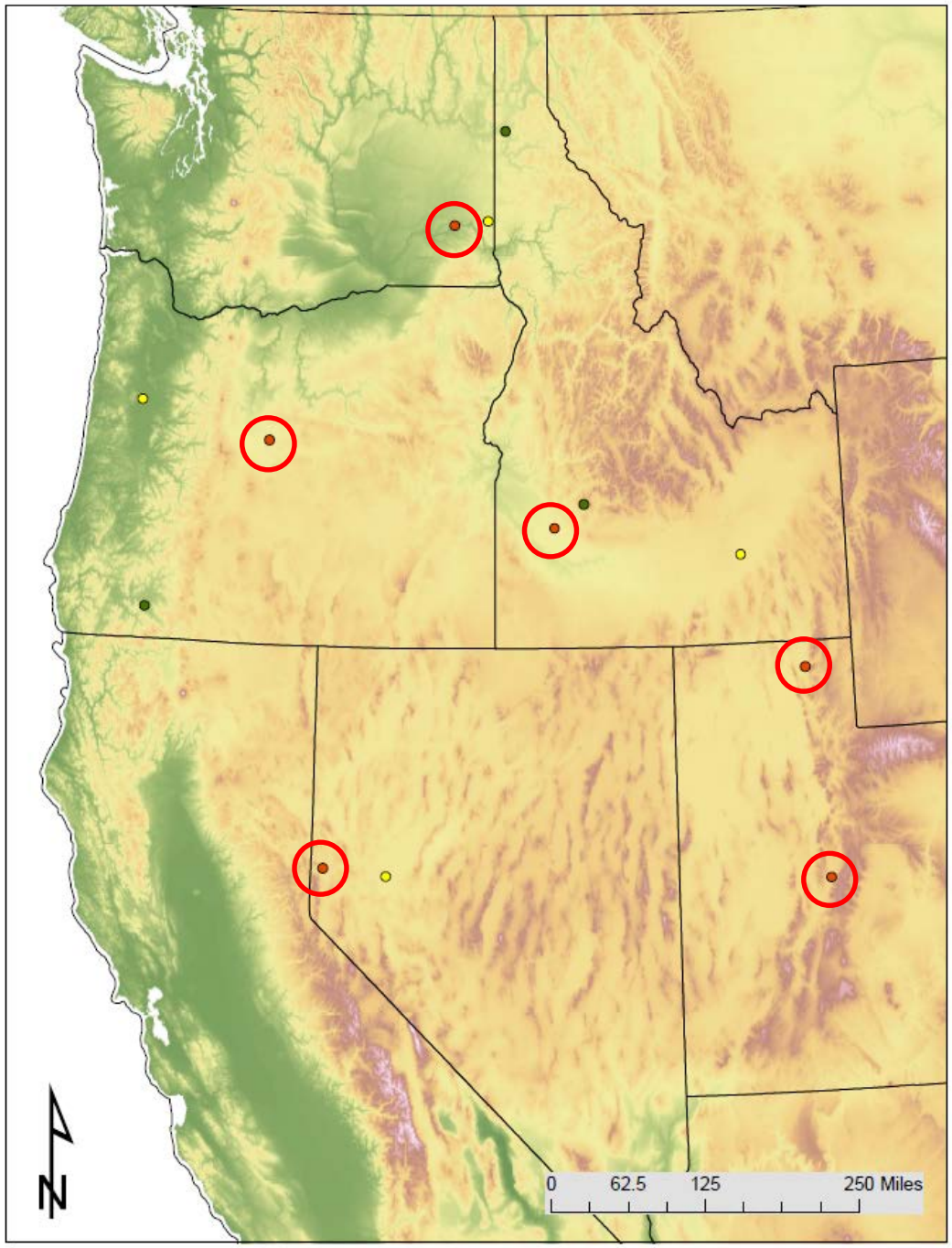


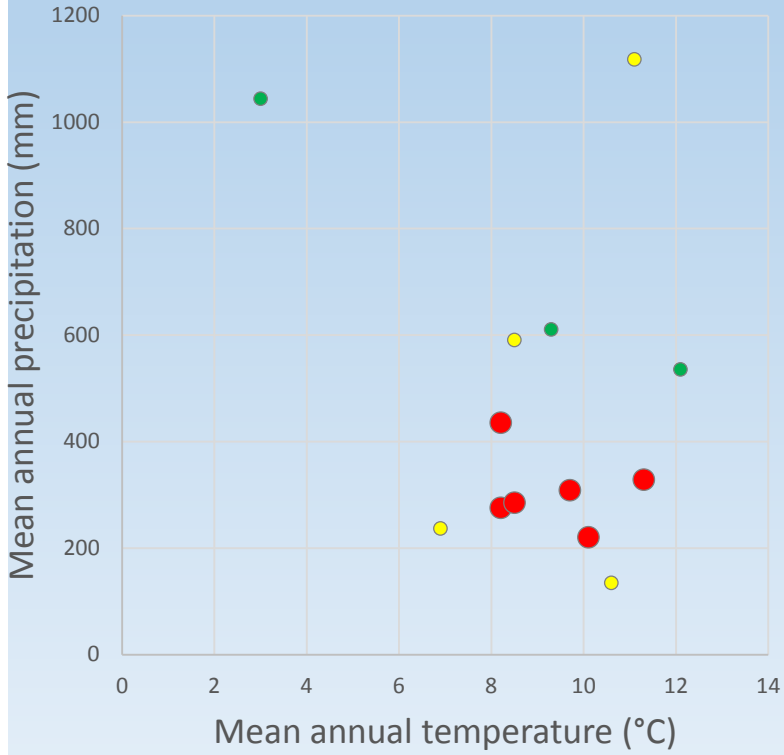
NRCS Plant Materials Centers

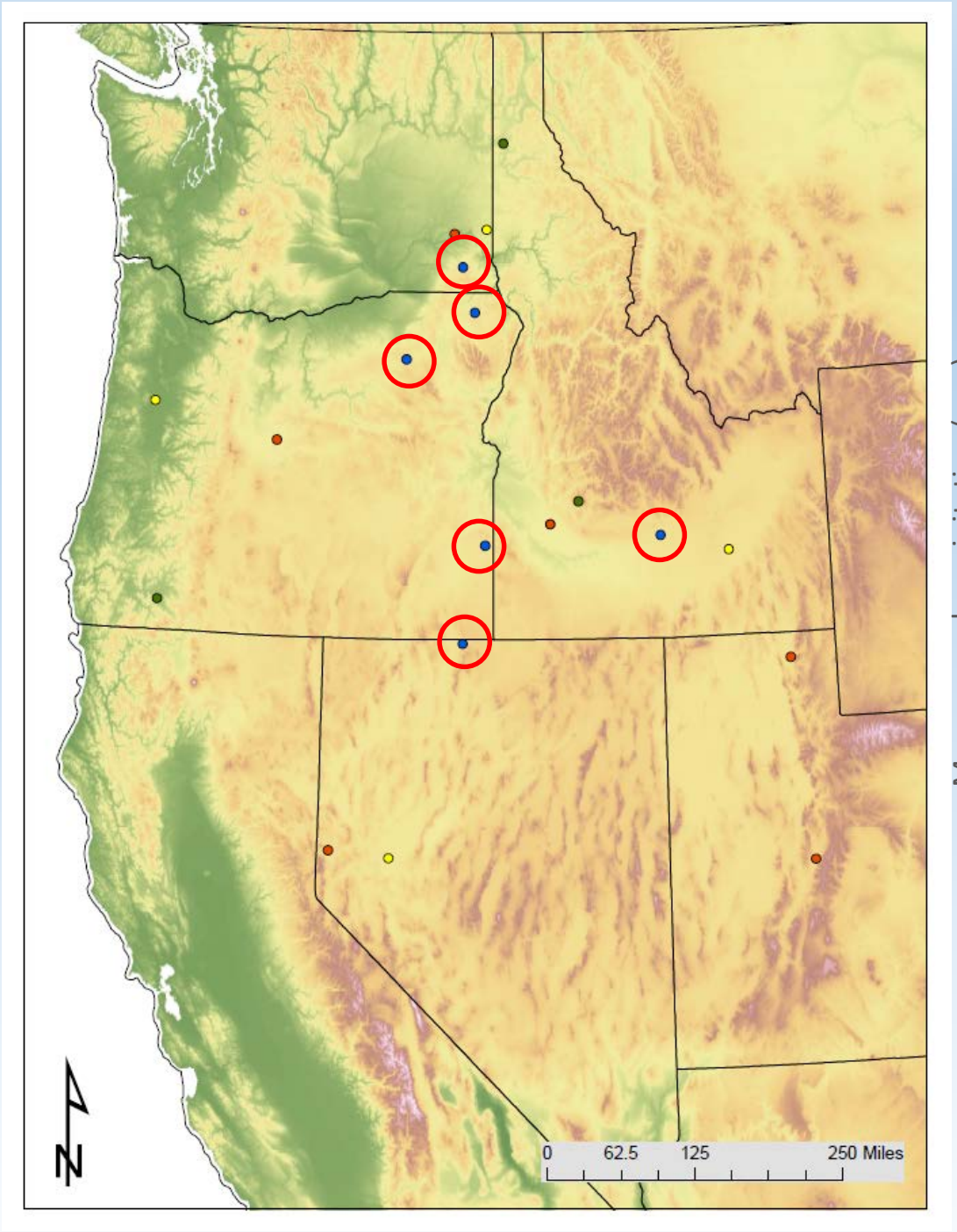




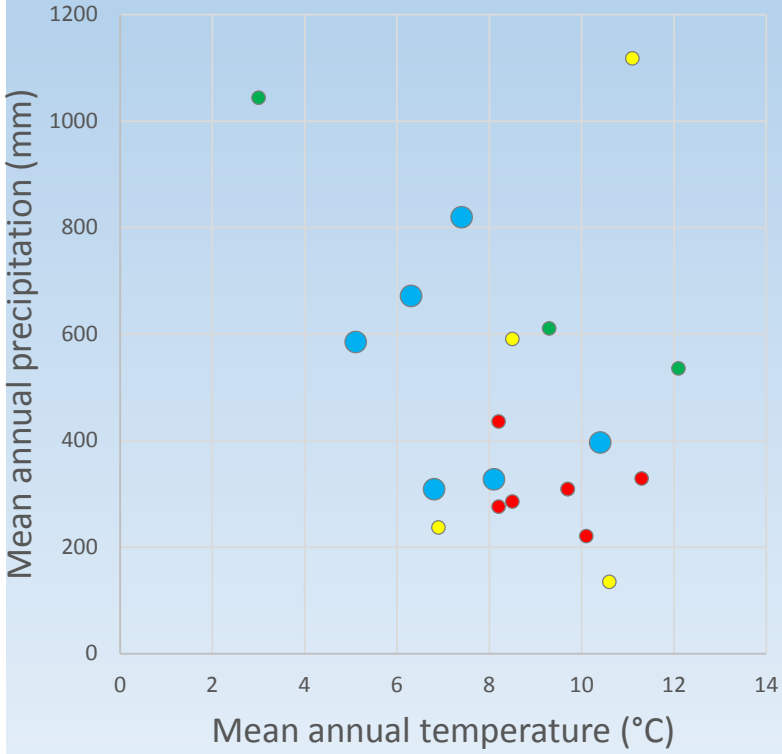
Various long-term research sites, universities and federal



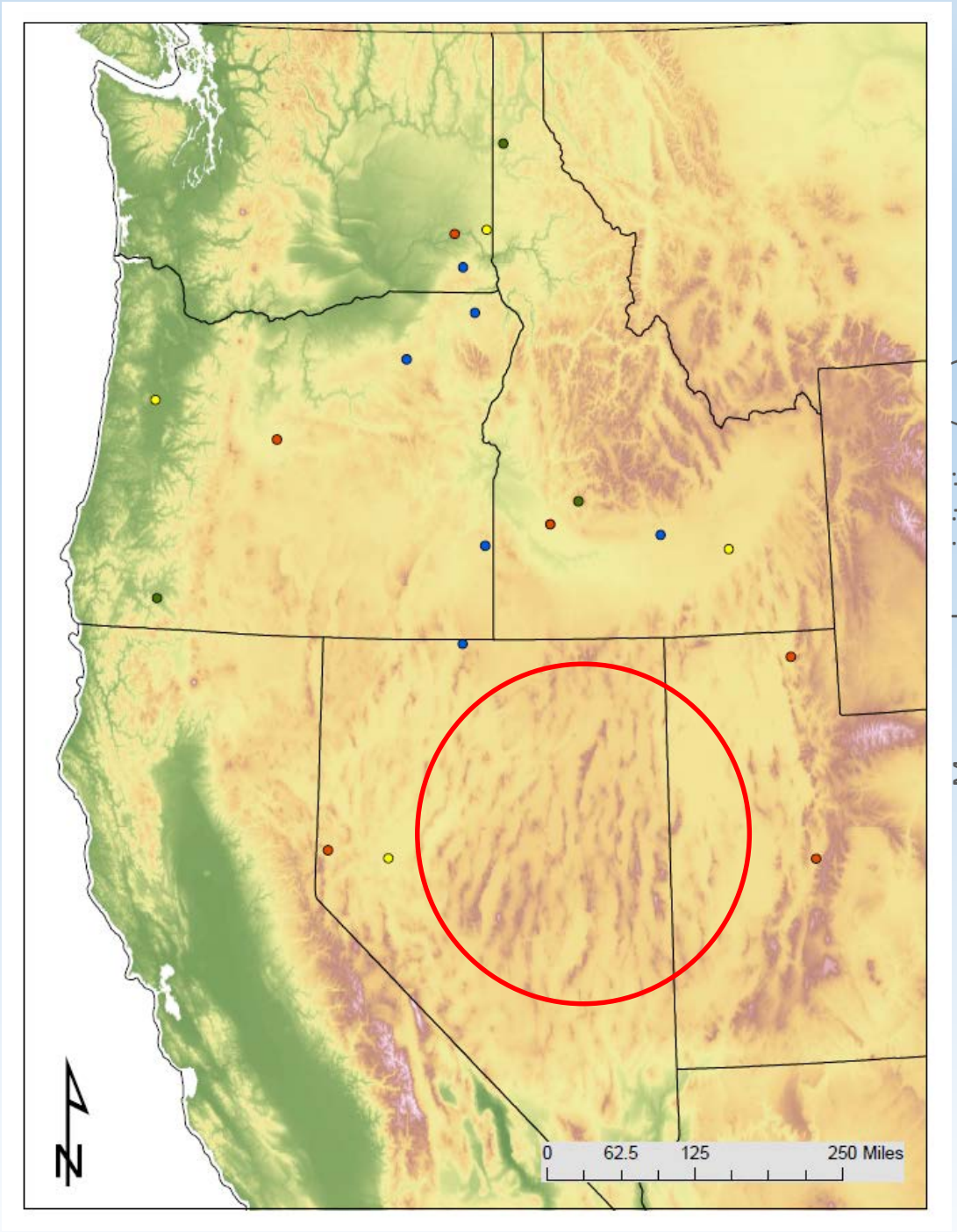


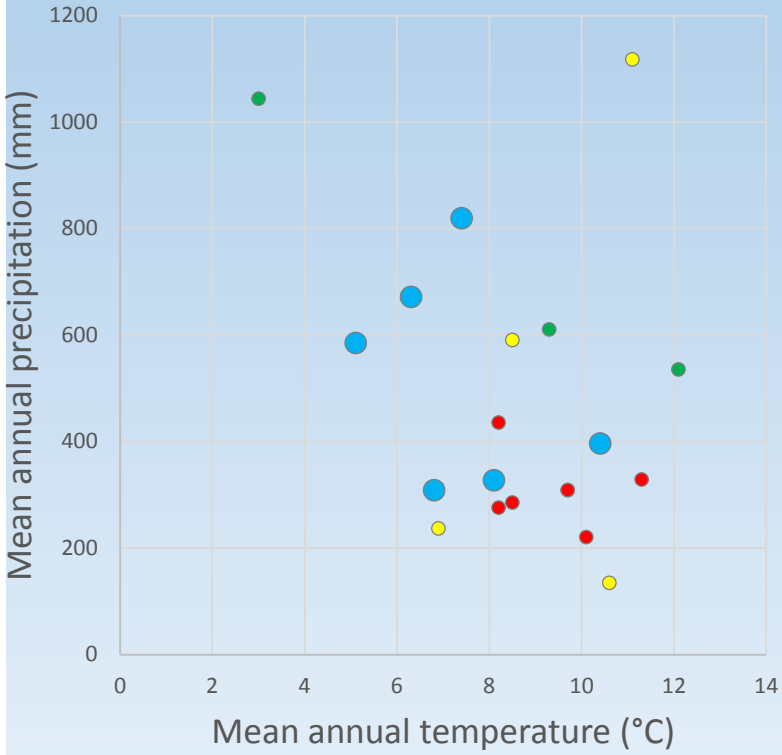


Bluebunch reciprocal transplant sites with extra infrastructure (fences)



Developing more sites in Nevada





Showy goldeneye
(*Heliomeris multiflora*)

Thickleaf penstemon
(*Penstemon pachyphyllus*)

Douglas' dustymaiden
(*Chaenactis douglasii*)

Hoary tansyaster
(*M. canescens*)

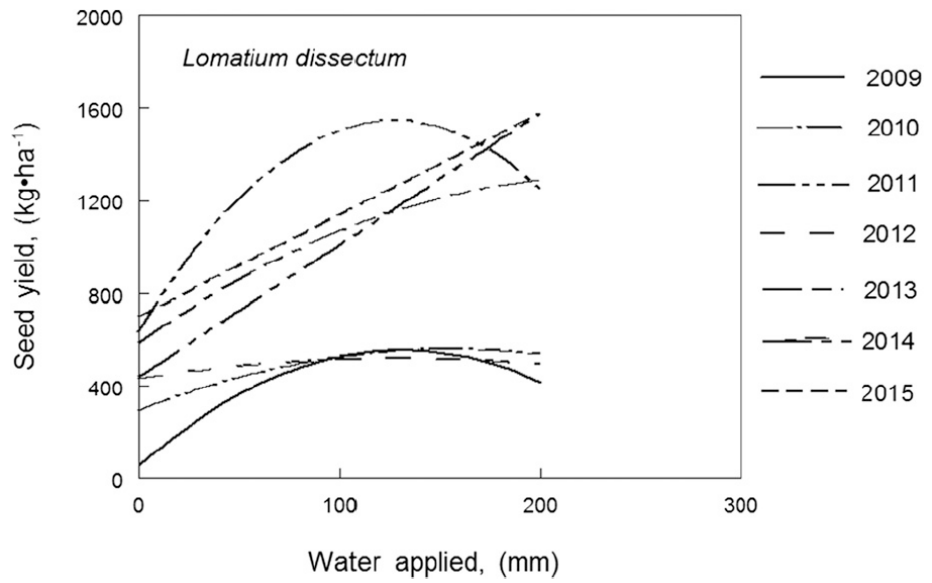
Nettleleaf horsemint
(*A. urticifolia*)

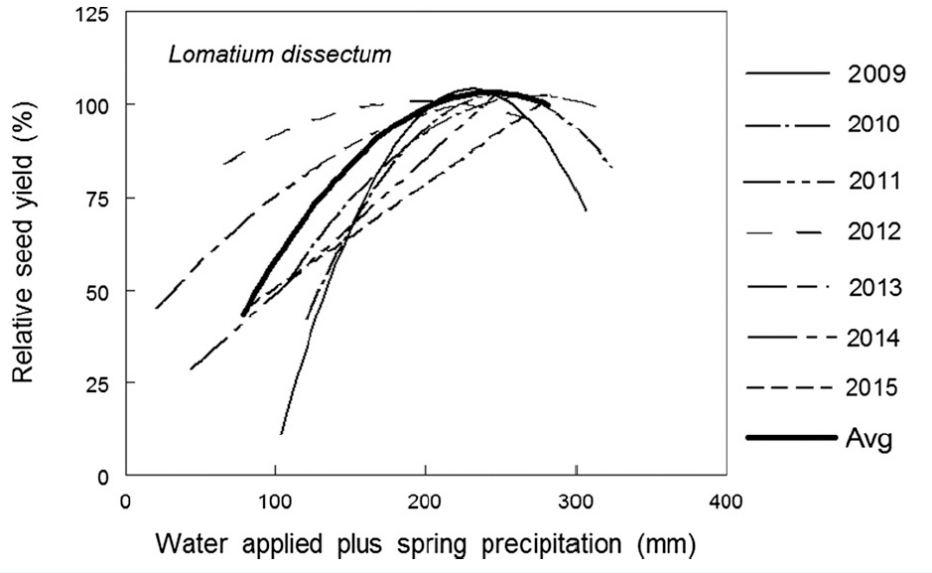
Yellow beeplant
(*Cleome lutea*)

Globemallow
(*S. grossulariifolia*)

Seed production

The importance of proper irrigation

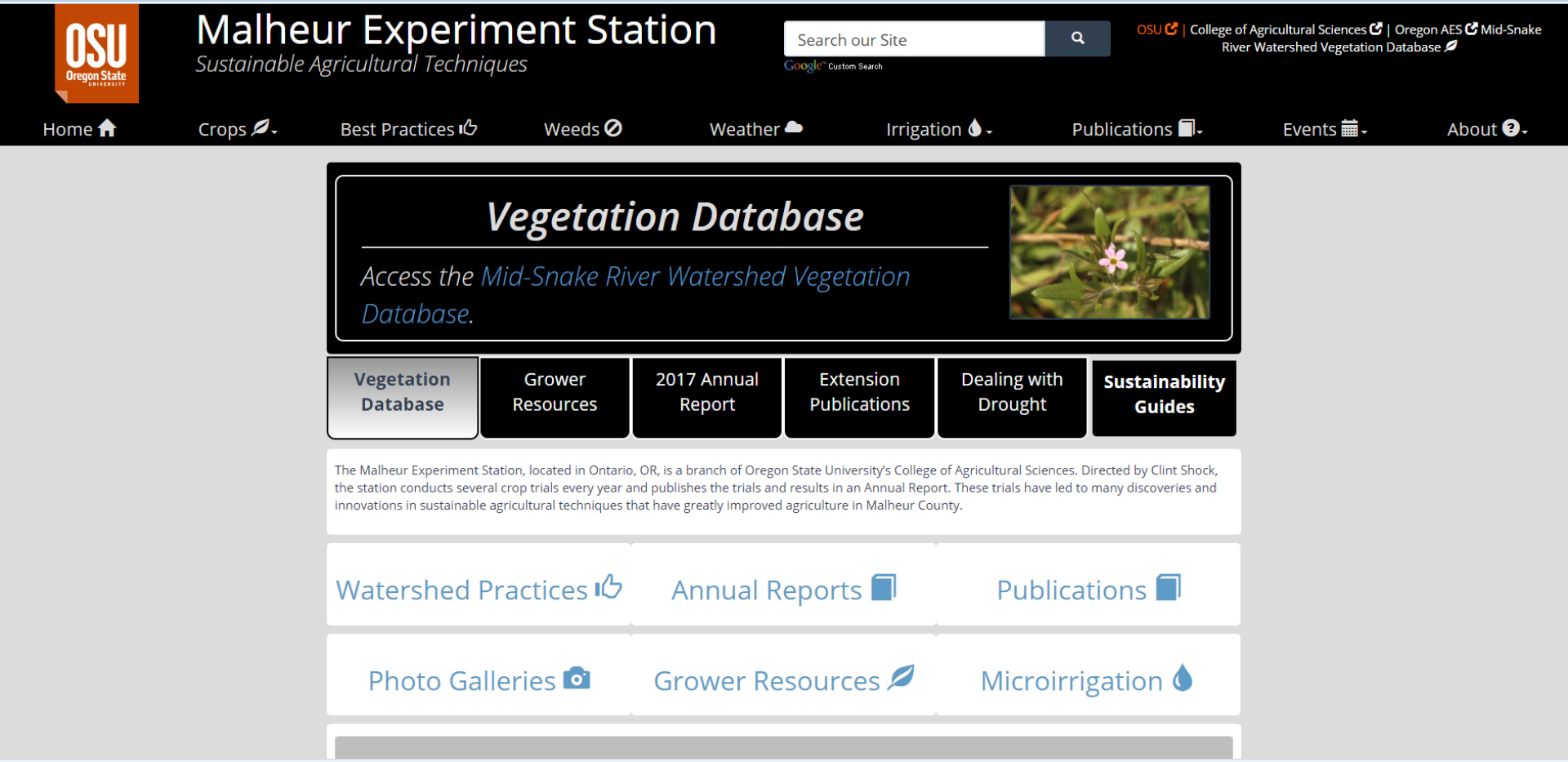




Shock et al. 2016, HortScience

The importance of proper irrigation

Species	Common name	Precipitation Seasons	Respond to irrigation?	Optimal total water (mm)	Irrigation over long-term average (mm)	Average optimized yield (kg/ha)
Astragalus filipes	basalt milkvetch	N/A	No	N/A	N/A	47
Dalea ornata	Blue Mountain prairie clover	Fall, Winter, Spring	Yes	393	163	396
Dalea searlsiae	Searls' prairie clover	Fall, Winter, Spring	Yes	412	182	412
Eriogonum heracleoides	parsnipflower or Wyeth buckwheat	None	Yes	126	126	353
Eriogonum umbellatum	sulphur-flower buckwheat	Spring	Yes	209	142	260
Lomatium dissectum	fernleaf biscuitroot	Spring	Yes	243	176	1097
Lomatium grayi	Gray’s biscuitroot	Fall, Winter, Spring	Yes	358	128	950
Lomatium nudicaule	barestem biscuitroot	N/A	No	N/A	N/A	505
Lomatium suksdorfii	Suksdorf's desertparsley	N/A	No	N/A	N/A	1086
Lomatium triternatum	nineleaf biscuitroot	Spring	Yes	282	215	1529



Malheur Experiment Station: **www.cropinfo.net**

Thank you!

Collaborators

Brad St. Clair, USFS
Holly Prendeville, USFS
Jeff Ott, USFS
Rob Massatti, USGS
Bryce Richardson, USFS
Steve Larson, ARS
Owen Baughman, TNC
Beth Leger, UNR
John Proctor, USFS
Fred Edwards, BLM
Sarah Kulpa, USFWS
Danny Summers, UDWR
Tyler Thompson, UDWR
Steve Petersen, BYU
Clint Shock, OSU

Funding

USFS, BLM, GBNPP, NFP, JFSP, USFWS, GBLCC