'Restoring' for future climates: prairie plant demography in a climate manipulation experiment across a latitudinal gradient

Paul Reed[1] | Megan Peterson[2] | Laurel Pfeifer-Meister[1] | Dan Doak[2] | Bill Morris[3]
Bitty Roy[1] | Bart Johnson[1] | Graham Bailes[1] | Aaron Nelson[1] | Scott Bridgham[1]
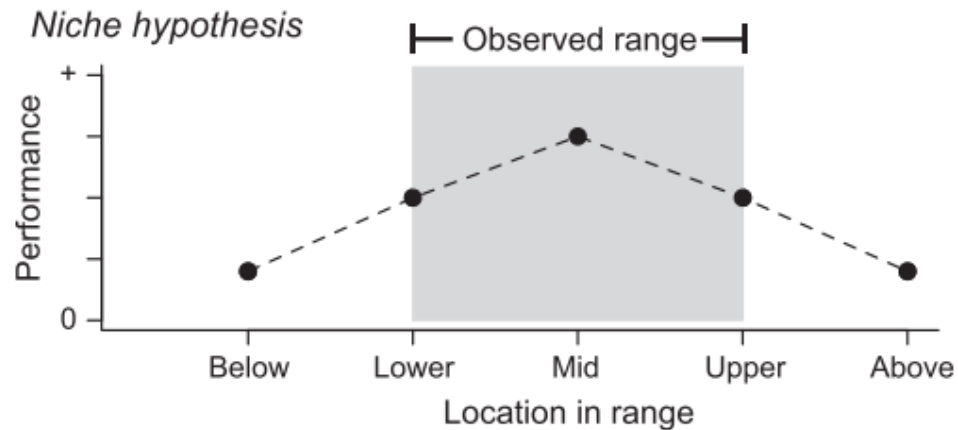
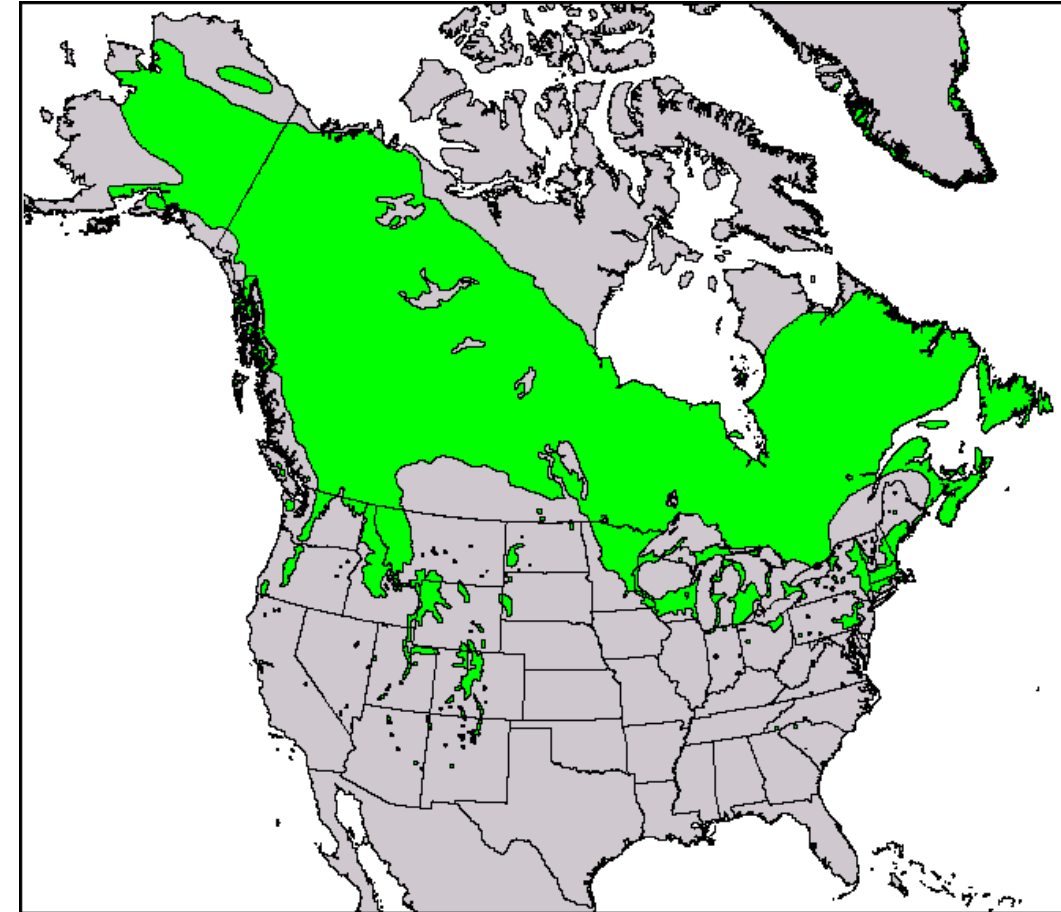[1]University of Oregon, USA | [2]University of Colorado Boulder, USA | [3]Duke University, USA

Species range distribution

Area of occurrence controlled by dispersal ability, climate/habitat tolerance, biotic interactions, etc.

Juniperus communis range map.
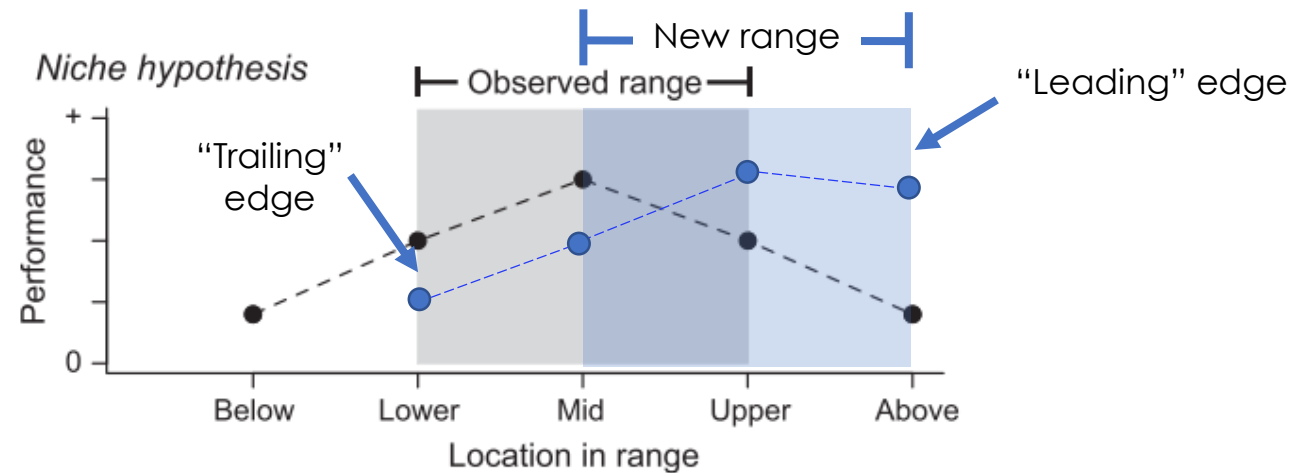

(Ettinger & Hille Ris Lambers, 2017)

(Thompson et al. 1999)

Climate change threatens species current ranges

Average shift of 6.1 km per decade towards the poles (across 99 taxa; Parmesan & Yohe, 2003)

To predict future shifts and species persistence: Critical to understand population responses to climate change across/beyond ranges
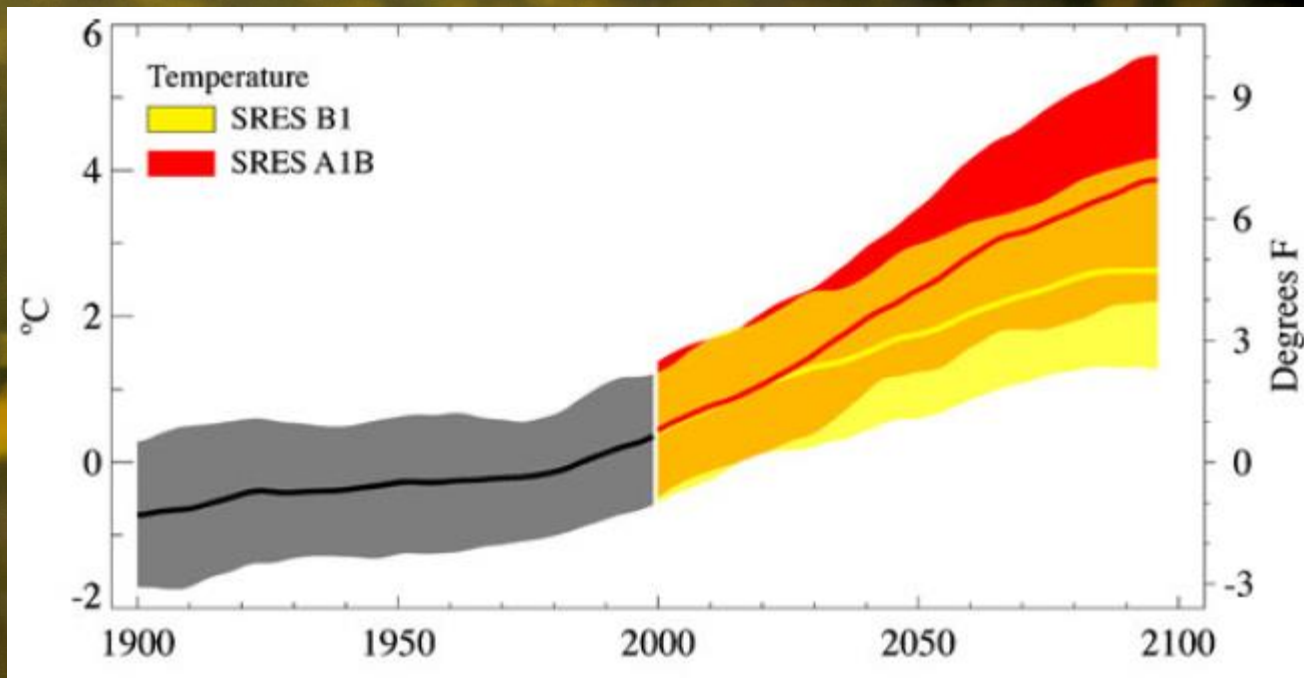

(Ettinger & Hille Ris Lambers, 2017)
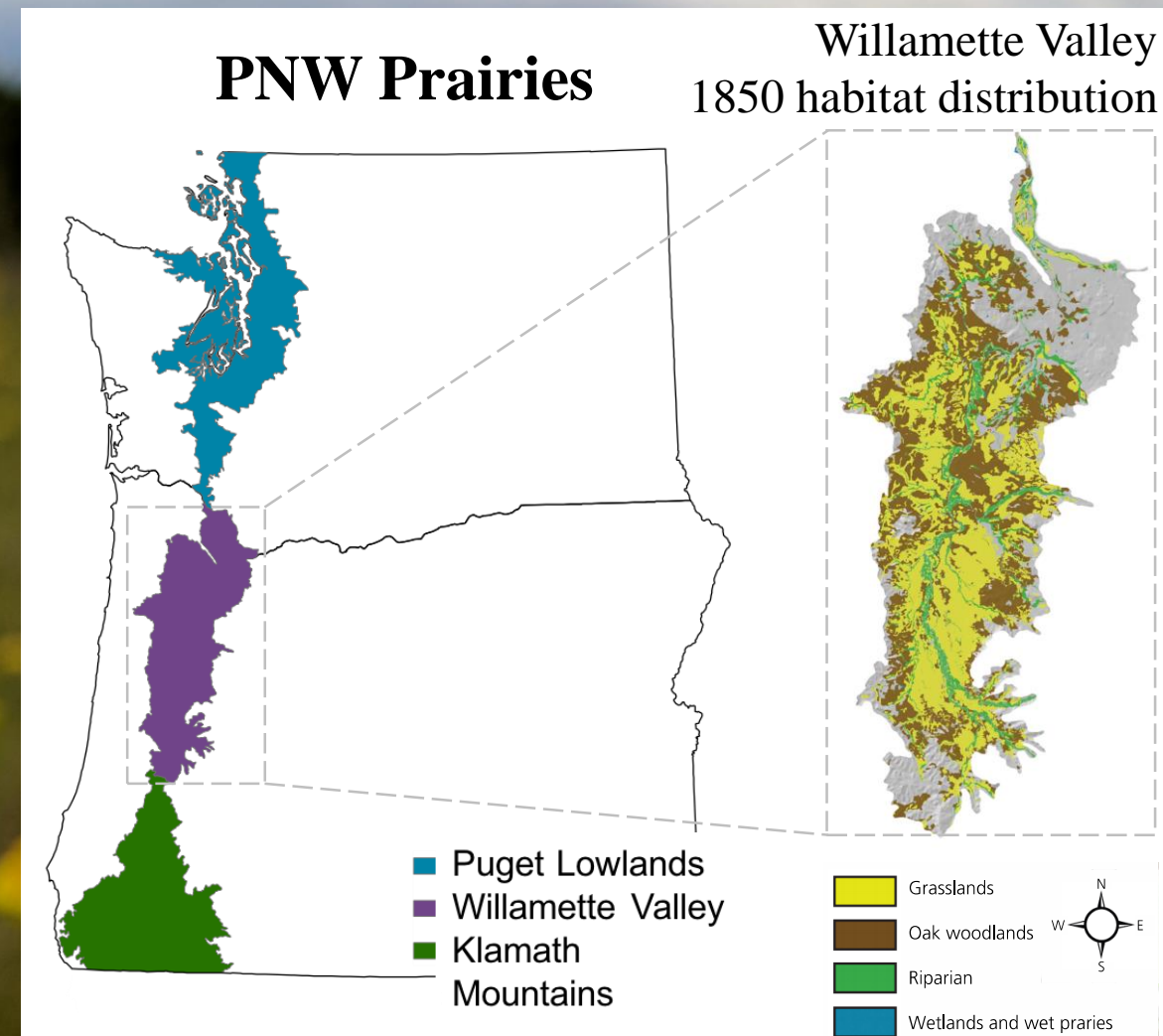

A theoretical range shift

A threat to native biodiversity

Projected temperature increase in the PNW

(Mote & Salathe, 2010)
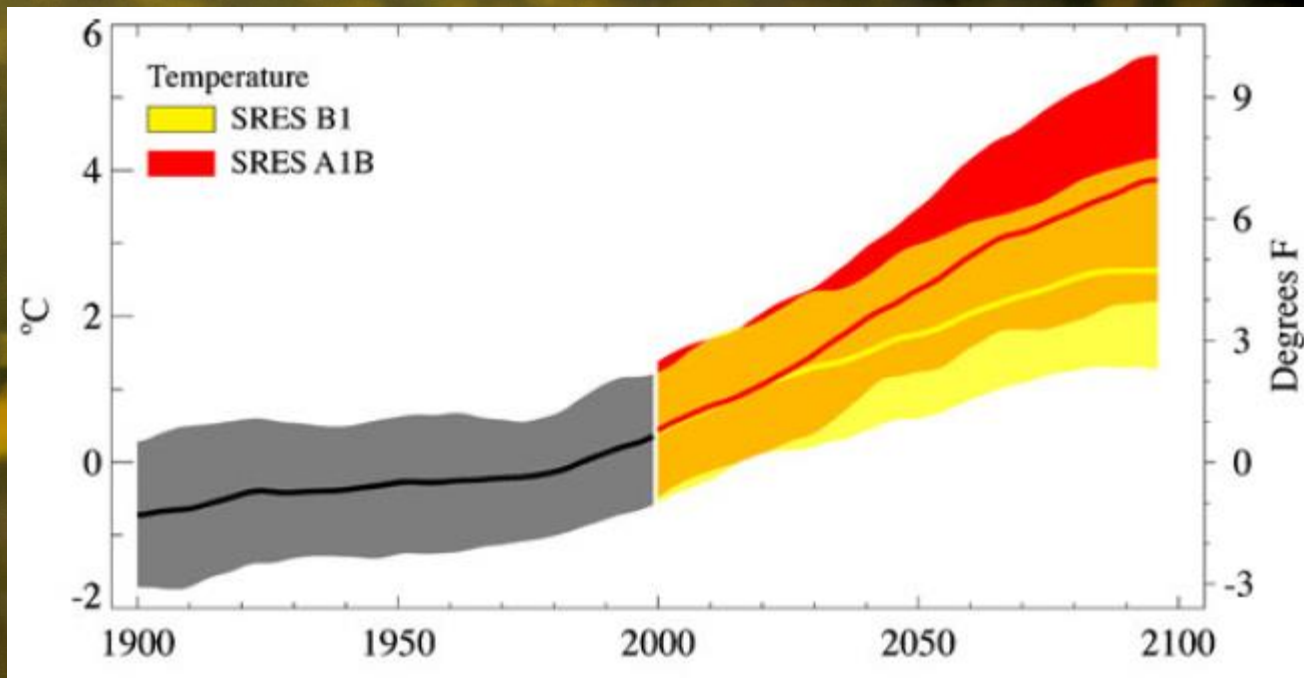
PNW Prairies

Willamette Valley
1850 habitat distribution

- Puget Lowlands
- Willamette Valley
- Klamath Mountains

- Grasslands
- Oak woodlands
- Riparian
- Wetlands and wet praries

Oregon Natural Heritage Information Center, 2004

A threat to native biodiversity

Projected temperature increase in the PNW

(Mote & Salathe, 2010)

PNW Prairies

Willamette Valley
2004 habitat distribution

- Puget Lowlands
- Willamette Valley
- Klamath Mountains

- Grasslands
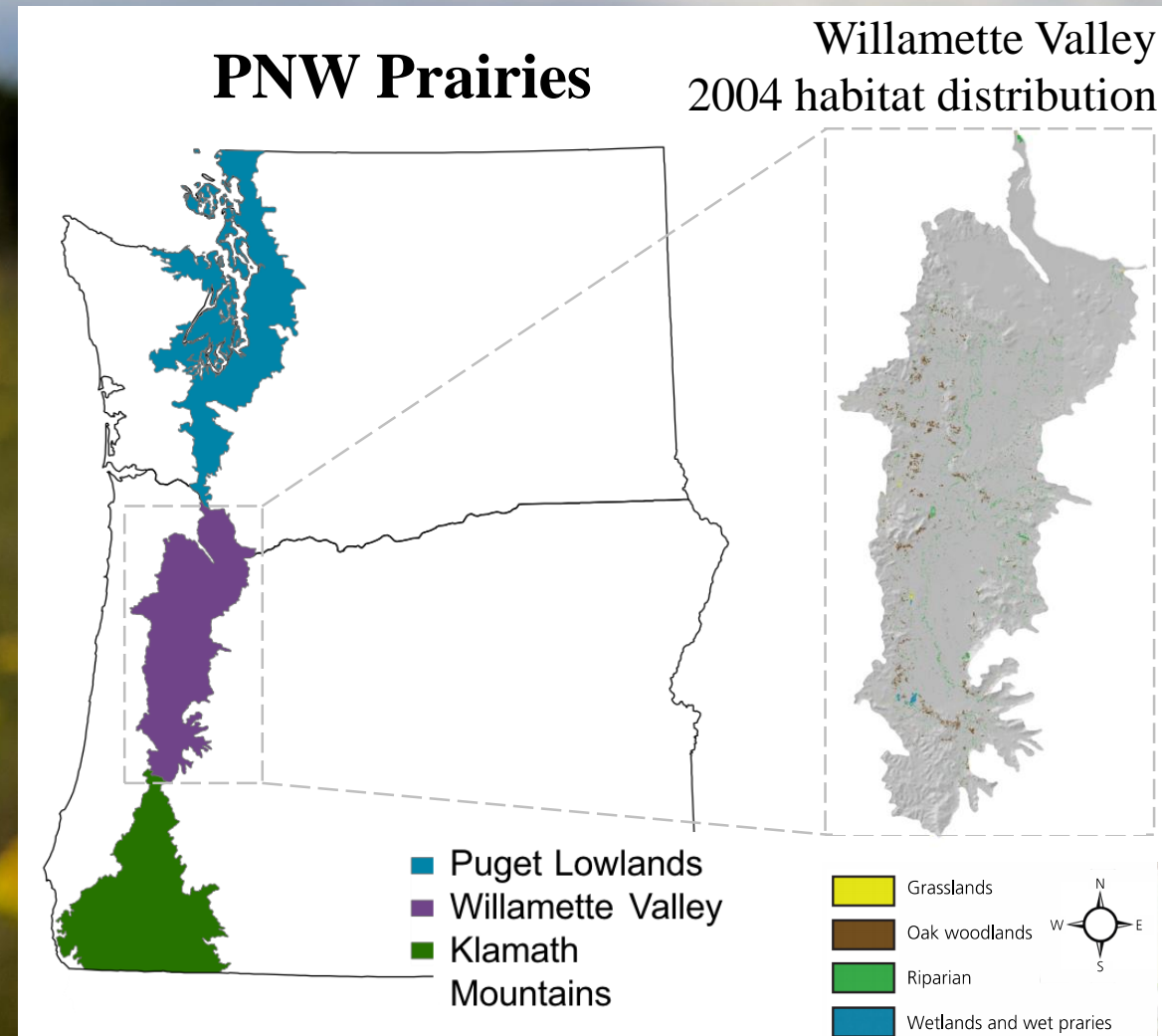- Oak woodlands
- Riparian
- Wetlands and wet praries
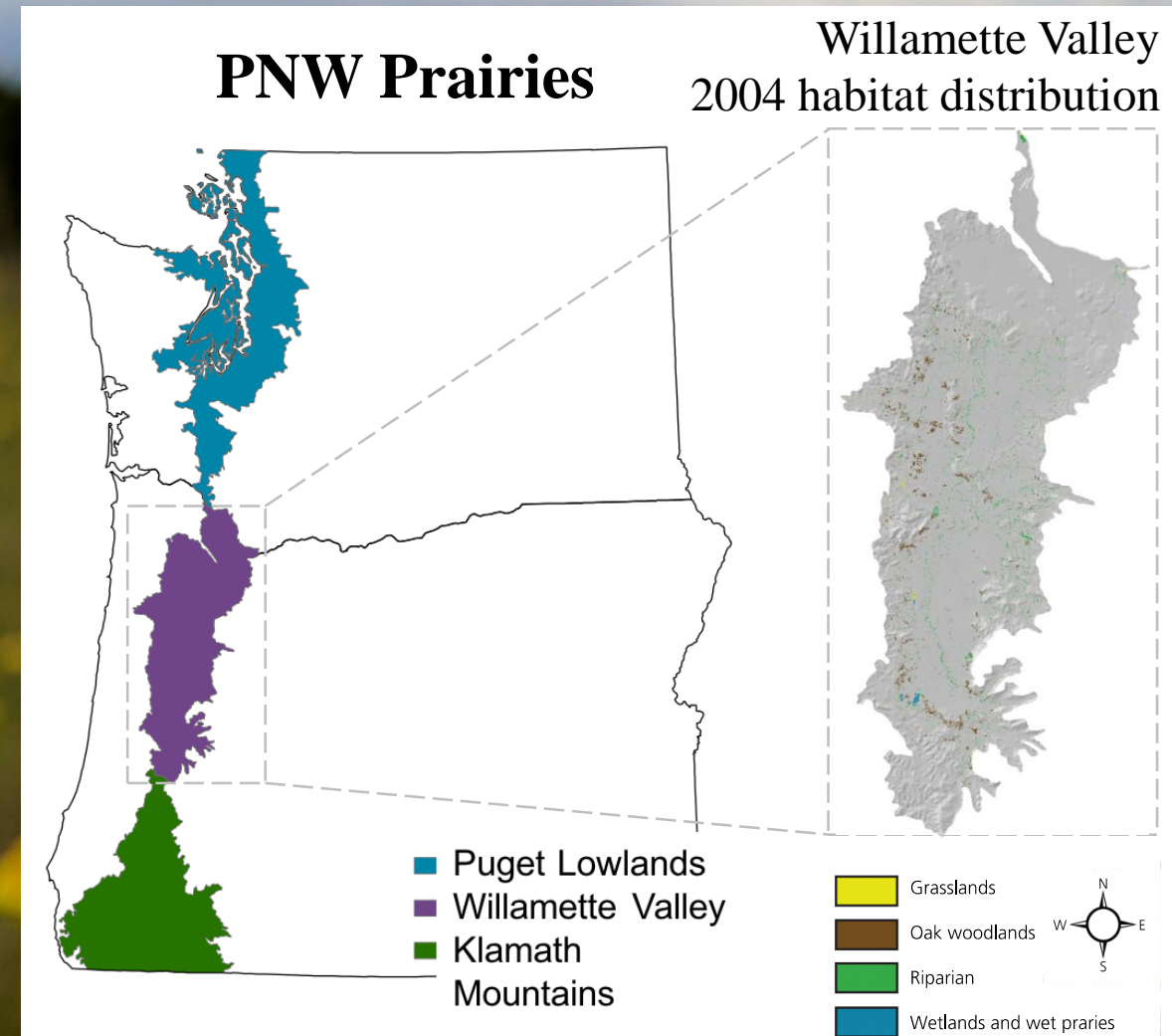
Oregon Natural Heritage Information Center, 2004

A threat to native biodiversity

Under future climates:

Can native prairie species persist in their current ranges?

Can they establish and maintain stable populations beyond their current northern limits?

PNW Prairies

Willamette Valley
2004 habitat distribution

- Puget Lowlands
- Willamette Valley
- Klamath Mountains

- Grasslands
- Oak woodlands
- Riparian
- Wetlands and wet praries

Oregon Natural Heritage Information Center, 2004

HOPS (Heating of Prairie Systems) Experiment

Studied species' demographic responses to a climate manipulation experiment across a latitudinal gradient in the Pacific Northwest
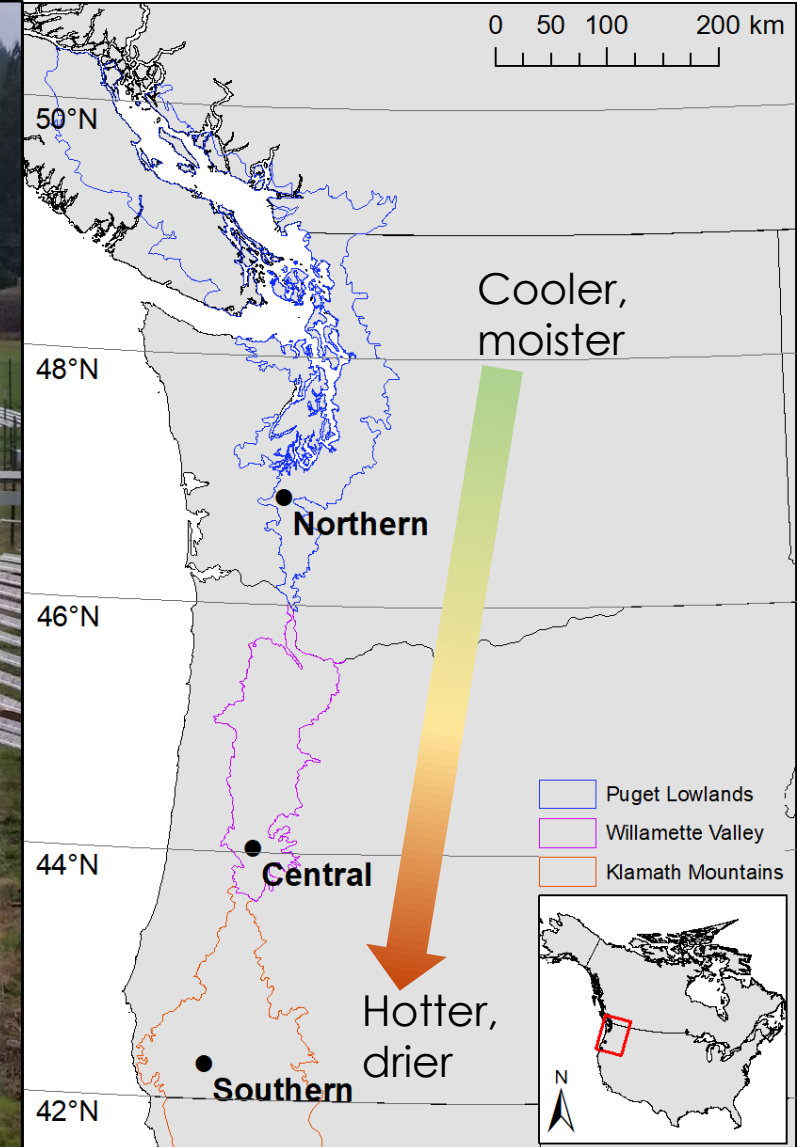
Climate treatments:

Control

Drought

Warming

Warming+ppt

Cooler, moister

Hotter, drier

Northern

Central

Southern

Puget Lowlands
Willamette Valley
Klamath Mountains

HOPS (Heating of Prairie Systems) Experiment

Studied species' demographic responses to a climate manipulation experiment across a latitudinal gradient in the Pacific Northwest
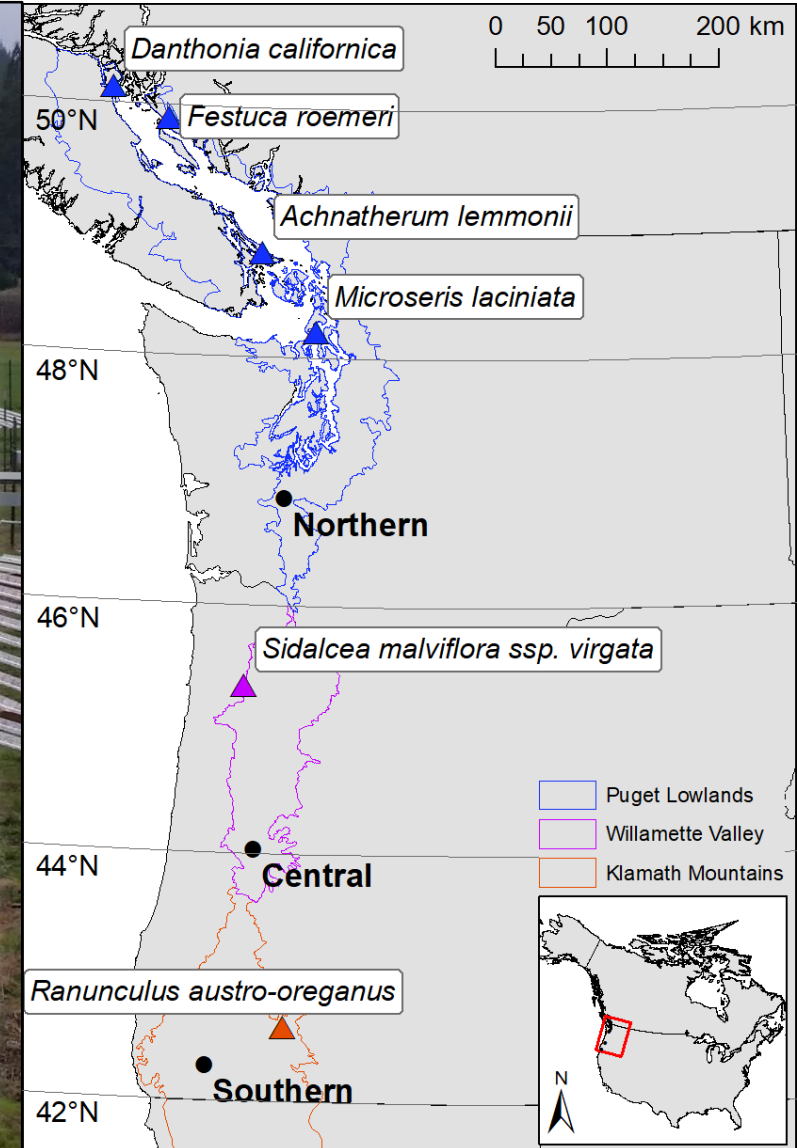
14 native prairie species:

Eight annuals

Six perennials

1 *Danthonia californica*
2 *Festuca roemeri*
3 *Achnatherum lemmonii*
4 *Microseris laciniata*
5 *Sidalcea malviflora ssp. virgata*
6 *Ranunculus austro-oreganus*

Danthonia californica
Festuca roemeri
Achnatherum lemmonii
Microseris laciniata

Northern

0 50 100   200 km

48°N

46°N

Sidalcea malviflora ssp. virgata

44°N

Central

Ranunculus austro-oreganus

Southern

42°N

50°N

Puget Lowlands
Willamette Valley
Klamath Mountains

Perennials: tracked individuals through 2016-2018 growing seasons

Modeled species vital rates:

- Survival

- Growth

- Fecundity
  - Probability of reproduction
  - Flower/fruit/seed production
  - Probability of germination

Perennials: tracked individuals through 2016-2018 growing seasons

- Used integral projection models (IPMs) that relate state of an individual (size) to its vital rates to project population dynamics

- Calculated population growth rates (λ) for each treatment at each site over both annual transitions

We hypothesized:

Climate does not currently limit range-restricted species' northern boundaries.

Warming and drought would cause population decline within current ranges but not beyond species' northern limits.

Range-restricted perennials established north of leading edges

Reproductive adults of *Ranunculus austro-oreganus* (left) and *Sidalcea malviflora* (right) at the Northern site in 2017.

Sidalcea malviflora ssp. virgata

Ranunculus austro-oreganus

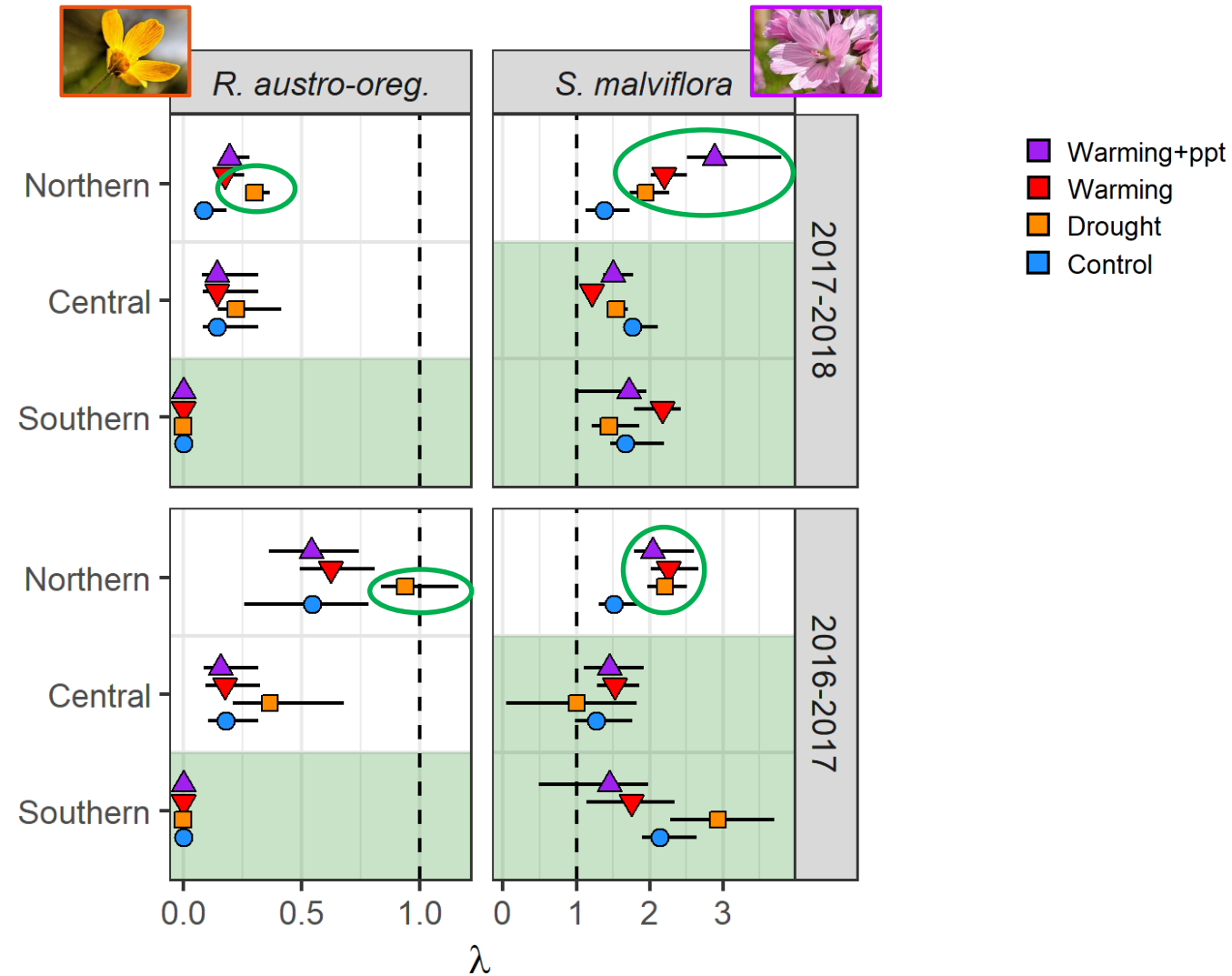| | Puget Lowlands |
| | Willamette Valley |
| | Klamath Mountains |
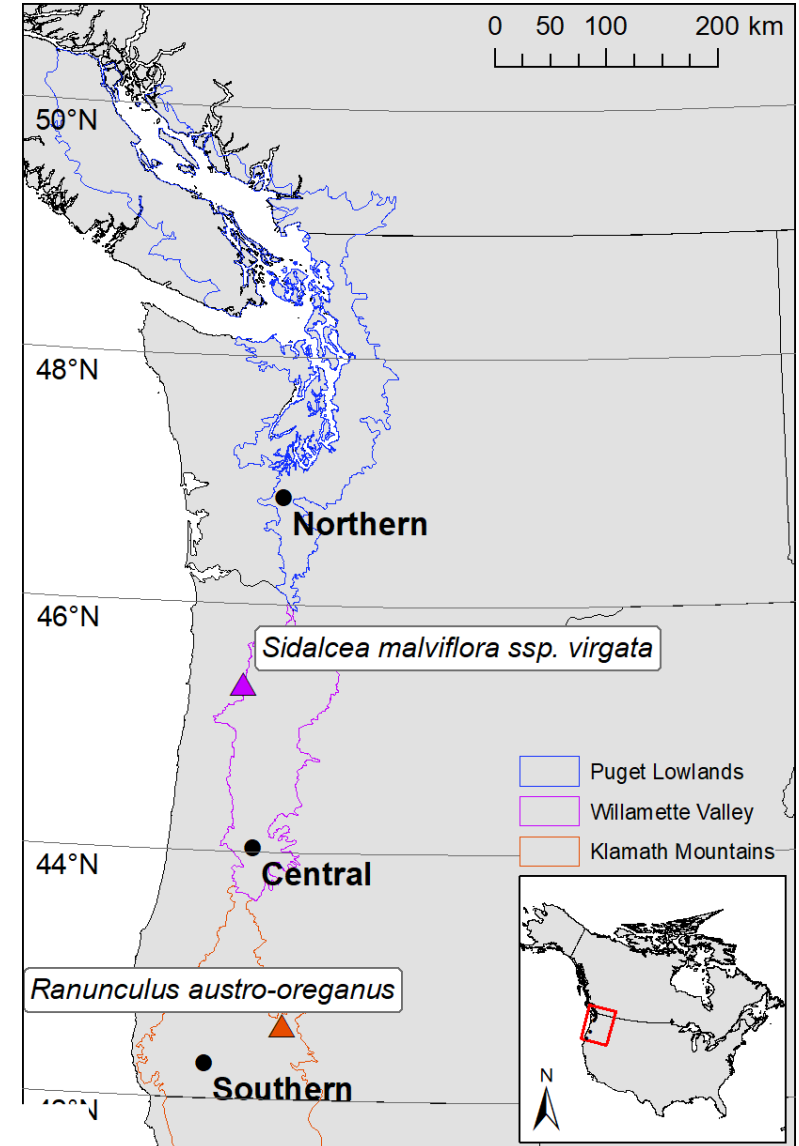
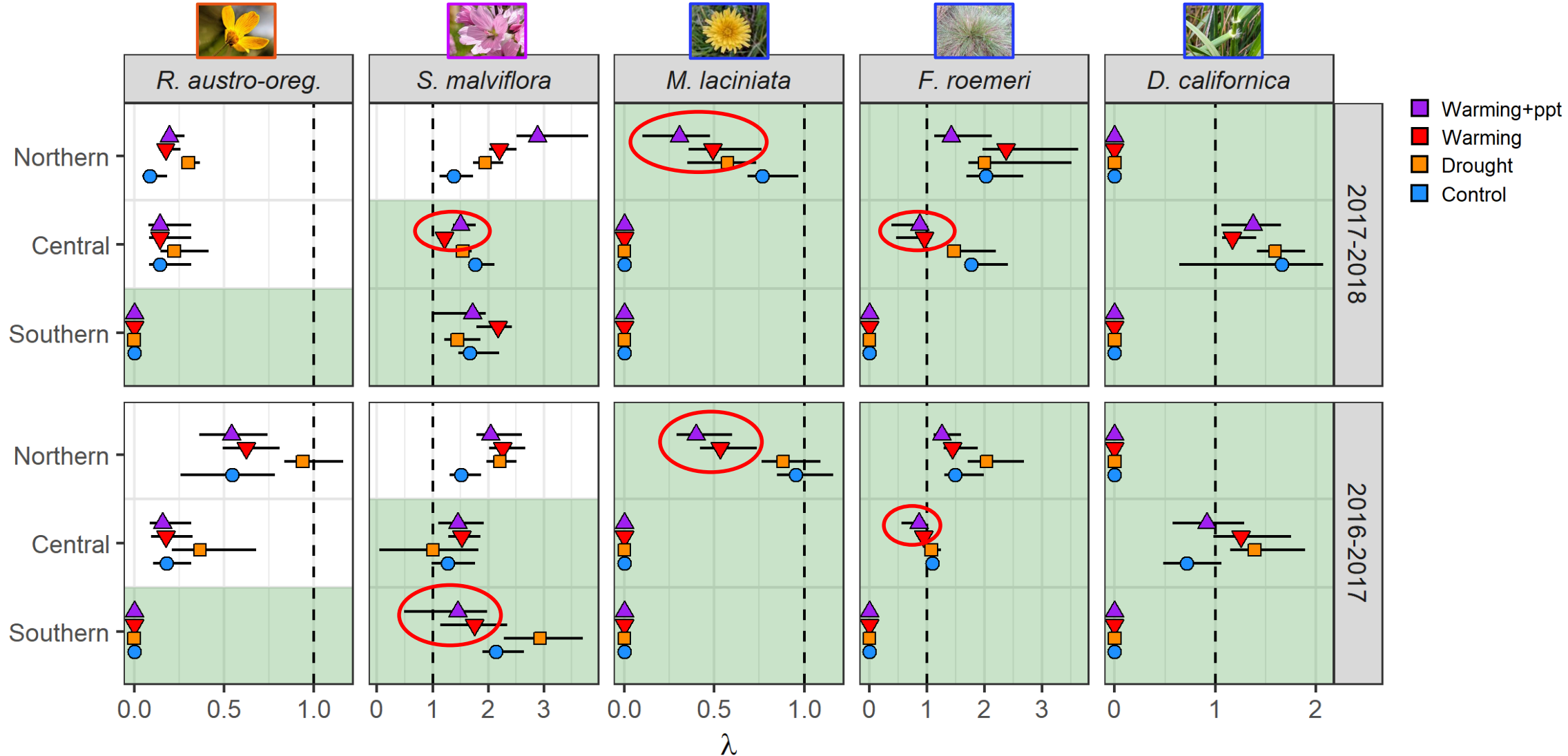# Most species failed to establish at one or more sites within current ranges, especially in the south
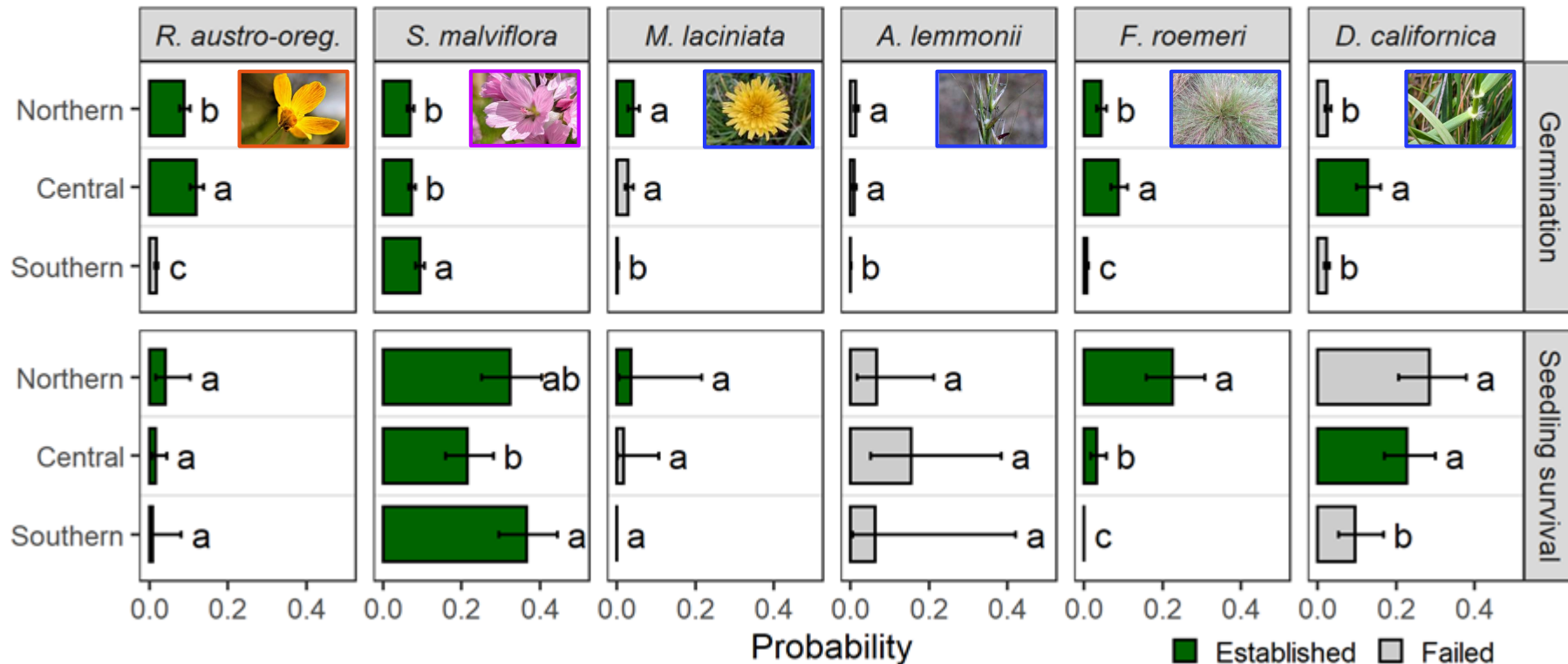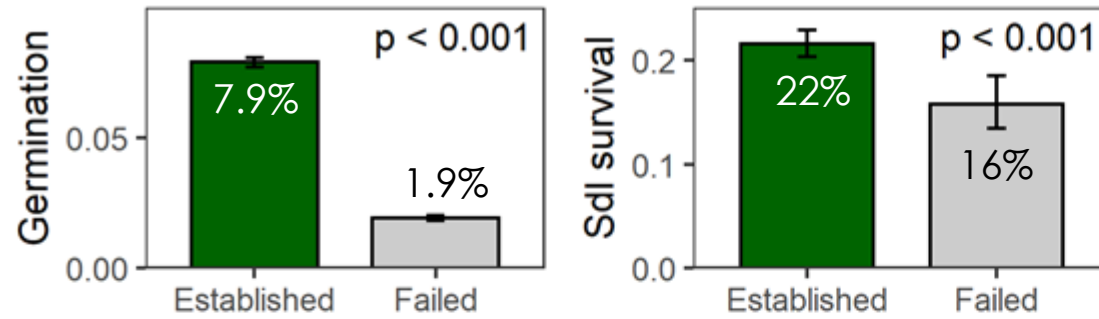
Climate treatments had neutral to positive effects on λ beyond northern limits of range-restricted species

However:

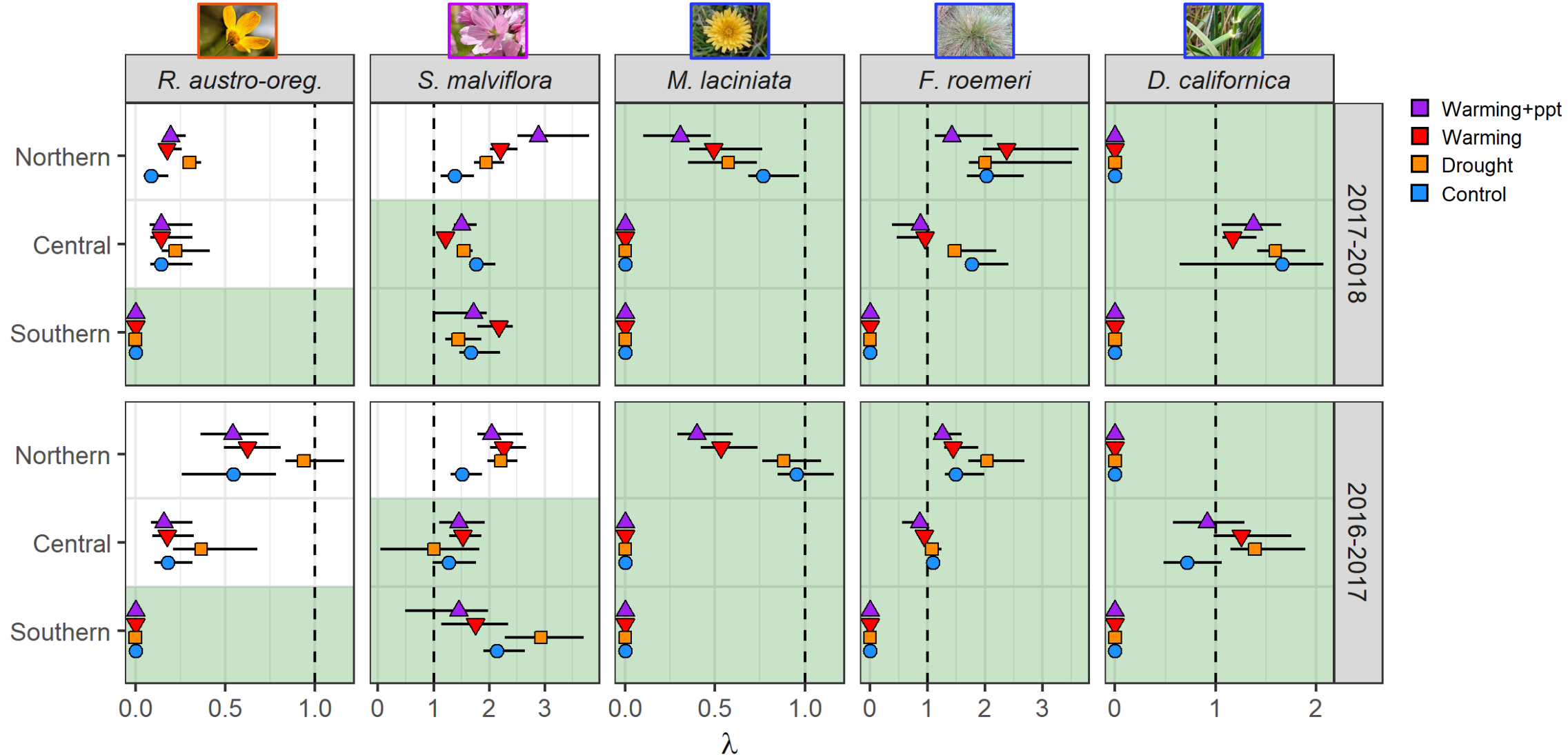*Ranunculus* populations still well below replacement level (λ < 1)

Warming had neutral to negative effects on λ within current ranges

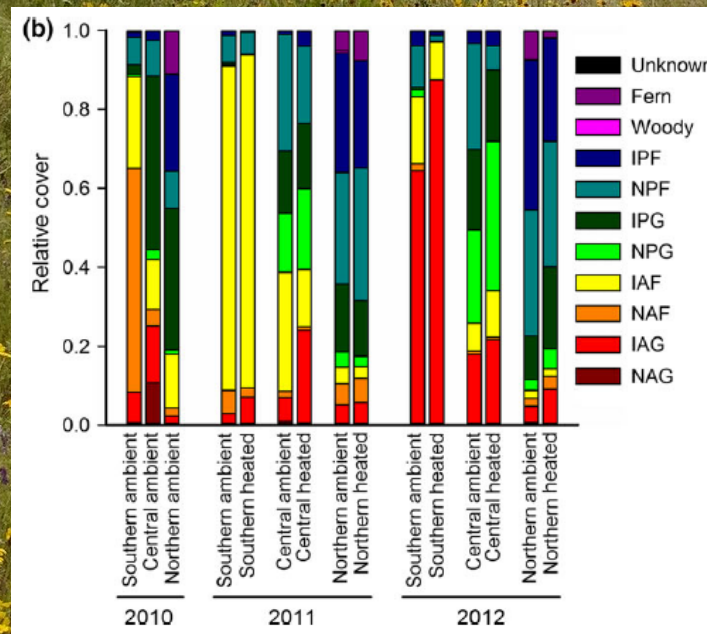# 'Leading-trailing' patterns observed, accentuated by climate change

Conclusions

Species face challenges within current ranges, especially towards the hotter, drier south.

"Californication" of PNW prairies

🟥 Invasive annual grasses

(Pfeifer-Meister et al., 2016)

A southern warming plot in 2017 dominated by the invasive winter-annual grasses *Bromus tectorum* and *Bromus hordeaceus*.

Conclusions

Species face challenges within current ranges, especially towards the hotter, drier south.

Climate change will make current ranges *less* hospitable…
But beyond ranges *more* hospitable.

Ranunculus austro-oreganus

Failed to establish within its range.

$\lambda \approx 1$ in four natural populations from 2015-2018. (Peterson et al., *in prep*)

Established north of range limit, but $\lambda << 1$.

Endemic to a single county in SW Oregon.

Microseris laciniata

Only established in the north, where $\lambda \leq 1$ and $\ll 1$ under warming.

$\lambda < 1$ in four natural populations from 2015-2018.
(Peterson et al., *in prep*)

Achnatherum lemmonii

Failed to establish with germination ~1.0%.

Greenhouse germination ~0.05%.

Natural populations are small and disjunct. *Inbreeding depression?*

$\lambda \leq 1$ in four natural populations from 2015-2018.
(Peterson et al., *in prep*)
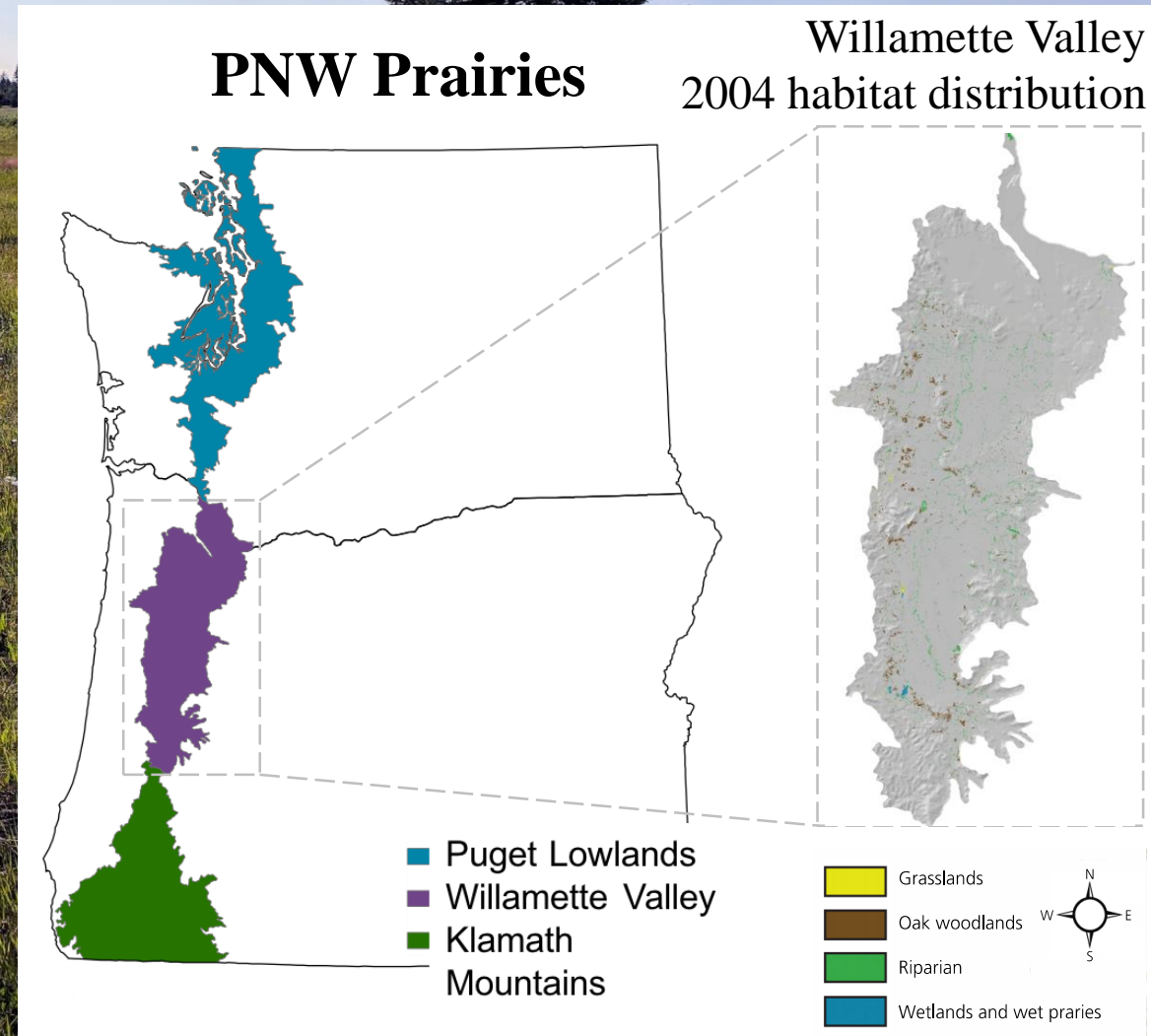

Photo: Silver Falls Seed Company

Restoring for future climates

Restoring historic populations may be difficult.

- Plant plugs to aid establishment

- Actively manage to promote genetic diversity

- Increase habitat connectivity to facilitate natural migrations

Can species disperse to new habitat?

- If not – intervention may be necessary to save species from extinction

PNW Prairies

Willamette Valley
2004 habitat distribution

- Puget Lowlands
- Willamette Valley
- Klamath Mountains

- Grasslands
- Oak woodlands
- Riparian
- Wetlands and wet praries

Acknowledgments

Questions?

Contact: Paul Reed
preed@uoregon.edu