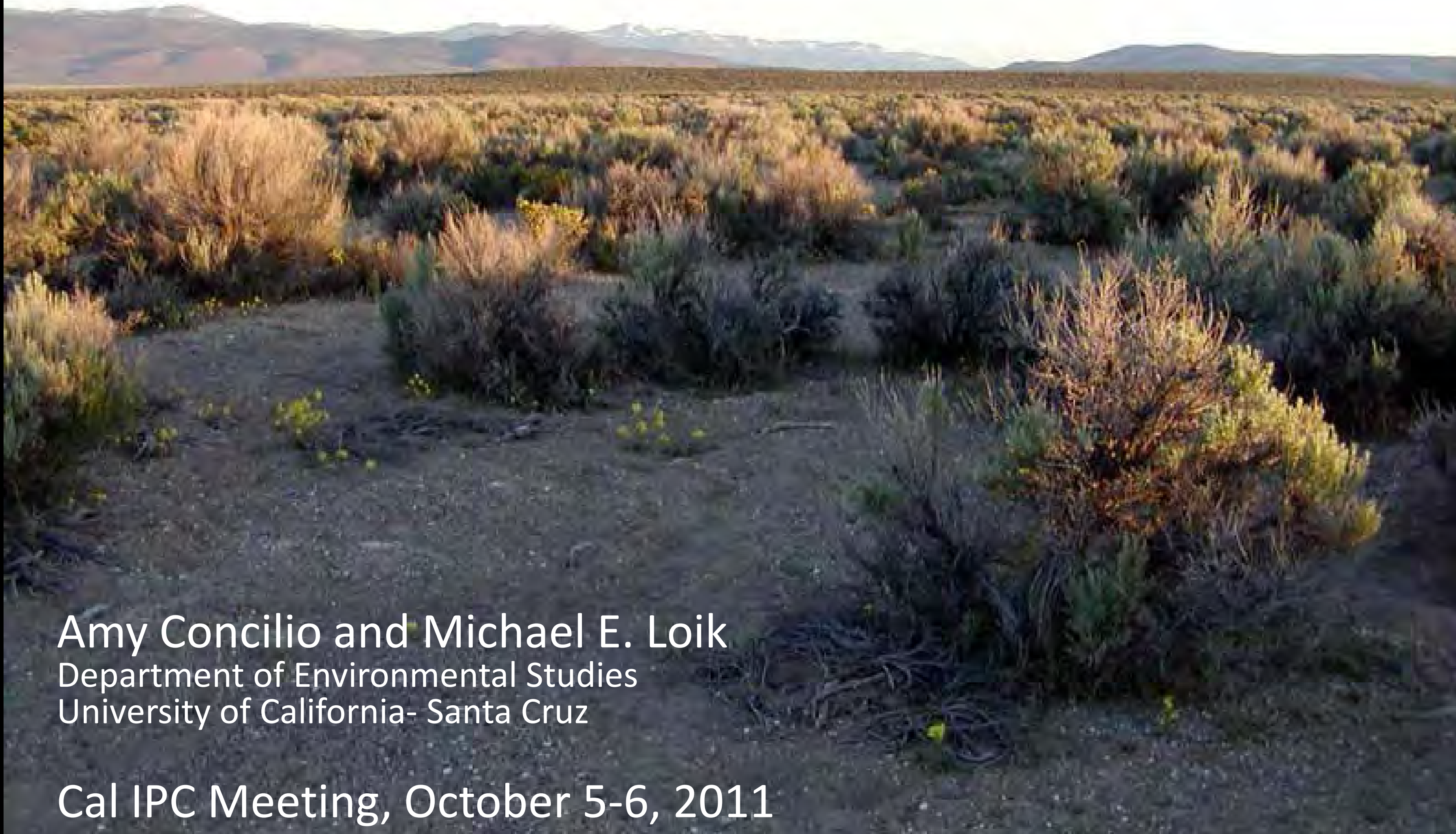
Effects of changing precipitation patterns on the spread of *Bromus tectorum* L. in the eastern Sierra Nevada and implications for management



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Cal IPC Meeting, October 5-6, 2011

Outline of Talk

- Climate change in the Sierra Nevada
- *Bromus tectorum* spread in the Intermountain West
- Effects of changing snow and rain on *B. tectorum* in the eastern Sierra Nevada
- Implications for management

Climate Change Predictions for CA

Moser et al. 2009. AN UPDATE ON CLIMATE CHANGE SCIENCE IMPACTS AND RESPONSE OPTIONS FOR CALIFORNIA. Prepared for the CA Energy Commission

- Increase in temperature
- Magnitude of precipitation uncertain
- Shift from snow to rain
- Decrease in snow accumulation
- Earlier snow melt
- Snow line shifts upward in elevation

How will changes in precipitation affect plant communities in the Sierra Nevada?

→ Invasive plant species?

→ Cheatgrass?

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Bromus tectorum

- Also known as cheatgrass, downy brome, drooping brome, downy chess
- Annual grass native to Eurasia and the Mediterranean region
- Considered invasive in many parts of the world
- Introduced to the US in the mid 1800s, spread throughout the Intermountain West

Cheatgrass is now the dominant species on more than 100 million acres of the Intermountain West (Whisenant 1989).

Cheatgrass in the Great Basin

Bromus tectorum, Cheatgrass

Great Basin sagebrush steppe

Inc fuel surface-to-volume ratio & horizontal fuel continuity

New fuel characteristics facilitate ignition

Increase in fire frequency and extent

More frequent fires favor cheatgrass

Cheatgrass in the Eastern Sierra

- Small populations
- Later germination
  - smaller individuals (15-20 cm vs. 50-60 cm tall)
  - lower biomass
- Coexists with native bunchgrasses

How will climate change affect cheatgrass spread at high elevation?

How will climate change affect cheatgrass spread?

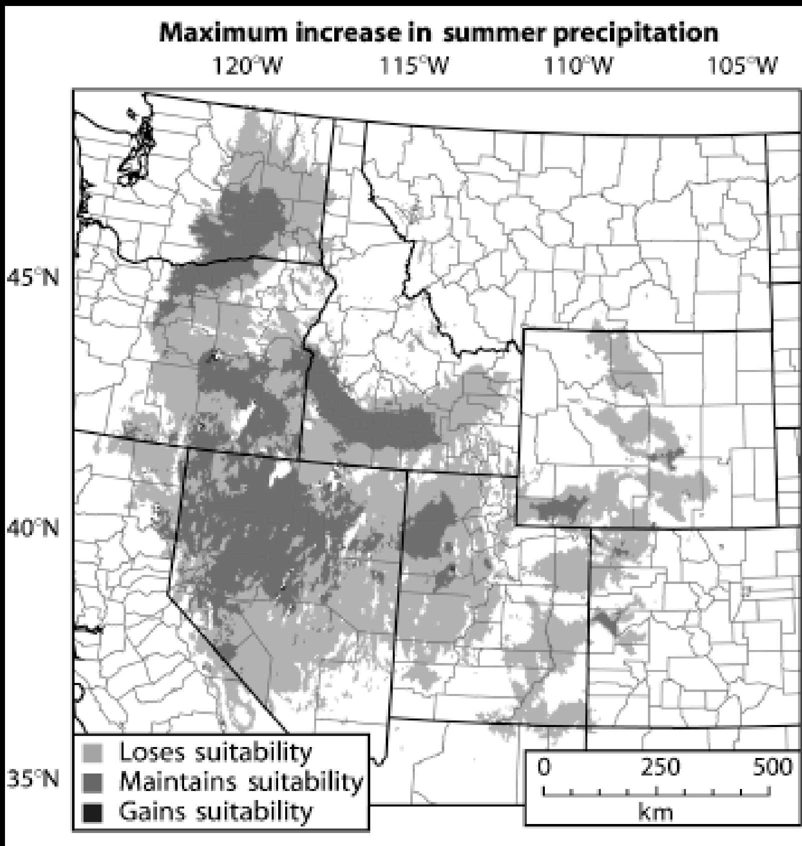
Observational and manipulative studies have shown that cheatgrass is influenced by…

- Interannual variation in precipitation (e.g., Stewart and Hull 1949; Mack and Pyke 1983; West and Yorks 2002; Bradley and Mustard 2005)
- Seasonality of precipitation (e.g., Miller et al. 2006; Bates et al. 2006)

At high elevation…

- Winter temperature (Chambers et al. 2007)
- Snow depth (Griffith and Loik 2010)

How will climate change affect cheatgrass spread?



Bradley 2009

Increased Summer Precipitation could lead to…

- increased competitiveness of native summer growing perennials
- reduced frequency of fire

Reduced Spring Precipitation may..

- decrease soil water resources for cheatgrass during its growing season

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Study Site
Eastern Sierra- Western Great Basin Desert
Valentine Eastern Sierra Reserve, Mammoth Lakes, CA

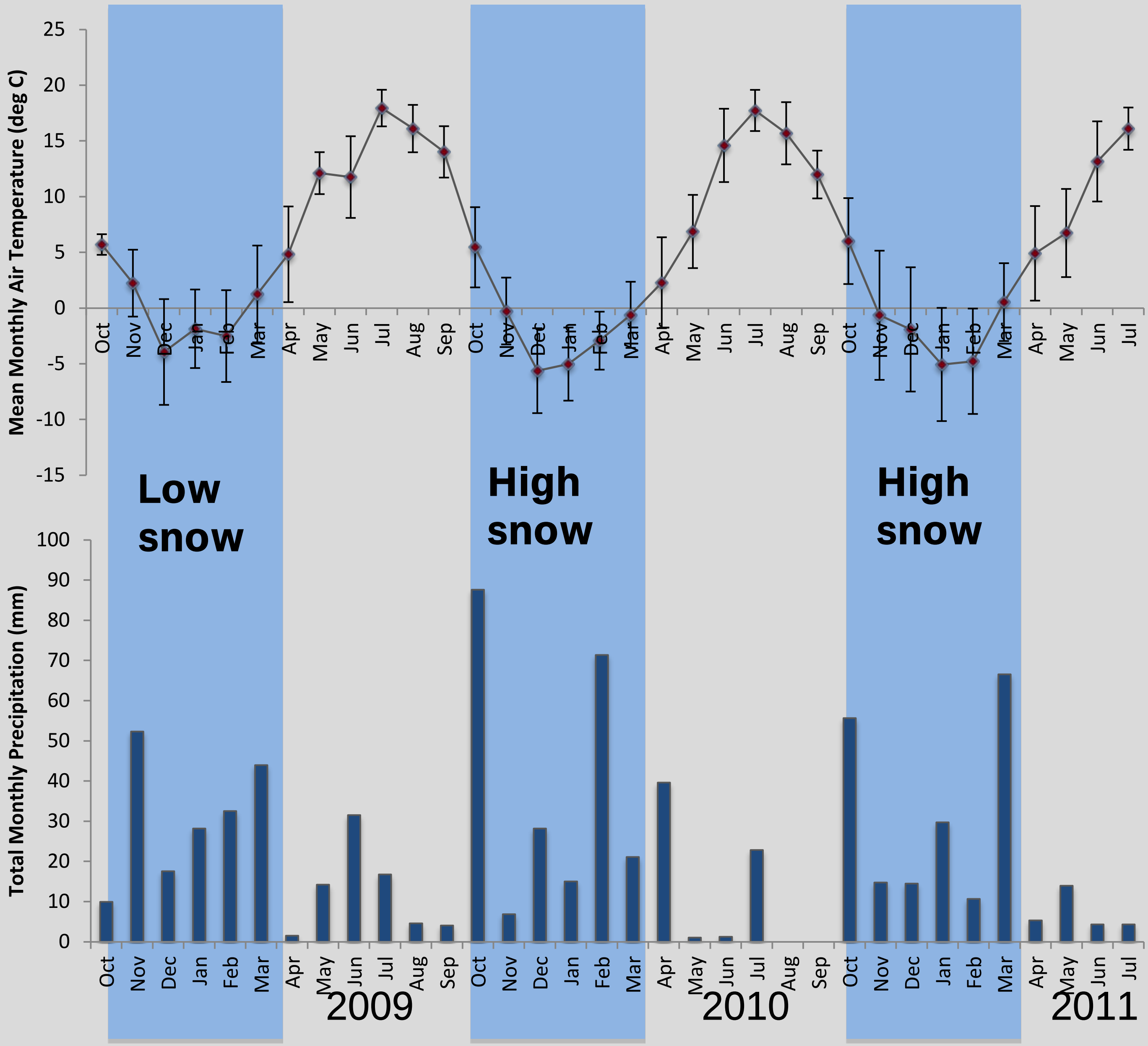
Elevation ~ 2175 m

Photo Source: http://www.fs.fed.us/rm/boise/research/gis/maps.shtml

Study Objectives

- How will *B. tectorum* respond to changing precipitation patterns at high elevation in the eastern Sierra Nevada?
  - Altered snow depth, melt timing
  - Additional spring rain events

- Does response vary by microhabitat?



Error bars are SEM. Data collected at Sierra Nevada Aquatic Research Laboratory.

Precipitation Manipulations

Type

Snow

Rain

Timing

Amb Melt | **Later Melt** | **Earlier Melt**

1X | **2X** | **3X**

Magnitude

Amb | **2X Amb** | **90% Amb**

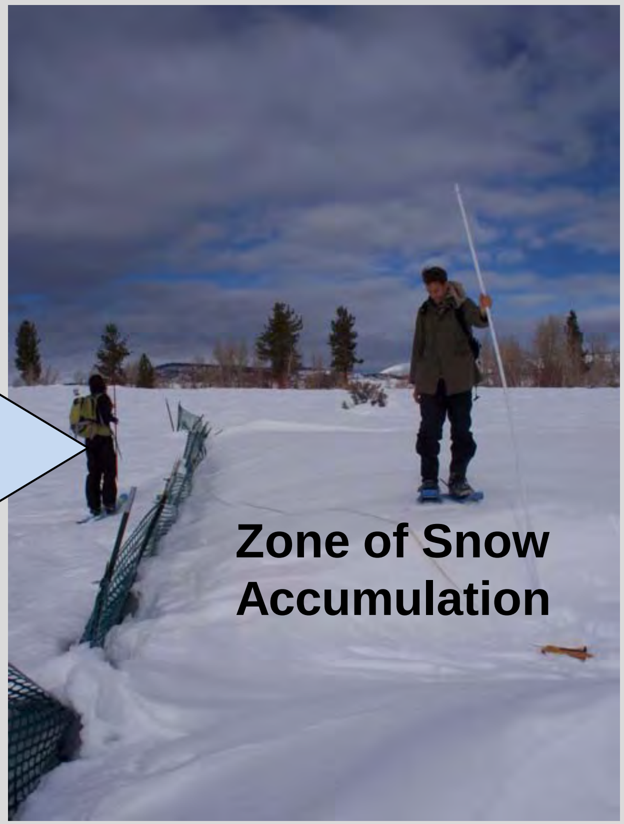
0.8 mm | **1.6 mm** | **2.4 mm** | **4.8 mm**

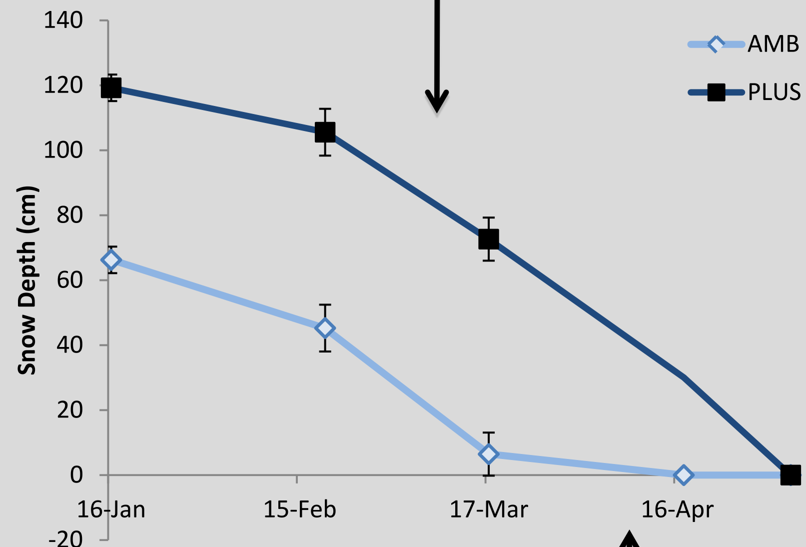
Average Size Storm Event April-June is 2.36 mm

Snow depth treatments

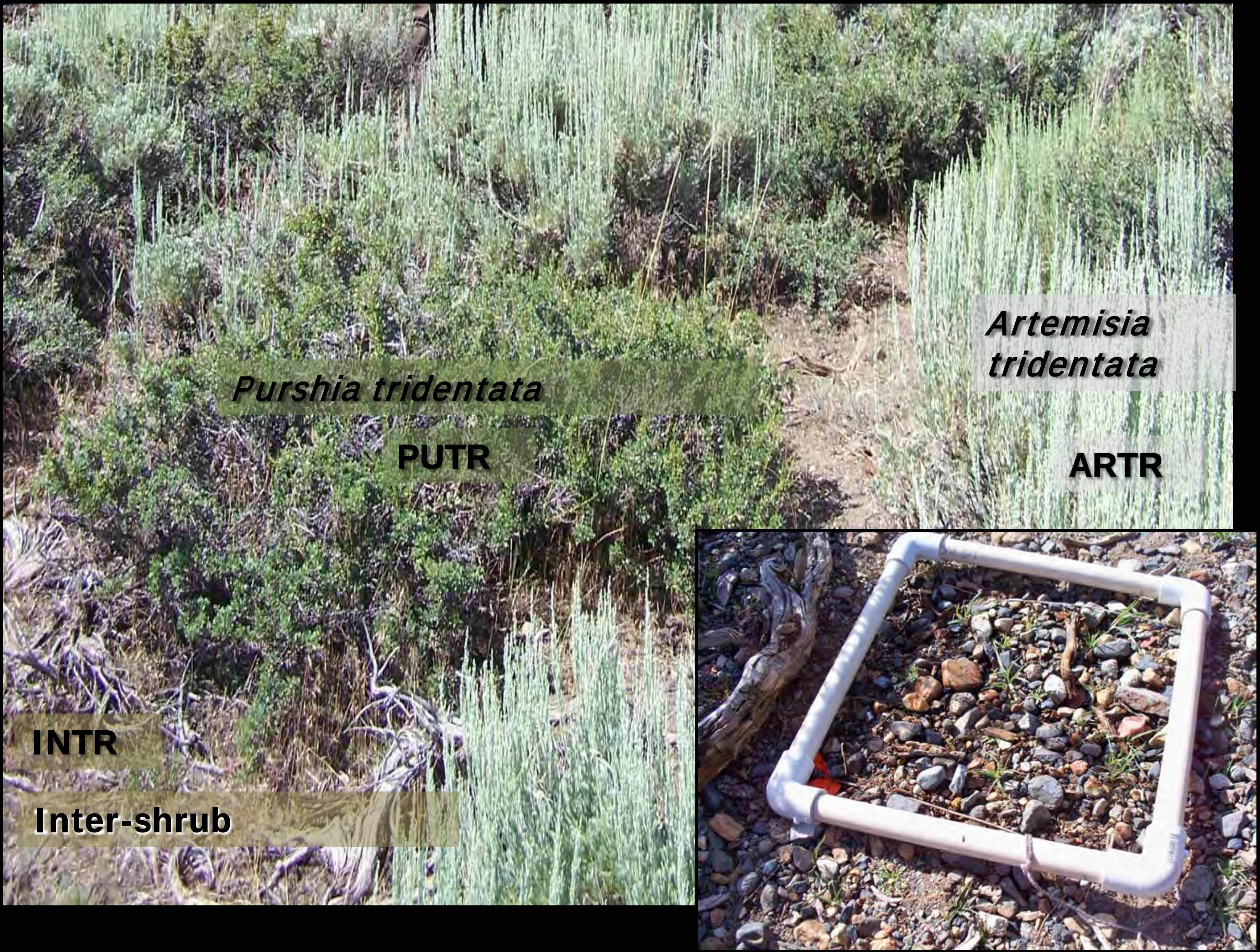
About 2X as much snow

Prevailing Winter Wind

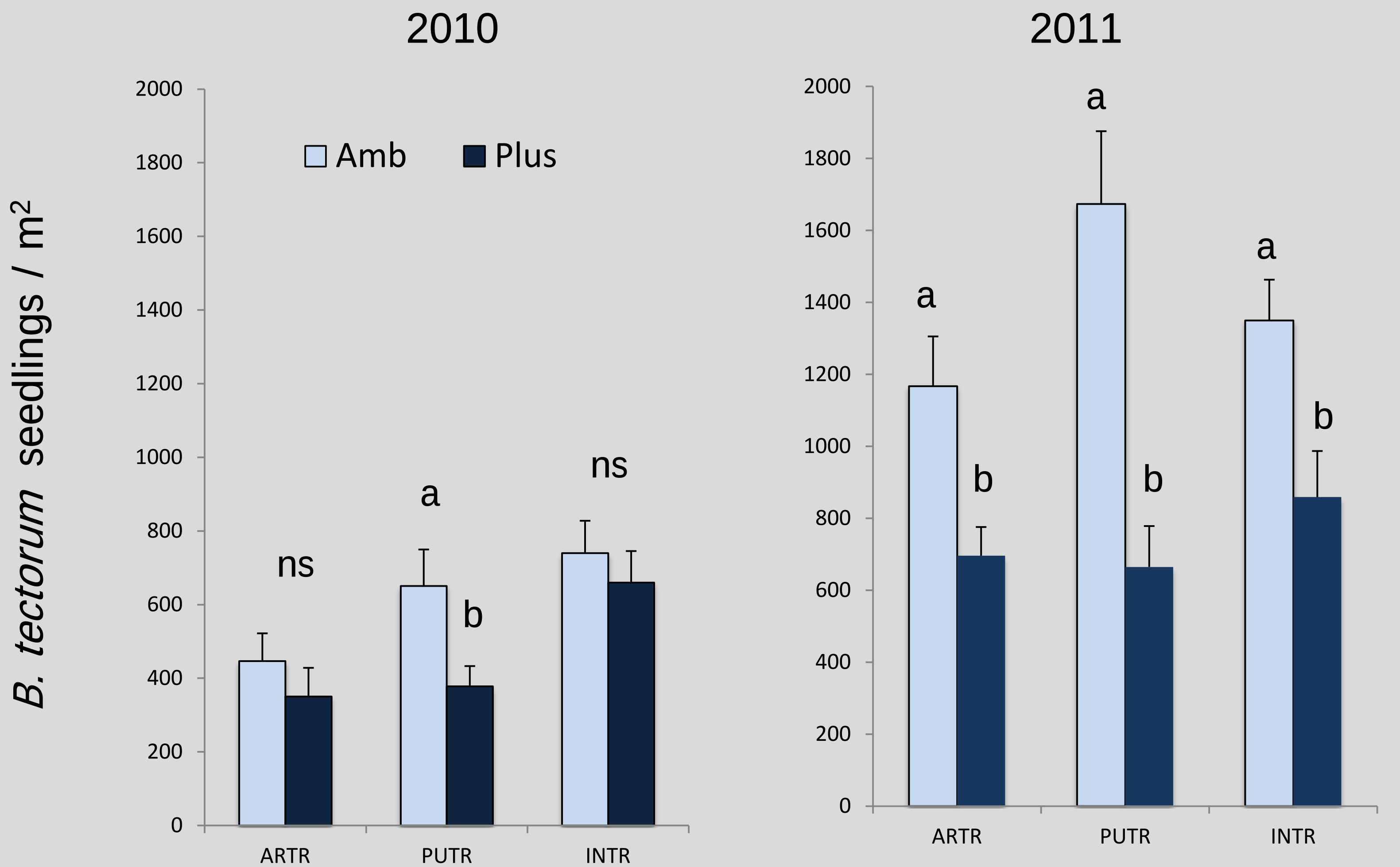




Earlier melt date in AMB

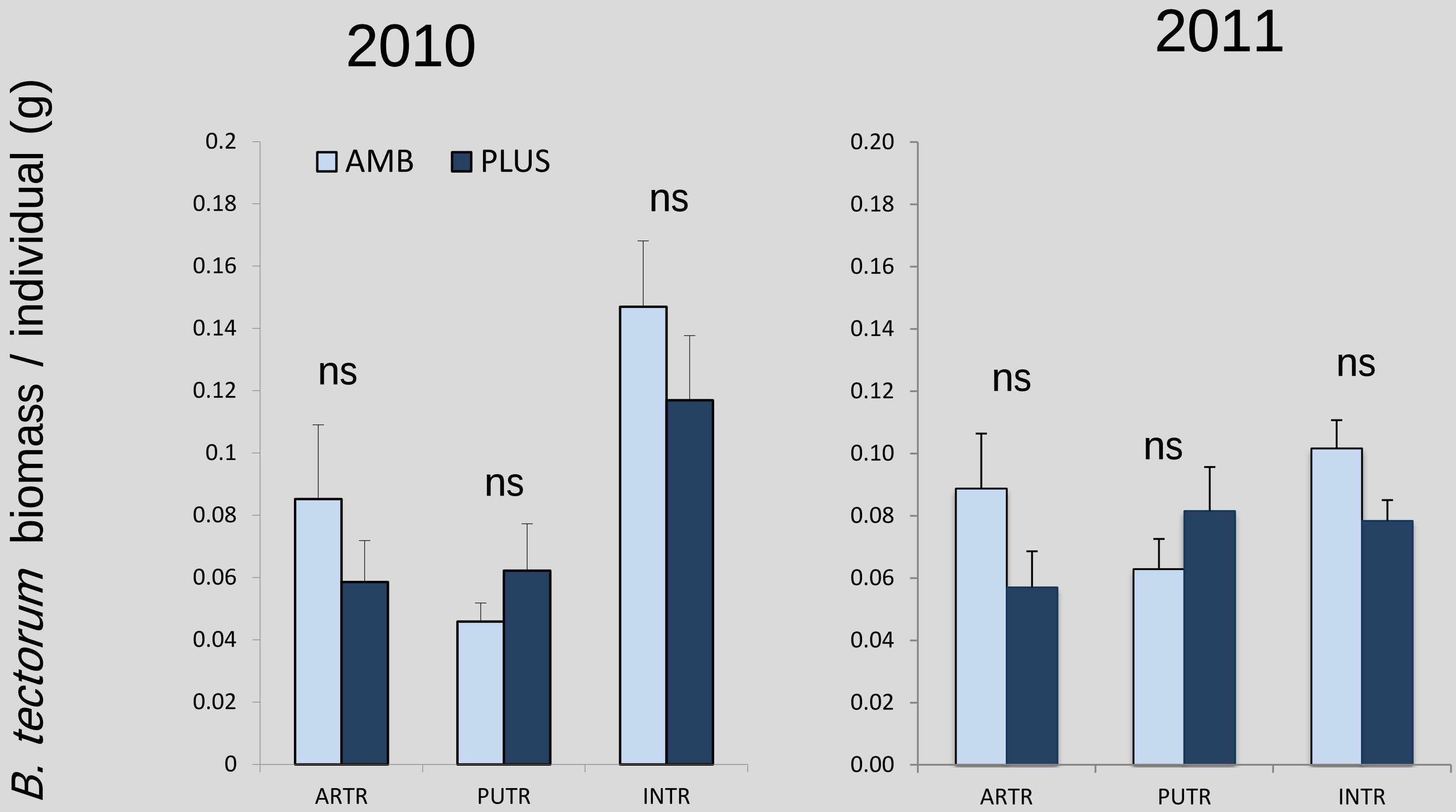

Artemisia tridentata
Purshia tridentata
PUTR
ARTR
INTR
Inter-shrub

Effect of increased snow on germination



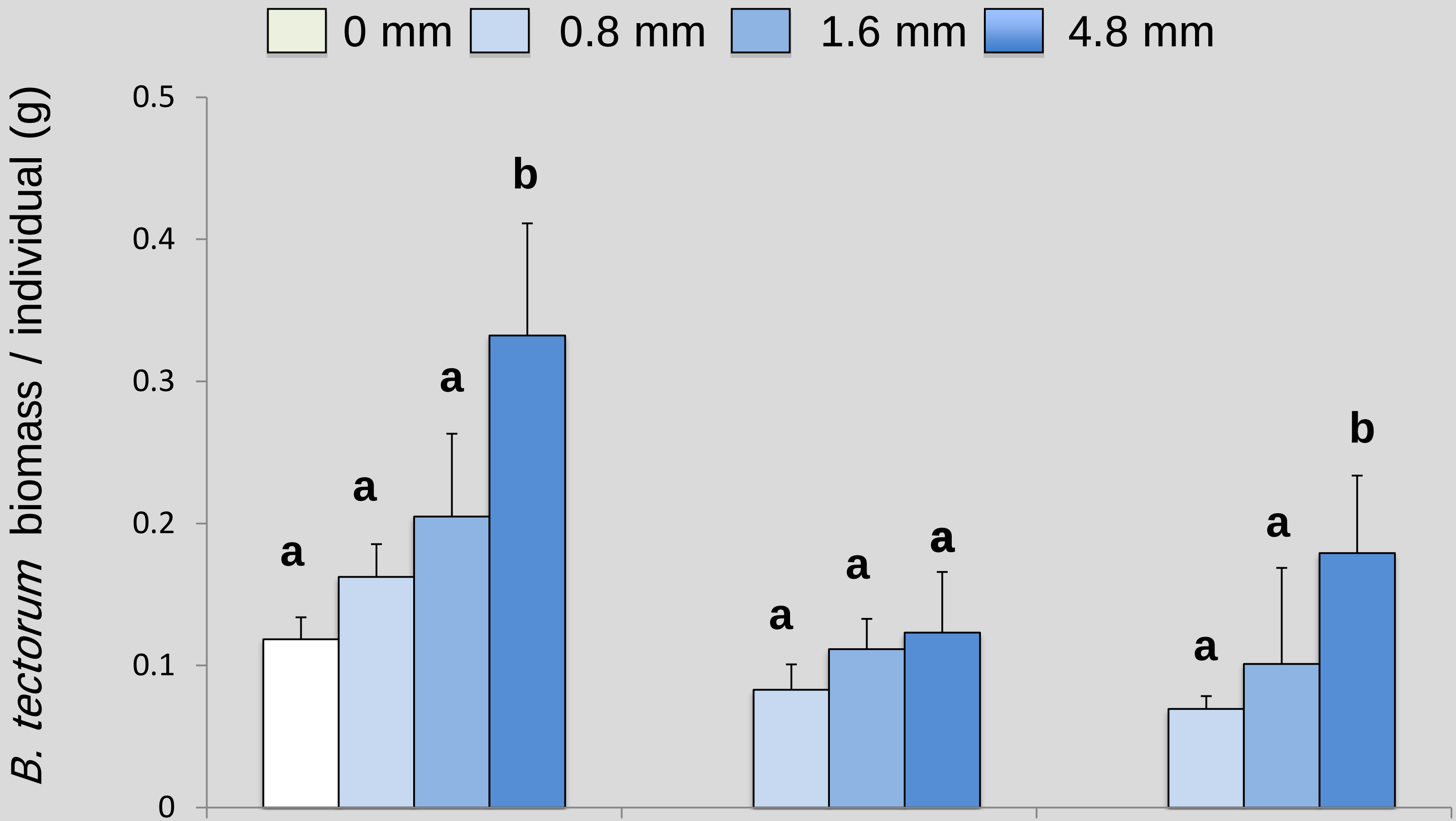
A greater snowpack resulted in decreased germination.

Effect of increased snow on biomass



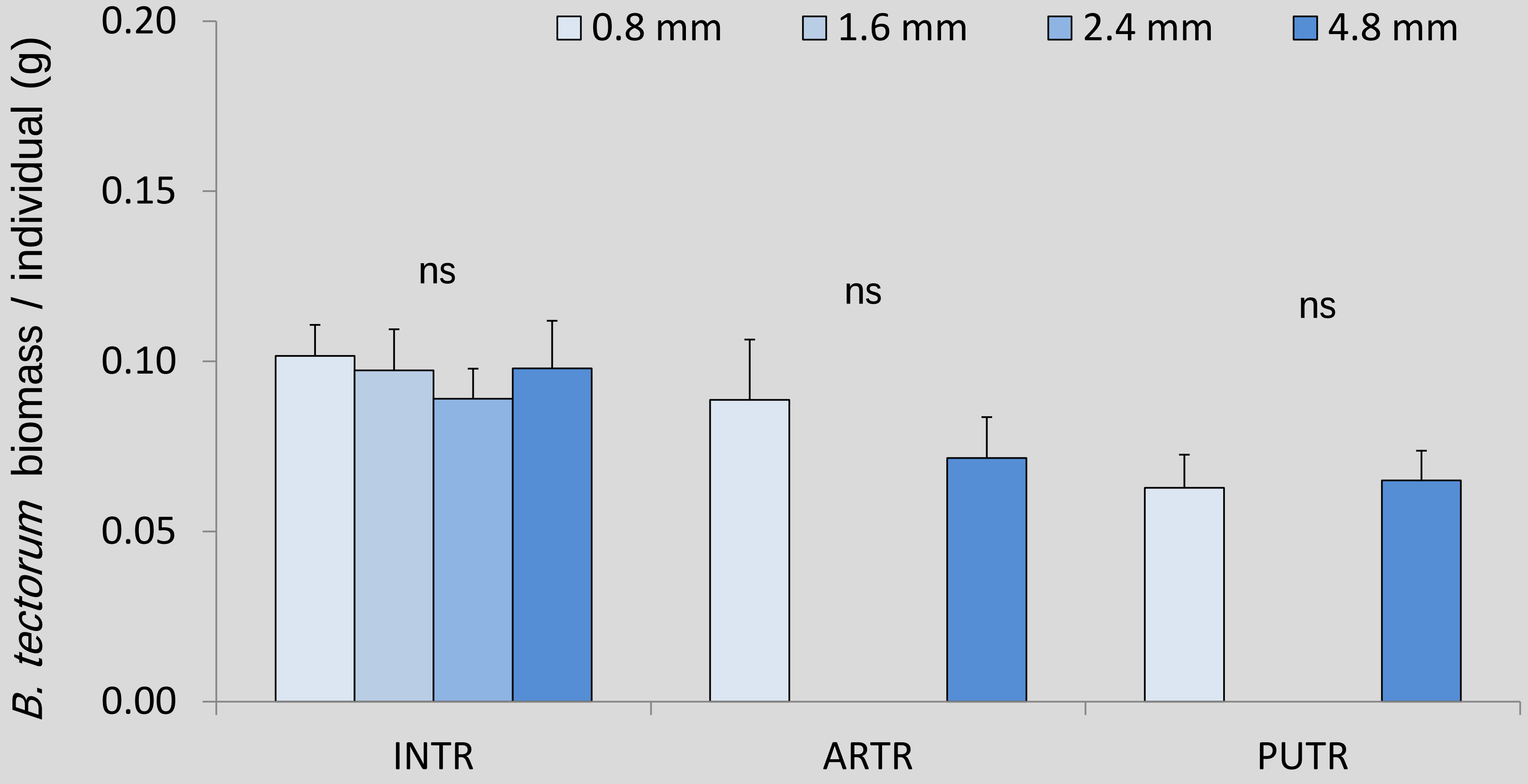
Snow depth had no effect on biomass at the time of harvest.

Effect of experimentally increased spring rain in a low snow year (2009)



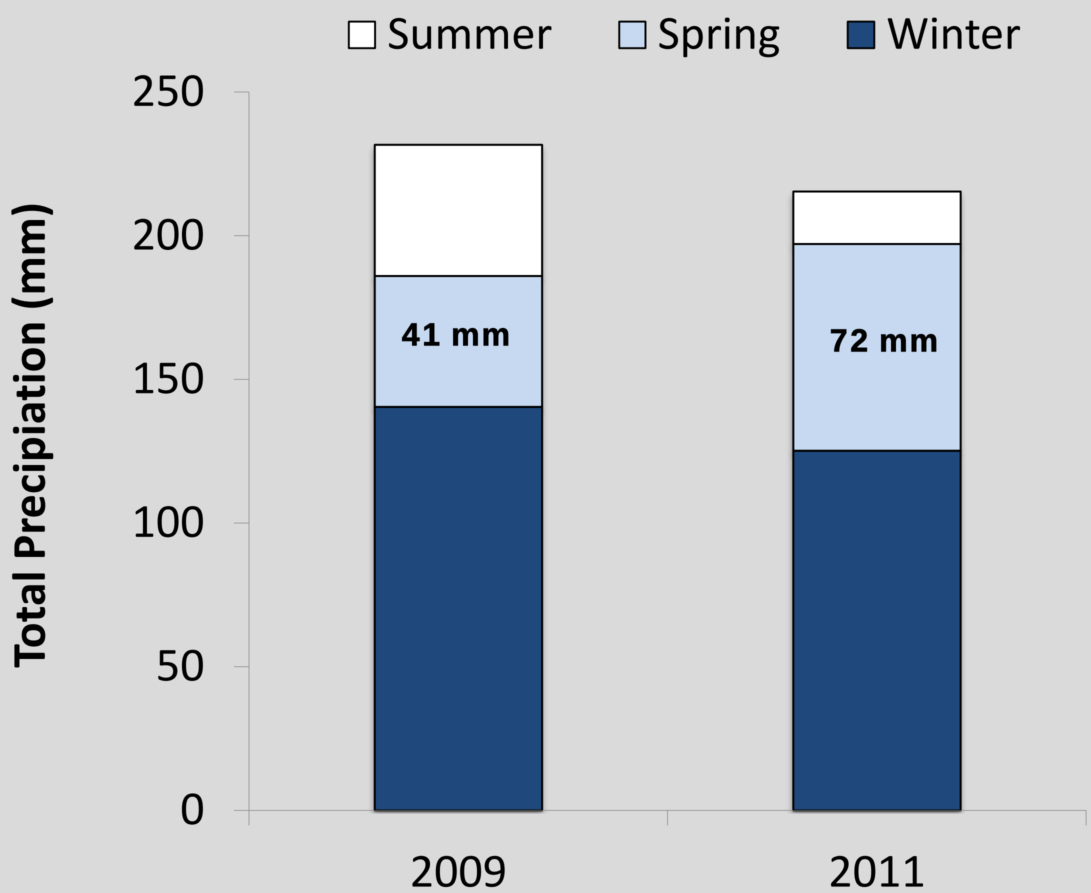
Supplemental water increased cheatgrass biomass in 2009.

Effect of experimentally increased spring rain in a high snow year (2011)



Supplemental water had no effect on cheatgrass biomass in 2011.

Differences in climate between years



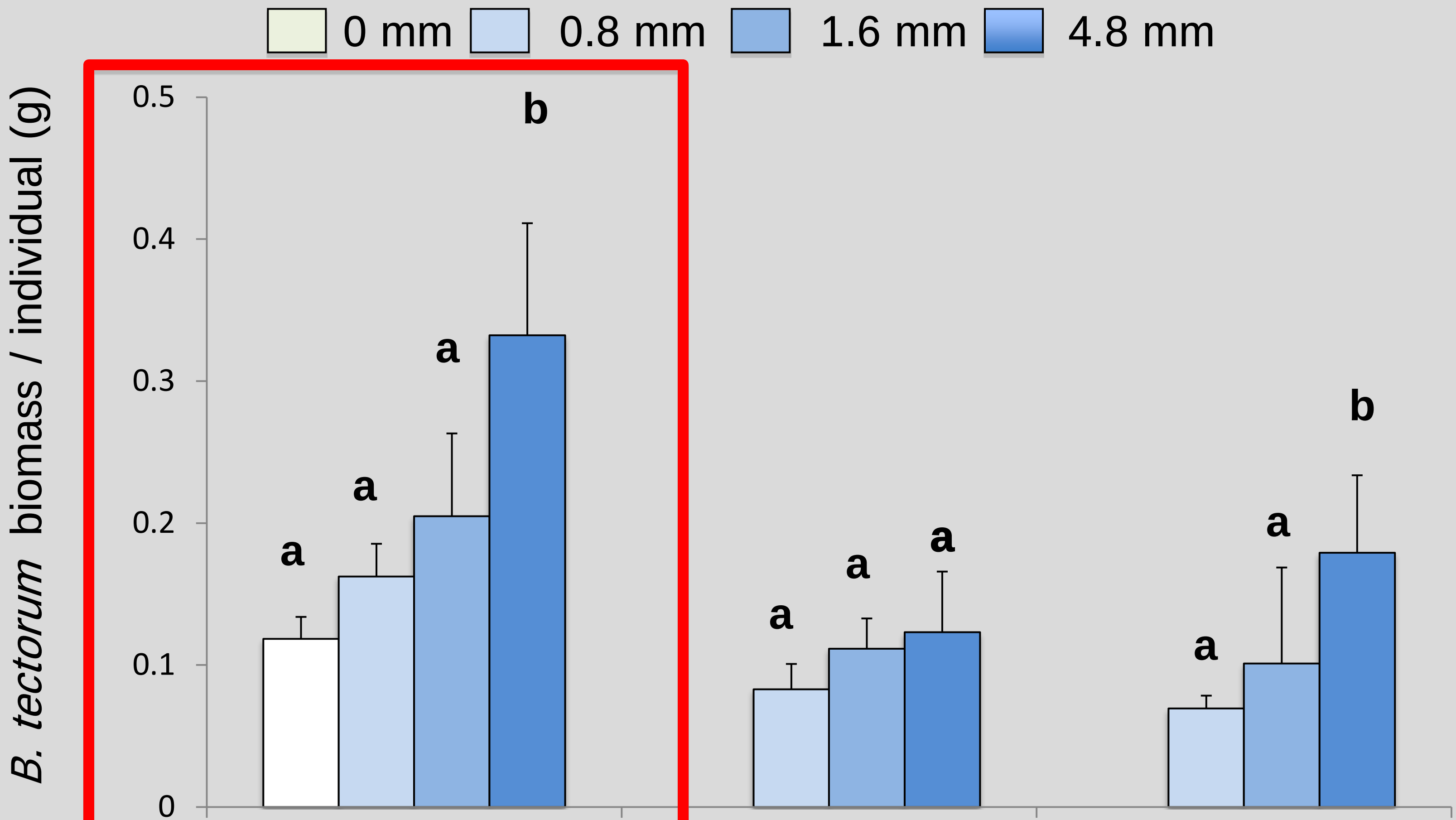
More spring rain fell in 2011, leading to higher soil moisture in late May 2011 compared to 2009.

Study Objectives

- How will *B. tectorum* respond to changing precipitation patterns at high elevation in the eastern Sierra Nevada?
  - Altered snow depth, melt timing
  - Additional spring rain events

- Does response vary by microhabitat?

Effect of experimentally increased spring rain in a low snow year (2009)



Response was the most pronounced in the INTR microhabitat.

Summary of results

- RESPONSE TO SNOW
  - Increased snow resulted in decreased cheatgrass germination, but had no effect on biomass

- RESPONSE TO SPRING RAIN
  - Simulated increases in spring rain resulted in increased cheatgrass biomass in a low snow year with lower ambient spring rainfall

- COMBINED EFFECT OF SNOW AND RAIN
  - Indirect effects of snow?
  - In years of low snow accumulation, spring rain may be more influential on cheatgrass growth.

Summary of results (cont.)

- MICROHABITAT
  - Response to increased rain was most pronounced in intershrub spaces
  - With just a 10 % increase over ambient levels of spring rainfall, cheatgrass biomass tripled in the intershrub plots.

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Management Implications

- With a shift toward more spring rain, the eastern Sierra Nevada may be more susceptible to cheatgrass invasion at high elevation

    - Cheatgrass exhibits boom and bust cycles based on annual snow and rainfall (e.g., Hull 1949; West and Yorks 2002; Bradley and Mustard 2005)

    - High rainfall years may provide windows of opportunity for cheatgrass to increase dramatically at high elevation

Management Implications

- With a shift from snow to rain, the eastern Sierra Nevada may be more susceptible to cheatgrass invasion at high elevation

- Fire risk will be increased if cheatgrass is more successful in intershrub spaces

Invasive Grass/ Fire Cycle

(D'Antonio and Vitousek 1992; Brooks et al. 2004)

Bromus tectorum, Cheatgrass

→

Great Basin sagebrush steppe

→

Inc fuel surface-to-volume ratio & horizontal fuel continuity

↓

New fuel characteristics facilitate ignition

←

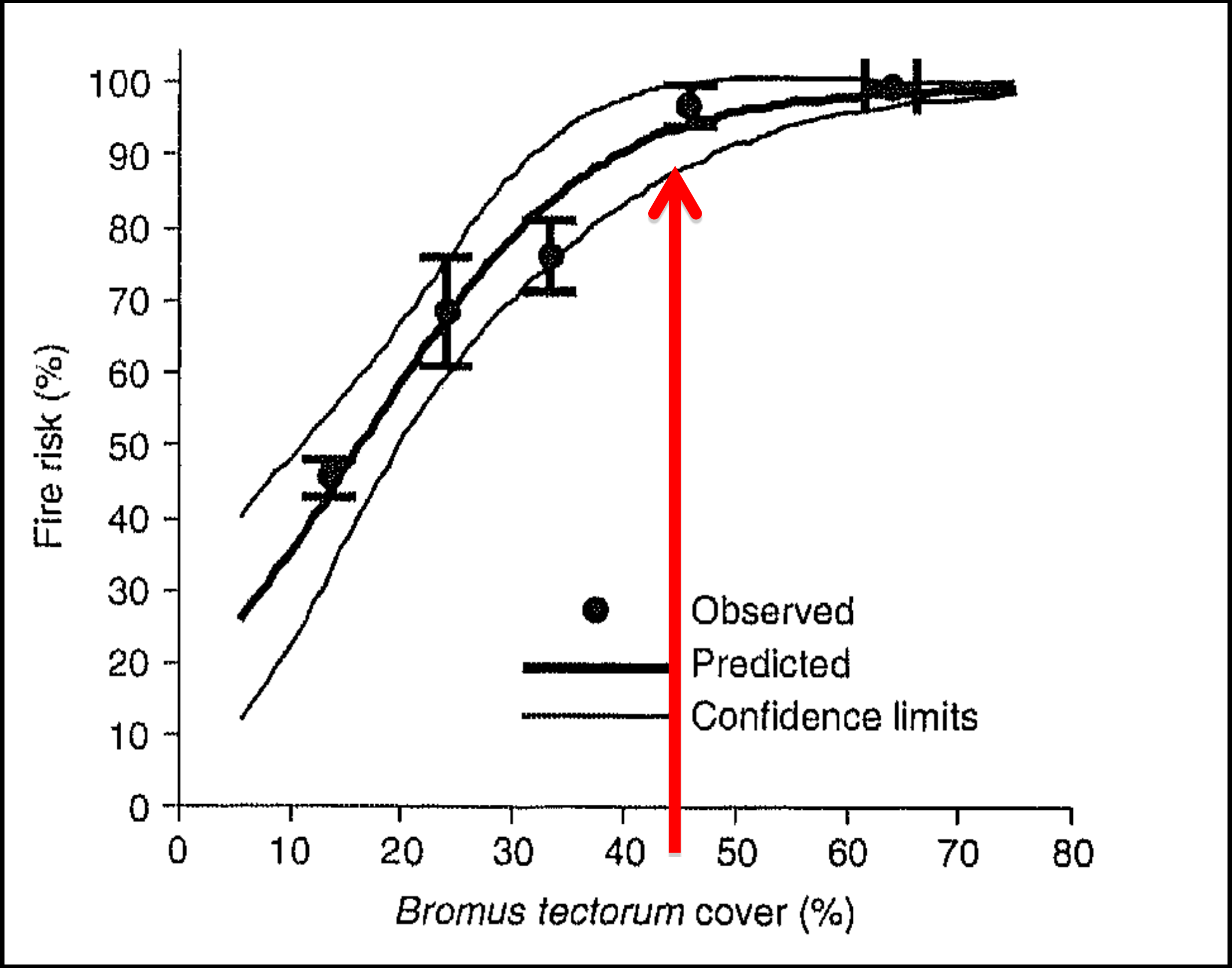
Increase in fire frequency and extent

←

More frequent fires favor cheatgrass

↑

Cheatgrass and Fire Risk



At ~46% cover, fire risk increases to 100%

Source: Link et al. 2006
Based on data collected in Grant County, WA

How will changes in precipitation interact with other agents of global change to affect plant communities?

* Grazing
* Fire
* Nitrogen Deposition

Recommendations for Management

- Monitor high elevation populations of cheatgrass
- Eradicate outlier populations
- Minimize transport of seeds to uninvaded sites
- Use management tools that aim to decrease cheatgrass biomass in years of high spring rain

Acknowledgements

- PhD advisor, Michael E. Loik
- Committee: Jayne Belnap, Weixin Cheng
- Funding from the EPA STAR, VESR, STEPS Institute, Mildred E. Mathias Research Grant, CNPS
- Alden Griffith, Holly Alpert, Sharon Martinson, Catherine Wade, Tim Krupnik, Kathy Hilimire, Daniella Schwiezer, and Mike Vasey
- Valentine Eastern Sierra Reserve staff: Dan Dawson, Kim Rose, Cabot Thomas, JD Delabar
- Field help from Michael Kanning, Erin Fitts, Jack Rusk, Parker Weiss, Lucy Lynn, Catherine Wade, Adrian Verdu, Dave Griese, and Nik Bertulis