

## Objective 1

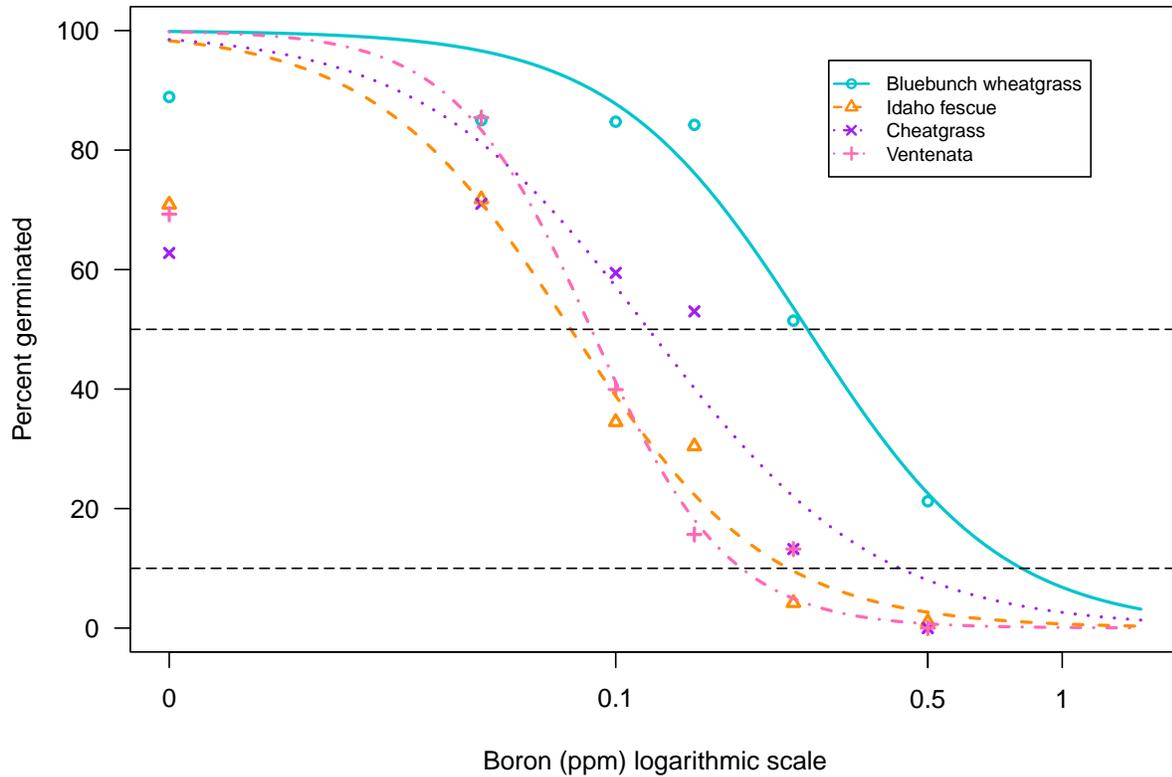


Figure 1: Impact of boron applications on germination percentage of native perennial grasses and non-native annual grasses, over two trials. Ten seeds were placed in a Petri dish (n=10 dishes) and monitored for 21 days in a growth chamber (20°/15°C, 10/14 light dark hours). Dose response curves fit with an LL.4 model with horizontal lines representing ED50 (the dose where germination is reduced by 50%) and ED90 rates. Bluebunch wheatgrass was the least impacted by boron application, followed by cheatgrass, then ventenata and Idaho fescue which did not differ from each other.

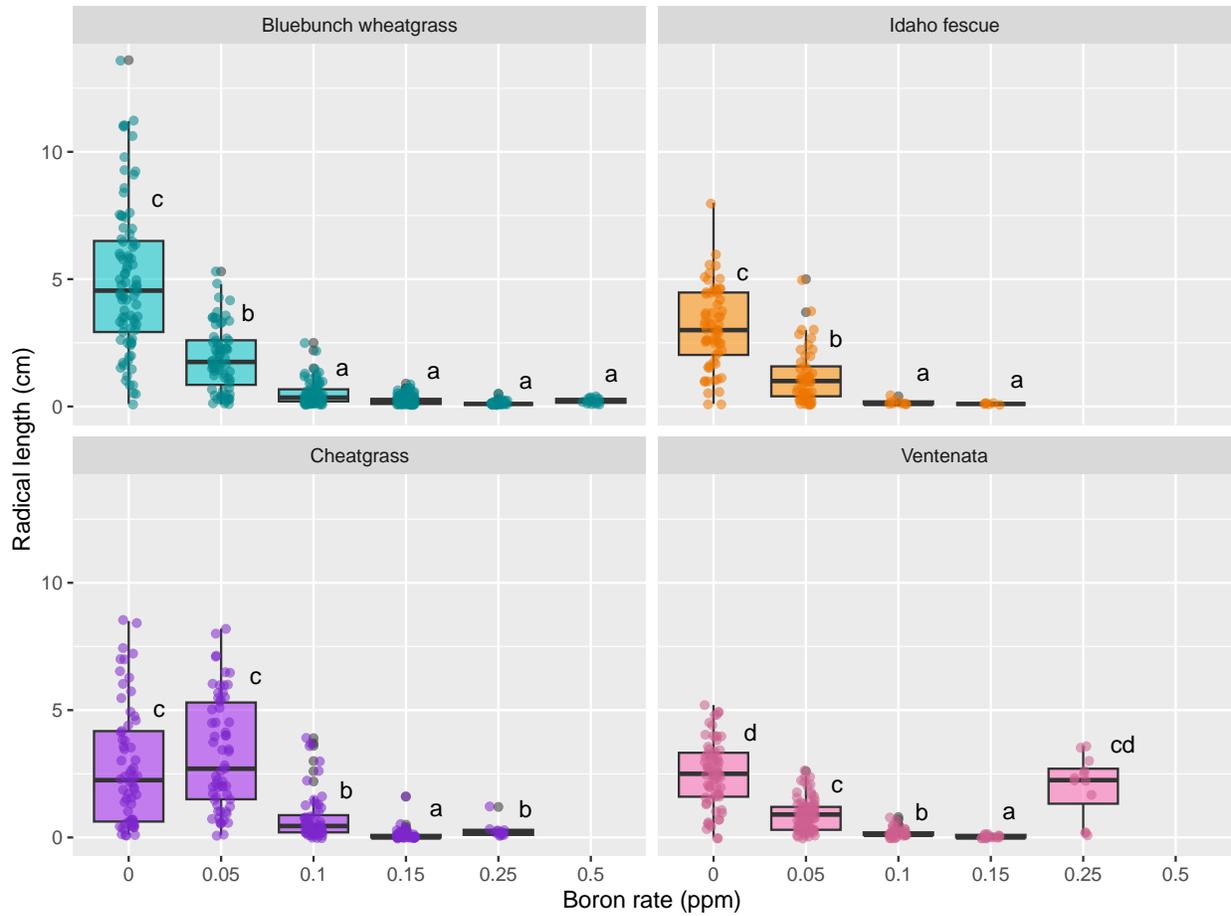


Figure 2: Impact of boron applications on radical length (cm) per plant of germinated native perennial grasses and non-native annual grasses, over two trials. Ten seeds were placed in a Petri dish (n=10 dishes) and monitored for 21 days in a growth chamber (20°/15°C, 10/14 light dark hours) after which the length of each radical of germinated seeds was measured. Compact letter display shows differences between rates within each species. A different letter signifies a difference in radical length due to boron application.

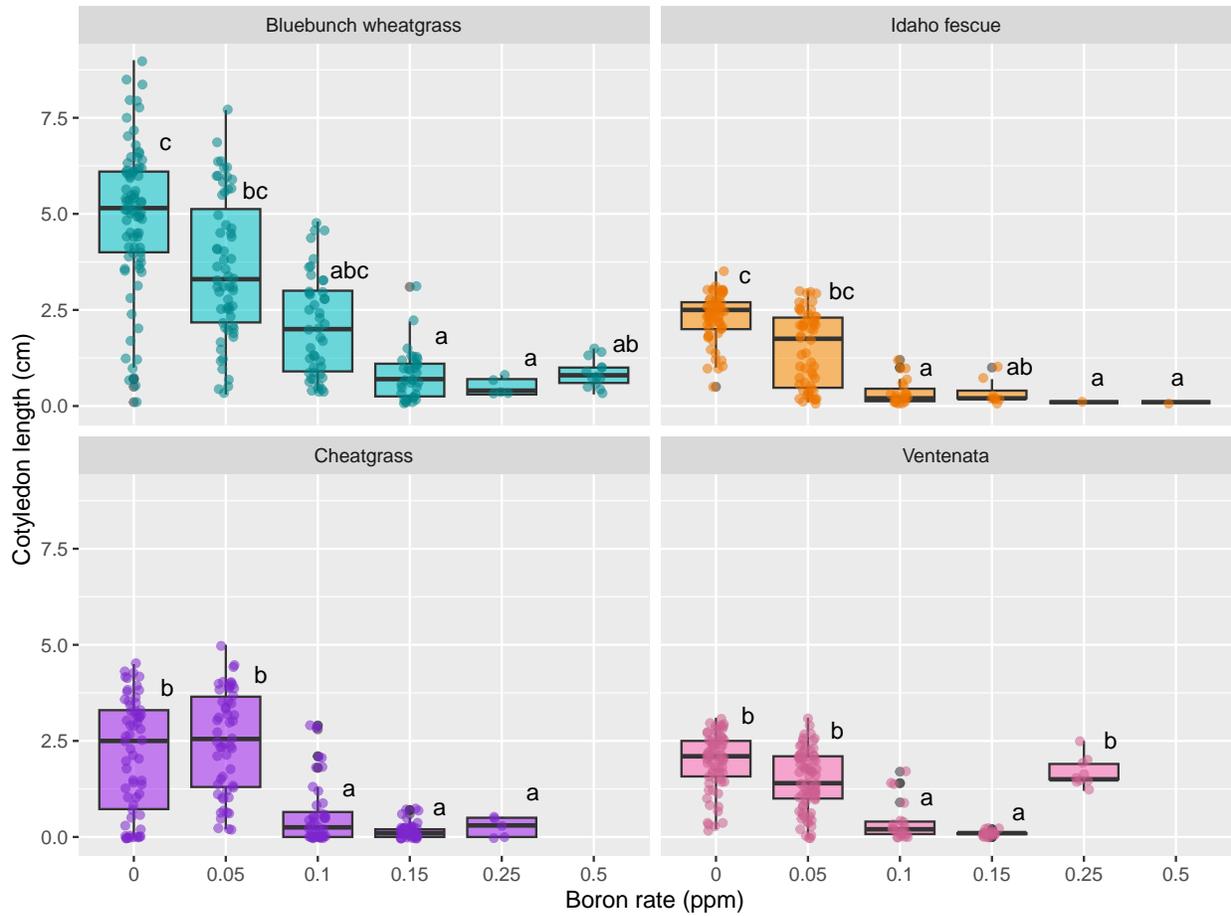


Figure 3: Impact of boron applications on cotyledon length (cm) per plant of germinated native perennial grasses and non-native annual grasses, over two trials. Ten seeds were placed in a Petri dish (n=10 dishes) and monitored for 21 days in a growth chamber (20°/15°C, 10/14 light dark hours) after which the length of each cotyledon of germinated seeds was measured. Compact letter display shows differences between rates within each species. A different letter signifies a difference in cotyledon length due to boron application.

## Objective 2

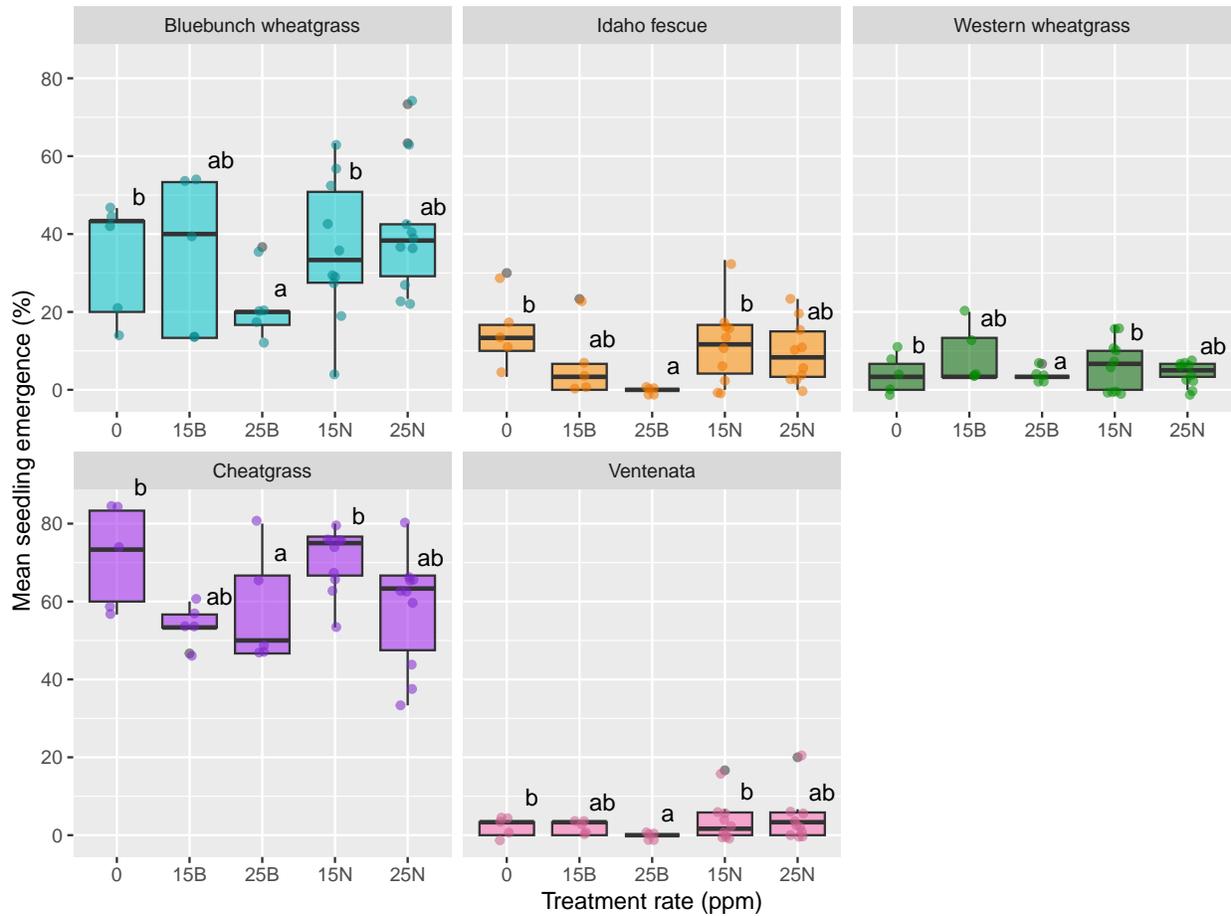


Figure 4: Impact of boron and NutraFix applications on emergence of native perennial grasses and non-native annual grasses grown in a soil medium for 28 days. Treatments include a non-treated control (0) (n=5), 15 ppm of boron (15B) (n=5), 25 ppm of boron (25B) (n=5), 15 ppm of NutraFix (15N) (n=10), and 25 ppm of NutraFix (25N) (n=10). Thirty seeds were planted in 12.5 cm diameter pots and grown in a controlled environment (23/6°C with 14/10 light dark hours) after which the number of seedlings that emerged were counted. Compact letter display shows differences between rates within each species.

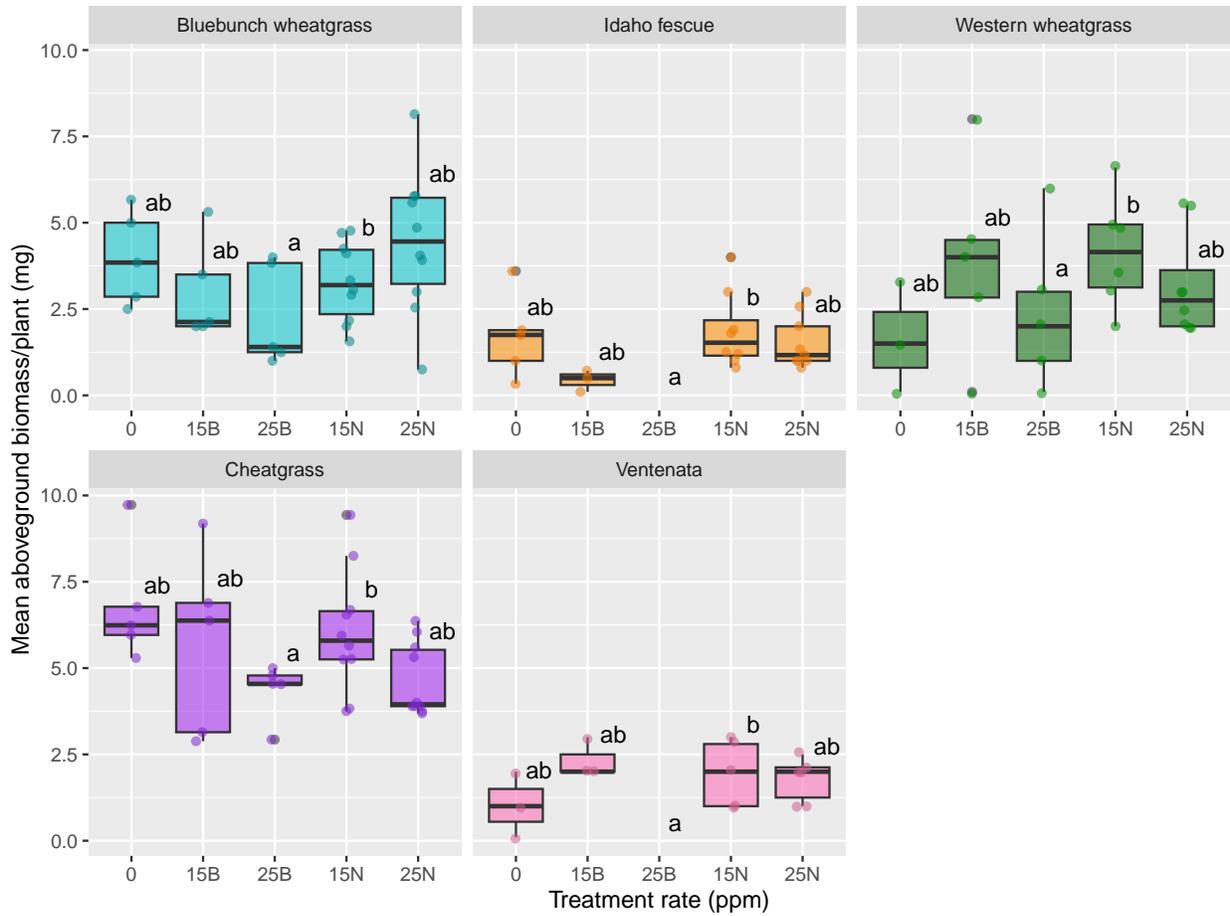


Figure 5: Impact of boron and NutraFix applications on aboveground biomass/plant (mg) of native perennial grasses and non-native annual grasses grown in a soil medium for 28 days. Treatments include a non-treated control (0) (n=5), 15 ppm of boron (15B) (n=5), 25 ppm of boron (25B) (n=5), 15 ppm of NutraFix (15N) (n=10), and 25 ppm of NutraFix (25N) (n=10). Thirty seeds were planted in 12.5 cm diameter pots and grown in a controlled environment (23/6°C with 14/10 light dark hours) after which aboveground biomass was harvested, dried for three days at 43°C, and weighed. Compact letter display shows differences between rates within each species.

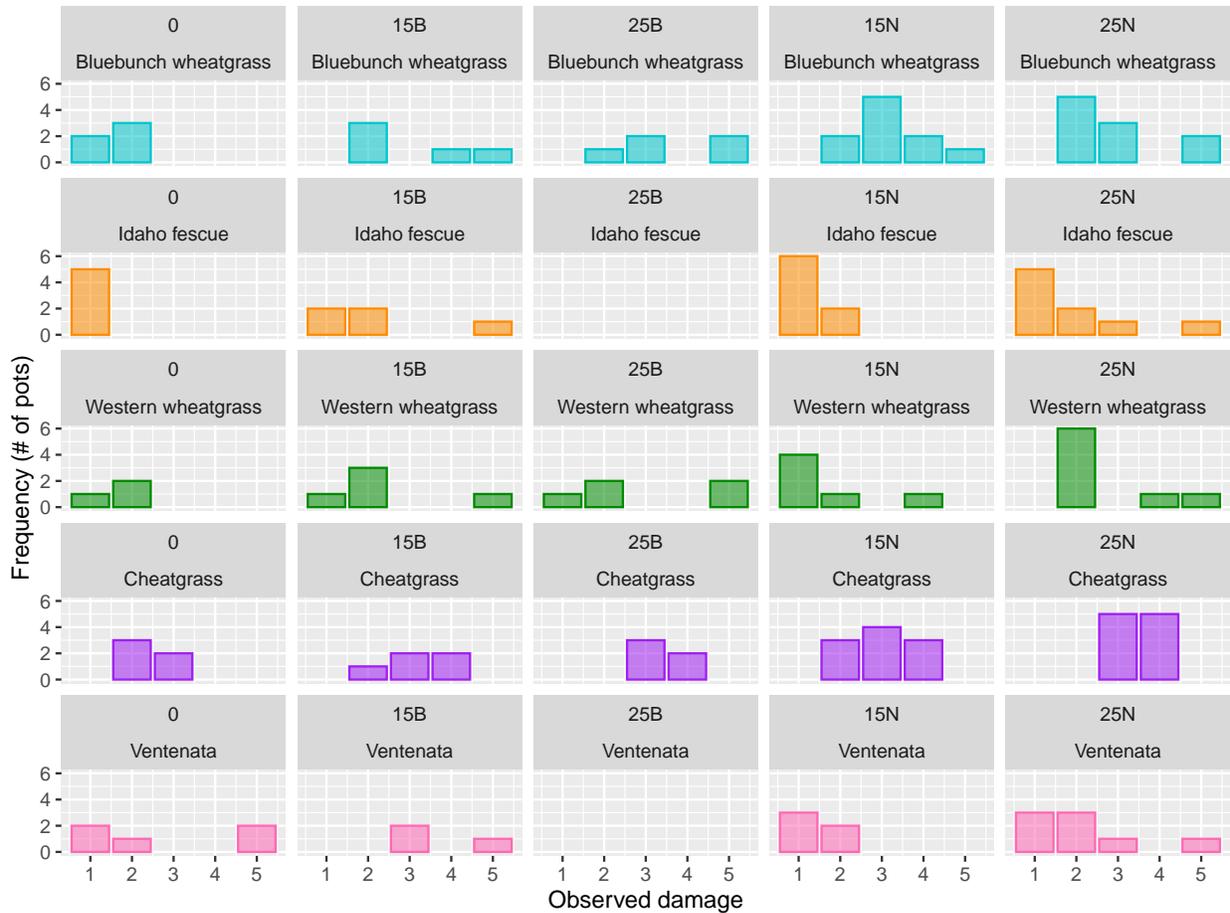


Figure 6: Distribution of observed damage to native perennial grasses and non-native annual grasses treated with boron and NutraFix applications grown in soil medium for 28 days. Treatments include a non-treated control (0) (n=5), 15 ppm of boron (15B) (n=5), 25 ppm of boron (25B) (n=5), 15 ppm of NutraFix (15N) (n=10), and 25 ppm of NutraFix (25N) (n=10). Thirty seeds were planted in 12.5 cm diameter pots and grown in a controlled environment (23/6°C with 14/10 light dark hours) after which visible damage to aboveground tissues was recorded. Damage values were assigned to entire pots based on average condition. Damage values range from 1-5 (1: not damaged– 5: very damaged).

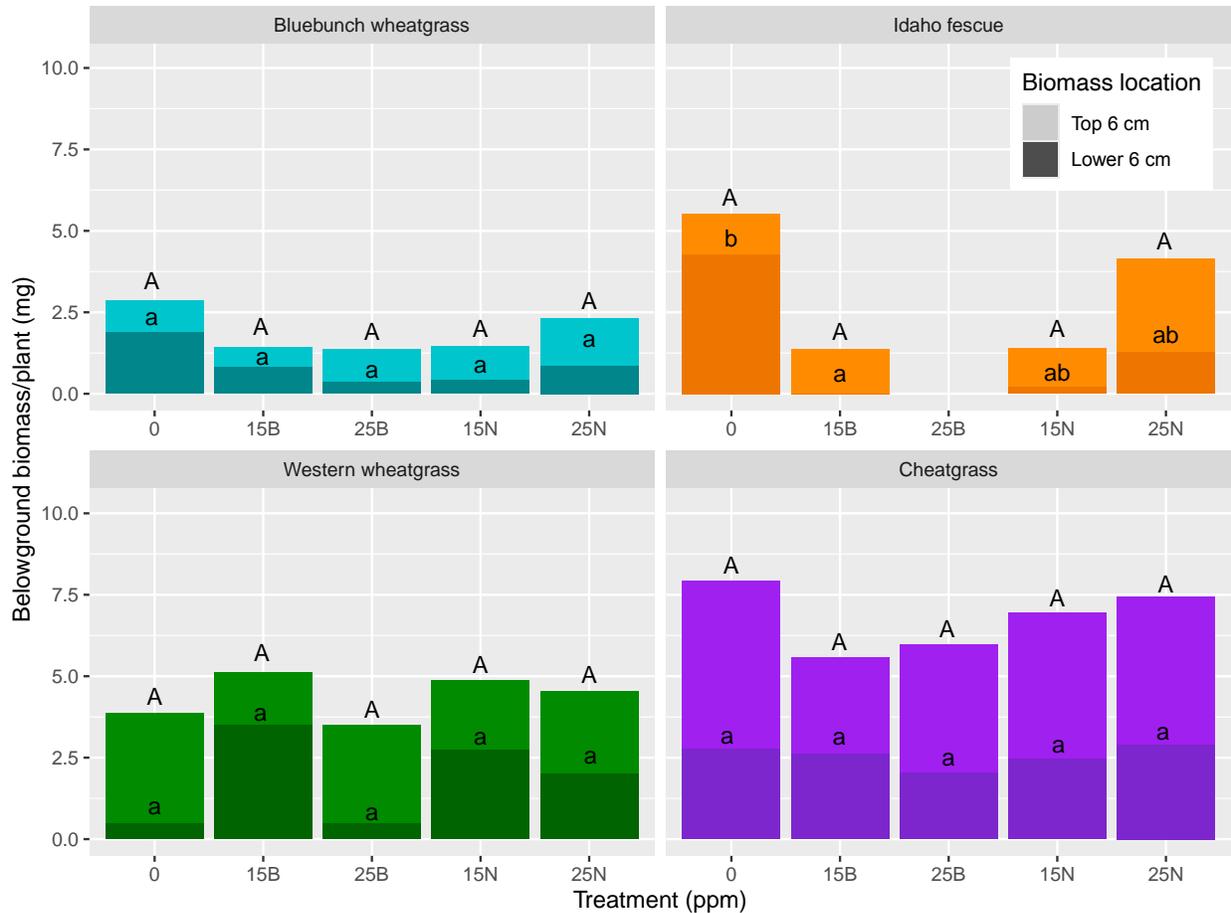


Figure 7: Impact of boron and NutraFix applications on belowground biomass/plant (mg) of native perennial grasses and non-native annual grasses grown in a soil medium for 28 days. Belowground biomass was split into two samples, biomass present in the upper 6 cm of the pot and biomass present in the lower 6 cm of the pot, represented by the shading of the stacked bars. Treatments include a non-treated control (0) (n=3), 15 ppm of boron (15B) (n=3), 25 ppm of boron (25B) (n=3), 15 ppm of NutraFix (15N) (n=6), and 25 ppm of NutraFix (25N) (n=6). Thirty seeds were planted in 12.5 diameter cm pots and grown in a controlled environment (23/6°C with 14/10 light dark hours) after which belowground biomass was harvested, dried for three days at 43°C, and weighed. Compact letter display shows differences between rates within each species. Capital letters showing differences between the upper biomass samples, and lower-case letters showing differences between the lower biomass samples.

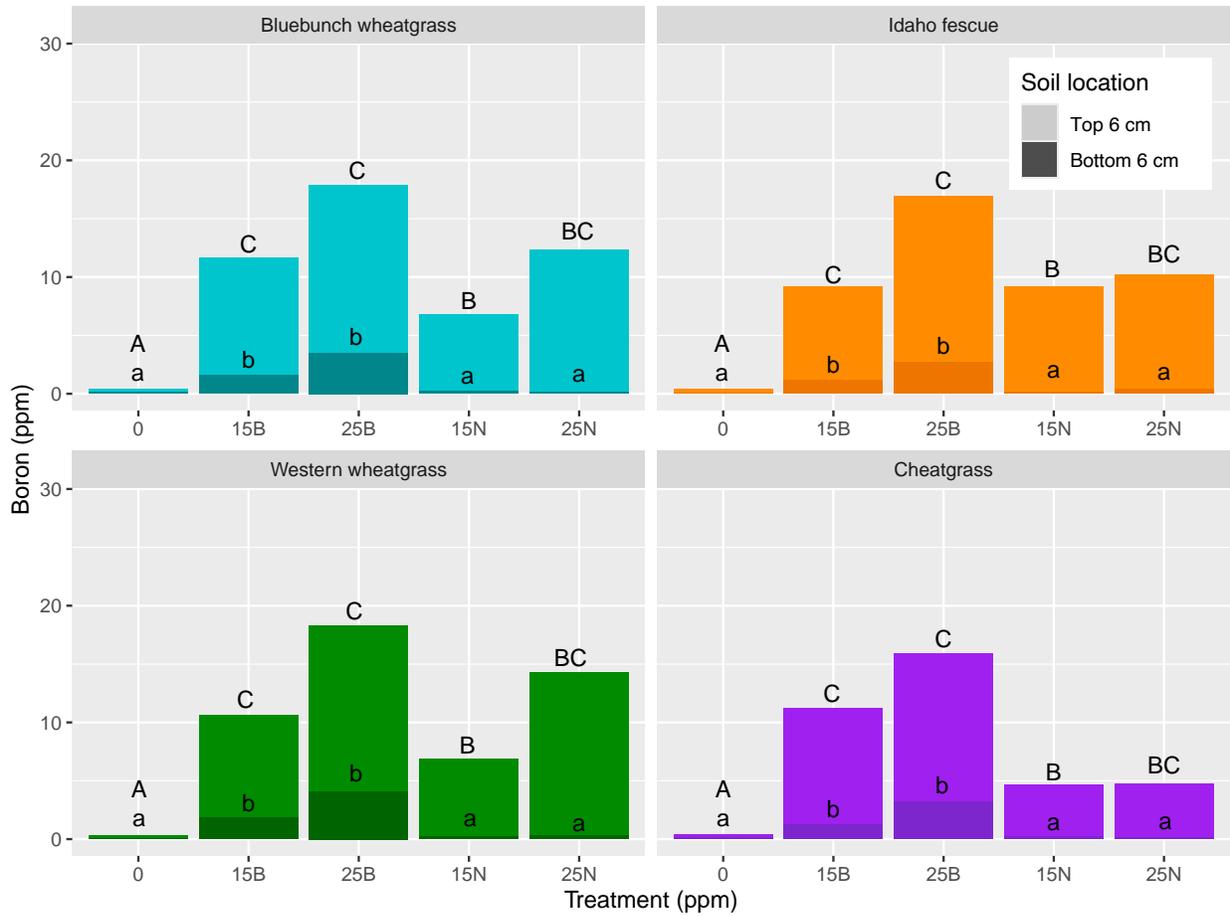


Figure 8: Impact of boron and NutraFix applications on soil boron (ppm) content taken from pots growing native perennial grasses and non-native annual grasses in a soil medium for 28 days. Soil was split into two samples, soil in the upper 6 cm of the pot and soil in the lower 6 cm of the pot, represented by the shading of the stacked bars. Soil was sampled after 28 days of plant growth in a controlled environment (23/6°C with 14/10 light dark hours). Boron content was analyzed by Agvise laboratories. Treatments include a non-treated control (0) (n=3), 15 ppm of boron (15B) (n=3), 25 ppm of boron (25B) (n=3), 15 ppm of NutraFix (15N) (n=6), and 25 ppm of NutraFix (25N) (n=6). Thirty seeds were planted in 12.5 cm diameter pots. Compact letter display shows differences between rates within each species. Capital letters showing differences between the upper soil samples, and lower-case letters showing differences between the lower soil samples.

### Objective 3

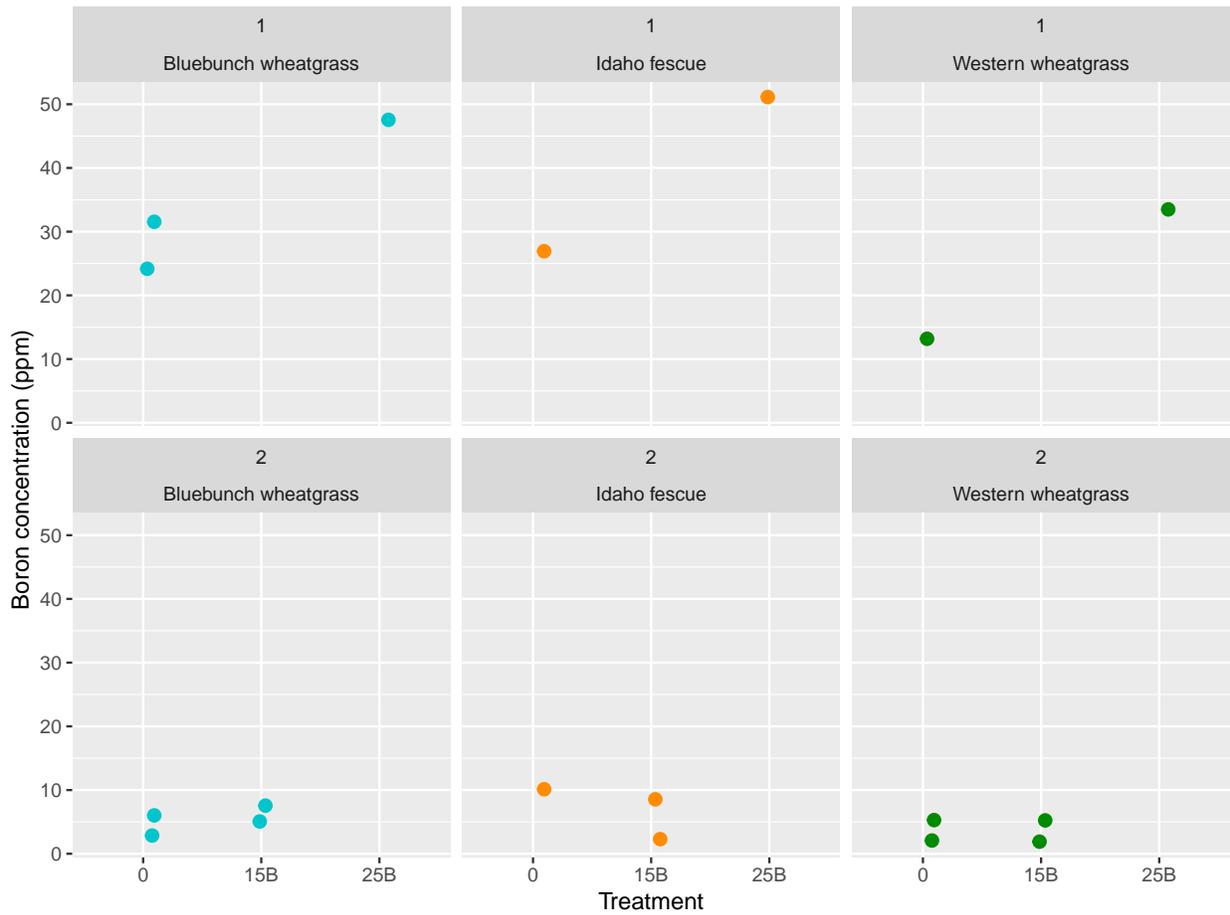


Figure 9: Impact of boron applications on boron concentration (ppm) in aboveground tissues of mature native perennial grasses, over two trials. Treatments include a non-treated control (0), 15 ppm of boron (15B), and 25 ppm of boron (25B). Individual plants were grown in a controlled environment for a total of 34 weeks (1) or 25 weeks (2), aboveground biomass was harvested eight- or six-weeks post treatment for trial 1 and 2 respectively and assessed for boron content. Unfortunately, insufficient biomass was produced to allow for statistical analysis.

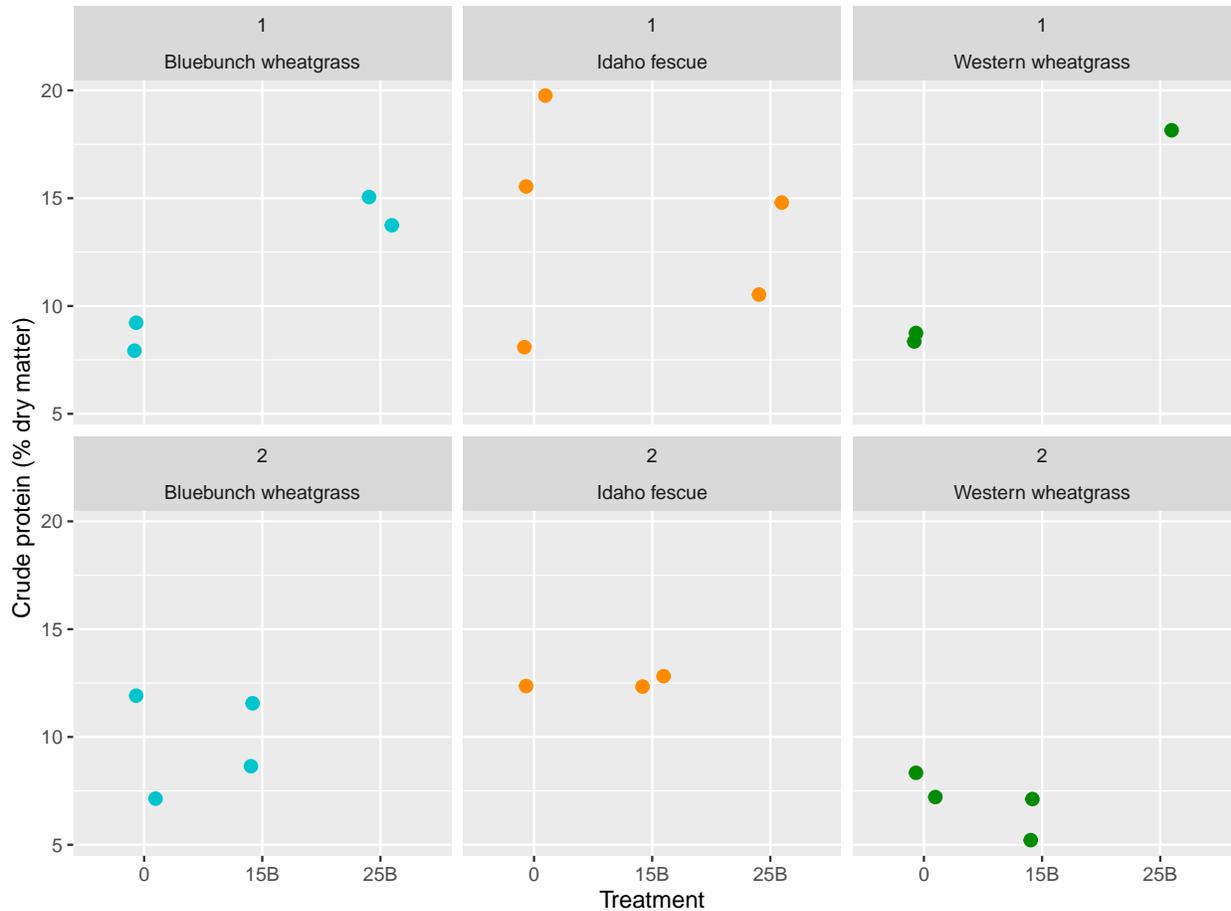


Figure 10: Impact of boron applications on crude protein (% dry matter) in aboveground tissues of mature native perennial grasses for two trials. Treatments include a non-treated control (0), 15 ppm of boron (15B), and 25 ppm of boron (25B). Individual plants were grown in a controlled environment for a total of 34 weeks (1) or 25 weeks (2), aboveground biomass was harvested eight- or six-weeks post treatment for trial 1 and 2 respectively and assessed for crude protein content. Insufficient biomass was produced to allow for statistical analysis for western wheatgrass in trial 1 and Idaho fescue in trial 2. Asterisk signifies a statistically significant treatment difference within the species and trial combination from a two-sample t-test.

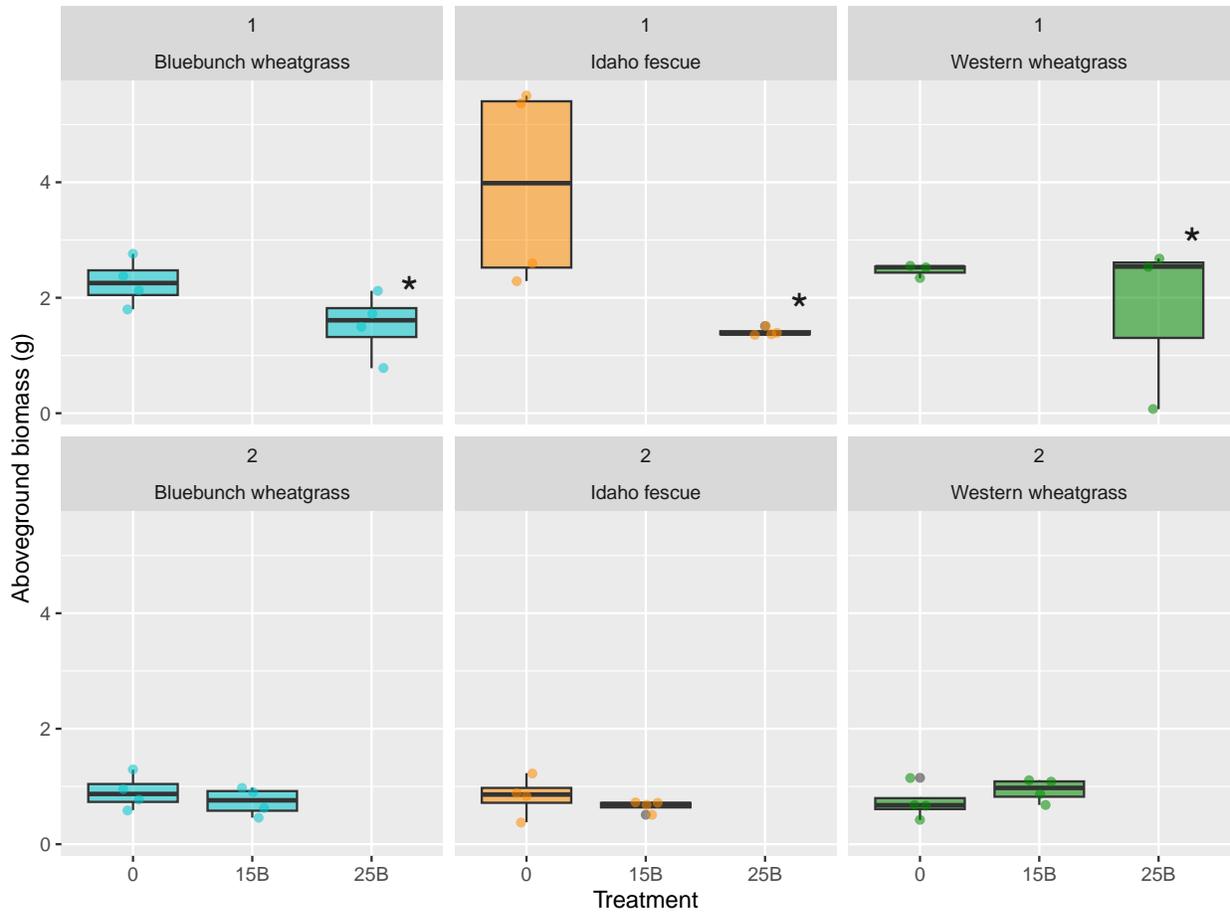


Figure 11: Impact of boron applications on aboveground biomass (g) of mature native perennial grasses for two trials. Treatments include a non-treated control (0), 15 ppm of boron (15B), and 25 ppm of boron (25B). Individual plants were grown in a controlled environment for a total of 34 weeks (1) or 25 weeks (2), aboveground biomass was harvested eight- or six-weeks post treatment, for trial 1 and 2 respectively, dried at 43°C for three days, and weighed. Asterisk signifies a statistically significant treatment difference within the species and trial combination.

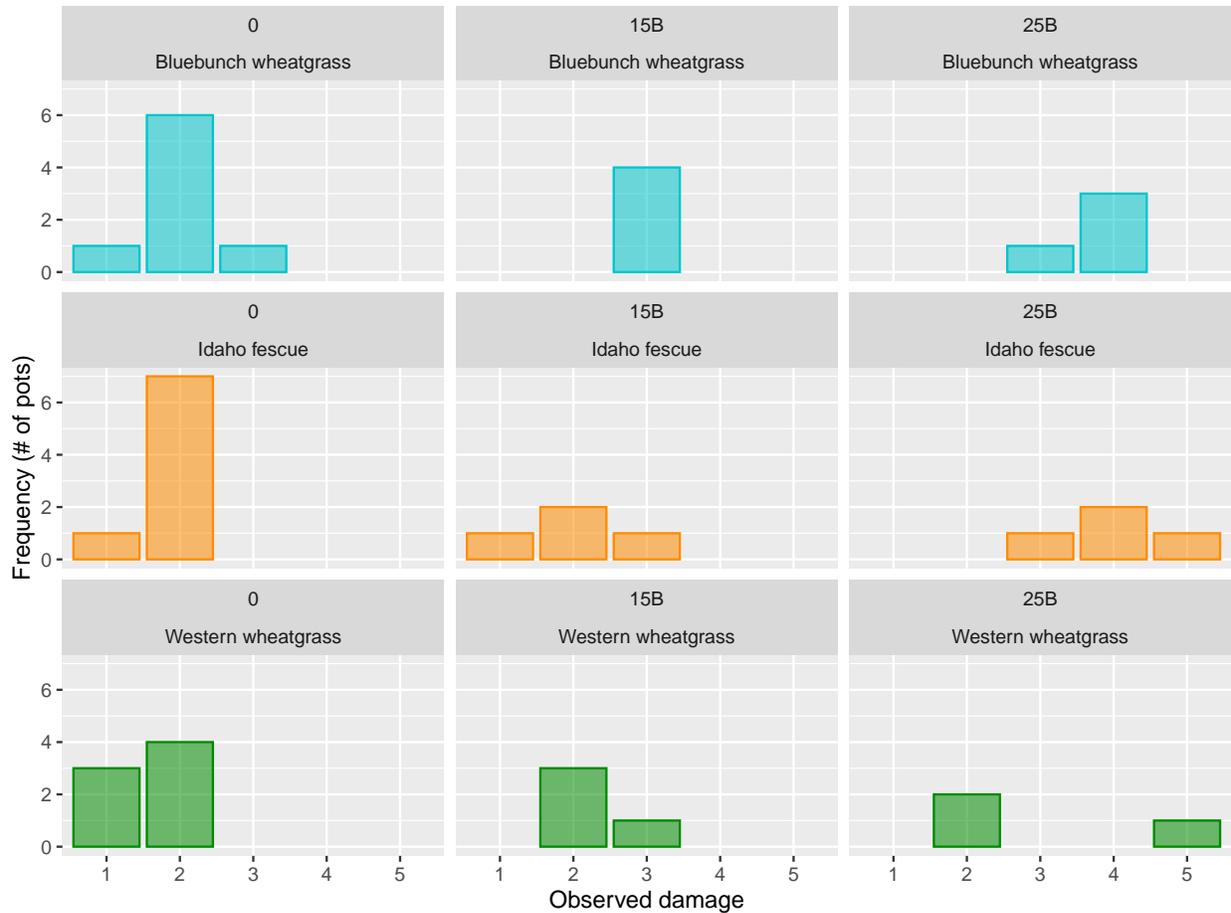


Figure 12: Distribution of observed damage of mature perennial grasses treated with boron and non-treated controls. Treatments include a non-treated control (0), 15 ppm of boron (15B), and 25 ppm of boron (25B). Individual plants were grown in a controlled environment for a total of 34 weeks (trial 1) or 25 weeks (trial 2), after which visible damage to aboveground tissues was recorded and are shown combined above. Damage values range from 1-5 (1: not damaged– 5: very damaged).

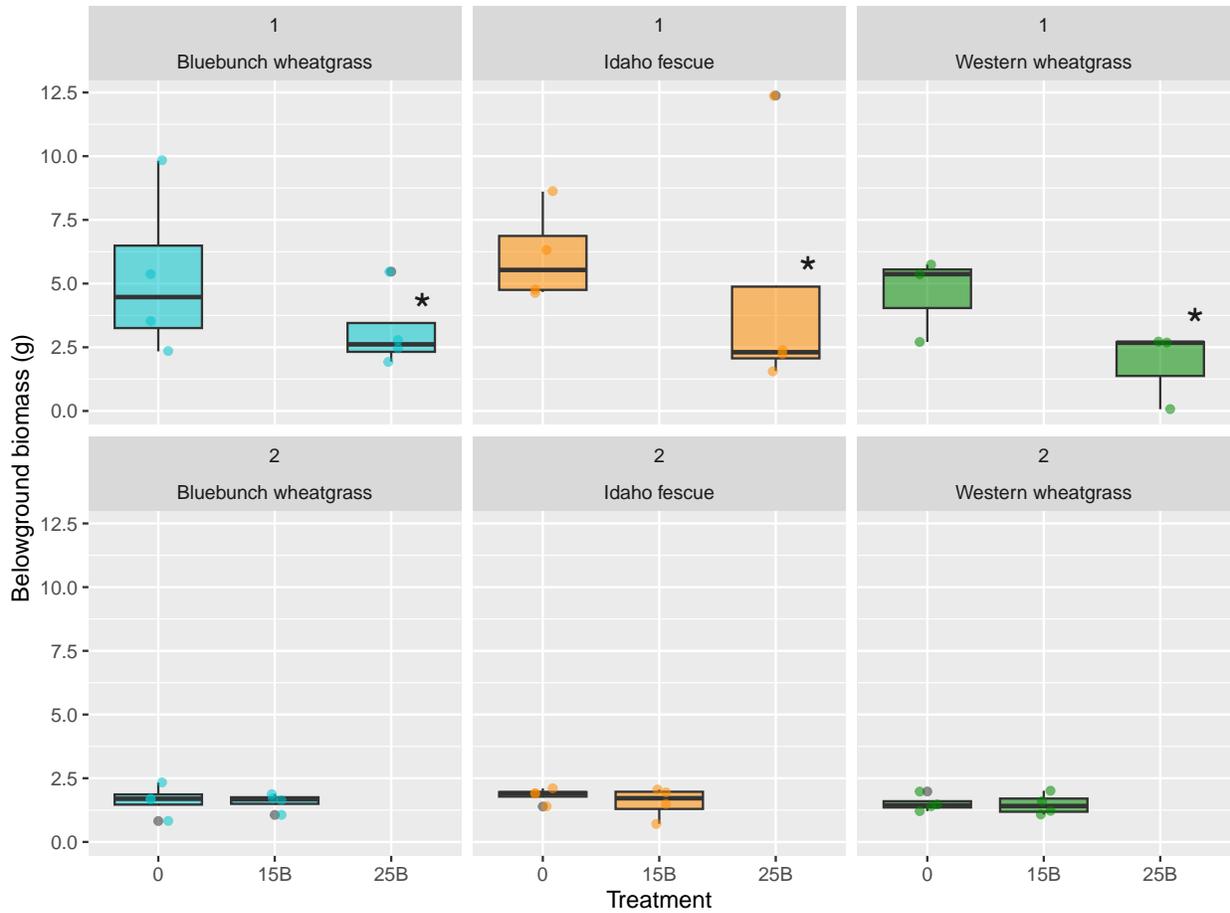


Figure 13: Impact of boron applications on belowground biomass (g) of mature native perennial grasses for two trials. Treatments include a non-treated control (0), 15 ppm of boron (15B), and 25 ppm of boron (25B). Individual plants were grown in a controlled environment for a total of 34 weeks (1) or 25 weeks (2), aboveground biomass was harvested eight- or six-weeks post treatment, for trial 1 and 2 respectively, dried at 43°C for three days, and weighed. Asterisk signifies a statistically significant treatment difference within the species and trial combination.

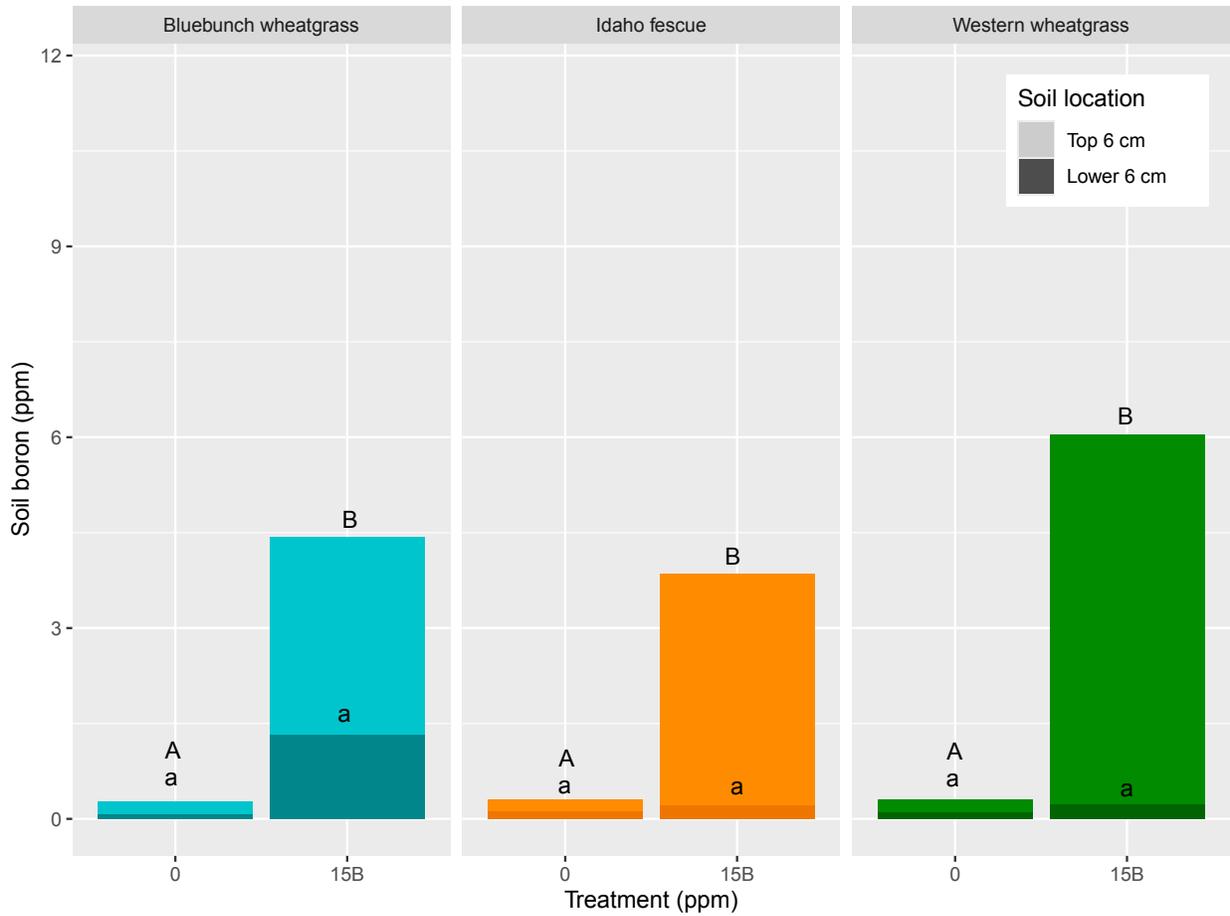


Figure 14: Impact of boron applications on soil boron (ppm) content when mature native perennial grasses were grown. Soil samples were only collected for trial 2. Soil was split into two samples, soil in the upper 6 cm of the pot and soil in the lower 6 cm of the pot, represented by the shading of the stacked bars. Treatments include a non-treated control (0) and 15 ppm of boron (15B). Individual plants were grown in a controlled environment for a total of 25 weeks, aboveground biomass was harvested six weeks post treatment, after which soil was collected. Boron content was analyzed by Agvise laboratories. Compact letter display shows differences between rates within each species. Capital letters showing differences between the upper soil samples, and lower-case letters showing differences between the lower soil samples.

#### Objective 4

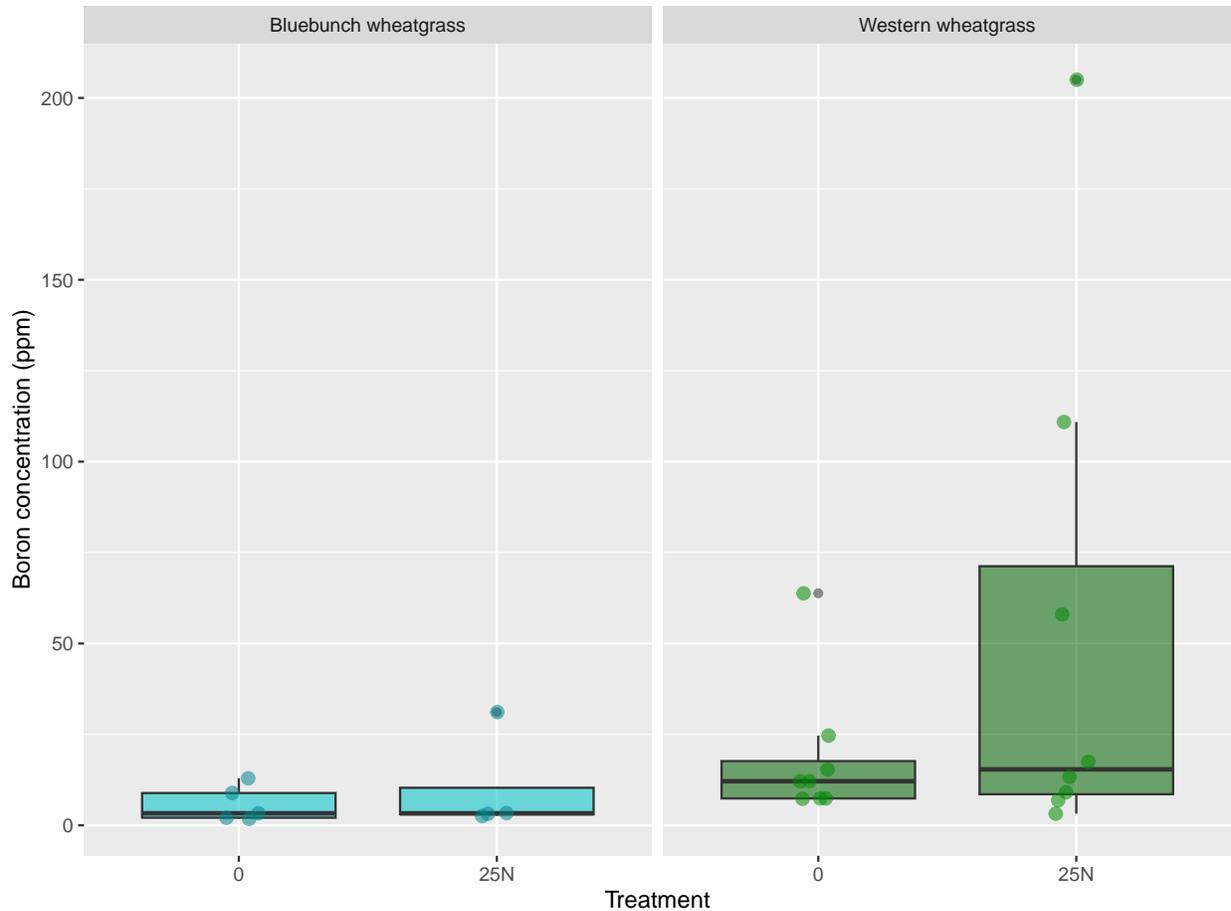


Figure 15: Impact of NutraFix applications on boron concentration (ppm) in aboveground tissues of mature native perennial grasses grown under field conditions. Treatments include a non-treated control (0) and 25 ppm of NutraFix (25N). Plots were established at two semi-arid rangelands in the fall of 2020 and sampled in mid-July of 2024 or established in the fall of 2021 and sampled mid-July of 2025. Each site contained 5 treatment replicates and all were sampled, however not all plots contained the target species. All aboveground biomass of western wheatgrass or bluebunch wheatgrass individuals present were collected from each plot (3.125 m<sup>2</sup>). Tissue samples were analyzed by either Cumberland Valley Analytical Services (2024 samples) or North Border Analytics (2025 samples).

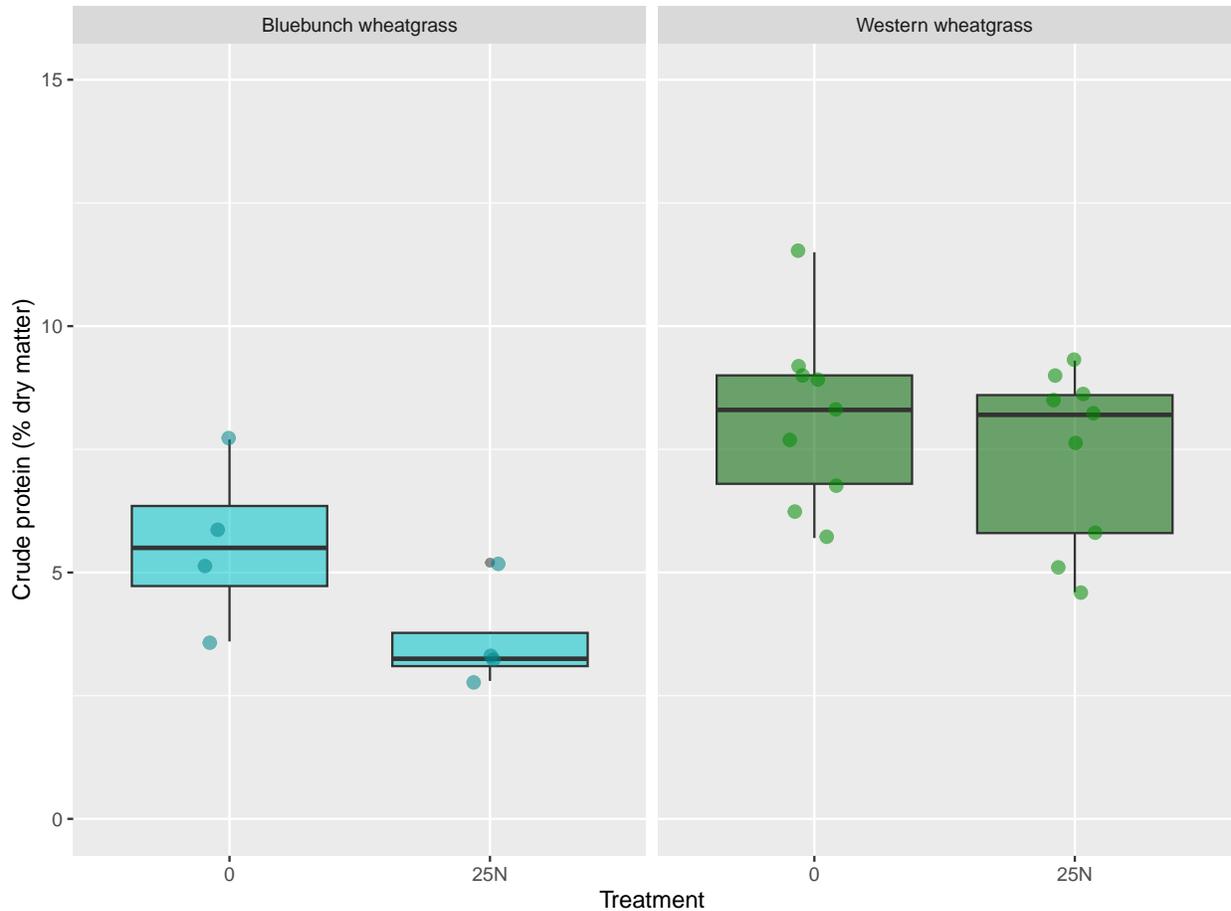


Figure 16: Impact of NutraFix applications on crude protein (% dry matter) in aboveground tissues of native perennial grasses grown under field conditions. Treatments include a non-treated control (0) and 25 ppm of NutraFix (25N). Plots were established at two semi-arid rangelands in the fall of 2020 and sampled in mid-July of 2024 or established in the fall of 2021 and sampled mid-July of 2025. Each site contained 5 treatment replicates, and all were sampled, however not all plots contained the target species. All aboveground biomass of western wheatgrass or bluebunch wheatgrass individuals present were collected from each plot (3.125 m<sup>2</sup>). Tissue samples were analyzed by either Cumberland Valley Analytical Services (2024 samples) or North Border Analytics (2025 samples).

Table 1: Mean values of soil analysis for each management treatment collected four years post treatment application (2024). Results are averaged over site, only boron showed a difference at the  $p < 0.05$  level, marked with an asterisk.

	Nitrate (#/acre)	Phosphorous (ppm)	Potassium (ppm)	Sulfur (#/acre)	Boron (ppm)	Zinc (ppm)	Iron (ppm)	Manganese (ppm)	Copper (ppm)	Magnesium (ppm)	Calcium (ppm)	Sodium (ppm)	OM (%)	pH
Control	2.5	9.7	334.1	14.6	<b>0.2</b>	1.3	46.3	32.9	0.7	211.4	1880.1	10.4	2.5	6.9
NutraFix	3.6	9.7	335.4	14.7	<b>0.7*</b>	1.6	33.7	27.7	0.8	218.4	1875.4	9.8	2.9	6.8