Downy brome management under future climate scenarios

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Growers in the Pacific Northwest (PNW) are likely to see shifts in agroecozones and will need to adapt practices as climate changes. Increasing mean annual temperatures, increasing spring precipitation, and decreasing summer precipitation have been observed in the PNW over the past 50 years. Changes in the PNW climate over the next century are projected to outpace recent trends. To aid in grower adaptation, better knowledge of weed response to climate change is needed.

Bromus tectorum (downy brome) is an invasive winter annual grass species, widespread throughout the winter wheat production regions of the PNW. Physiological development of downy brome occurs earlier in the season than does that of other winter annual grasses. Winter wheat yields can be reduced by up to 90% if downy brome is left uncontrolled, and even moderate infestations can significantly reduce profitability.

IMPACT

Both the projected changes in downy brome development and current distribution of downy brome accessions follow an east-west gradient. Since early-flowering accessions will be better adapted to warmer springs and less severe winters, it is likely that early-flowering accessions will experience a range expansion toward the east as climate changes.

Downy brome is difficult to control through cultural practices, and growers primarily rely on herbicides when conservation tillage is utilized. Multiple independent introduction events of downy brome have resulted in multiple inbred naturalized populations coexisting across landscapes (Figure 1). Selection often favors range expansion of pre-adapted biotypes rather that evolution of novel traits. Many phenotypic traits demonstrate high environmental plasticity; however, flowering time is a relatively stable trait of adaptive significance. The widespread distribution and stable influence of environment on flowering time make downy brome an ideal species for studying the impacts of climate change.

A previously published downy brome development model using cumulative growing degree days (GDD), starting on January 1 and with a base temperature of 0°C, has been used to predict mature seed set. According to the model, plants collected from the PNW set mature seed around 1,000 GDD.

Using this value, 14 climate models that adequately captured the historical characteristics of the PNW climate were downscaled to compare the mean calendar date when 1,000 GDD was reached from 1950 to 2005 to the projected mean calendar date for reaching 1,000 GDD from 2031 to 2060 (Figure 2). Across all models and locations, the calendar date at which 1,000 GDD was reached was projected to occur earlier in the year. This date advanced 10 to 30 days, depending on the model used. When models were averaged, the projected date advanced 15 to 25 days, depending on location. The projected calendar date to reach 1,000 GDD follows an east-west gradient across the projected region in all models. The eastern region of small grain production in the PNW is projected to have the least change, while the western region is projected to have the greatest advance in calendar date needed to reach 1,000 GDD.

Figure 1. *Downy brome variation in the Pacific Northwest. Photo by Nevin Lawrence.*

Downy brome accessions were collected from 95 locations within the winter wheat production region of the PNW. These accessions were brought to seed within greenhouse settings and later transplanted to a field site near Central Ferry, Washington in November 2012 (Figure 3). The field site was visited weekly, and plant development was recorded, along with accumulated GDD beginning January 1. Plant development differed by up to 3 weeks among accessions at the Central Ferry location, which is hypothesized to be the result of differing vernalization requirements to induce flowering.

When the distribution of early- and late-flowering accessions identified in the common garden experiment is plotted across the small grain production regions of the PNW, a strong spatial trend is evident. Early-flowering accessions are predominantly found in central Washington and north-central Oregon, while late-flowering accessions are more commonly located in the Palouse region of eastern Washington and northwestern Idaho. While the distribution of early- and late-flowering biotypes was heavily influenced by east-west orientation, north-south orientation did not significantly contribute to the distribution of accessions.

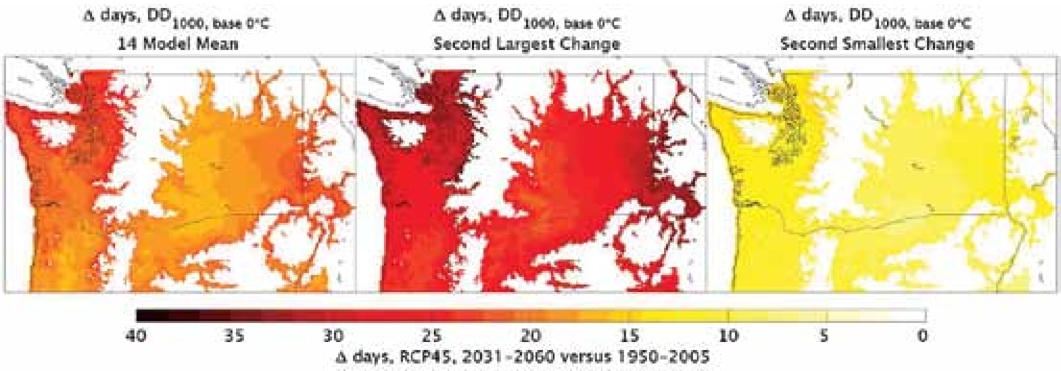
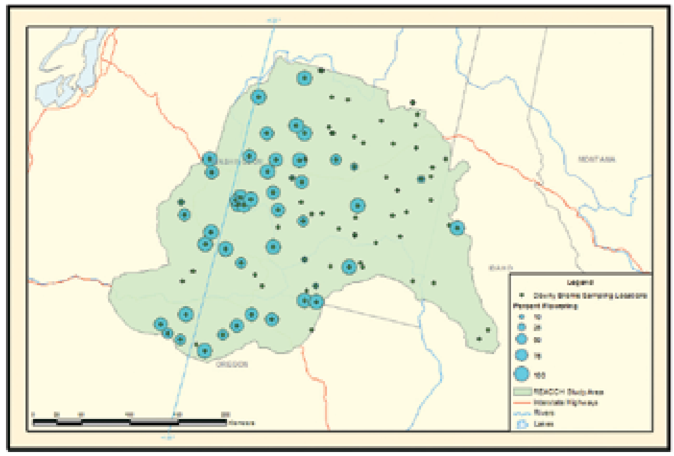


Figure 2. *Projected change in downy brome flowering date (at 1,000 growing degree days) across the Pacific Northwest.*

Both the projected changes in downy brome development and current distribution of downy brome accessions follow an east-west gradient. Those areas that contain late-flowering biotypes are projected to undergo the greatest amount of change in growing degree accumulation. As early-flowering accessions will be better adapted to warmer springs and less severe winters, it is likely that early-flowering accessions will experience a range expansion toward the east as climate changes. With downy brome development projected to advance in time, control inputs will likely need to advance in time as well. Across the high rainfall regions, timely applications are often delayed by spring moisture events. With advancing downy brome development and increasing spring moisture, control may be impacted. Range expansion of downy brome accession currently located in central Washington and Oregon could also result in the movement of herbicide resistance traits from the west to the east as several of the early-flowering accessions have tolerance to selected acetolactate synthase (ALS)-inhibiting herbicides.



Distribution of early and late flowering downy brome accessions in the PNW based on percent flowering at 880 GDD.

Further refinement of the downy brome development model could improve the accuracy and usefulness of future climate projections. Field studies are currently underway to incorporate greater spatial resolution of downy brome phenotypic variation. Additional work is also ongoing to incorporate historic climate changes as a covariate in the spatial analysis of current downy brome accession distribution.

Figure 3. *Downy brome common garden. Photo by Nevin Lawrence.*

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