



Growth in Mixtures of Bluebunch Wheatgrass, Cheatgrass, and Squarrose Knapweed Under Factorial Nitrogen and Phosphorus Additions to a Low-Nutrient Soil

Jeffrey Burnham¹, Eugene Schupp¹ and Thomas Monaco²; (1) Utah State University, (2) USDA ARS; Contact Author Email: jeff.burnham@usu.edu

In a greenhouse, relative success of bluebunch wheatgrass (*Pseudoroegneria spicata* (Pursh) A. L. ssp. *spicata*) in different soil nutrient environments was evaluated by planting it into each of four neighborhoods: monocultures of bluebunch wheatgrass, cheatgrass (*Bromus tectorum* L.), or squarrose knapweed (*Centaurea virgata* Lam. ssp. *squarrosa* (Willd.) Gugler), and a cheatgrass/squarrose knapweed mixture. Cheatgrass and squarrose knapweed were also planted in monoculture to contrast with each other. Upon emergence, nitrogen (ammonium nitrate) and phosphorus (mono- and dibasic sodium phosphate) were added to the low-nutrient soil in a fully factorial design, and plants were allowed to grow for 60 days receiving sufficient deionized water to maintain gravimetric soil moisture within 8%- 14% of soil dry weight. Bluebunch wheatgrass tiller number, dry shoot biomass, dry pot root biomass, and total water use varied directly and significantly with nitrogen, although interactions with phosphorus and neighborhood complicated these results. Total bluebunch water use and dry root biomass showed a three-way interaction, while nitrogen interacted significantly with neighborhood and separately with phosphorus on bluebunch tiller number. The same variables in cheatgrass monocultures exhibited three-way interactions, while in squarrose knapweed monocultures they responded significantly only to nitrogen addition. Although the effect of nitrogen on these species was fully expected, its interaction with phosphorus specifically, significantly greater growth in the presence of high nitrogen and high phosphorus, suggests that phosphorus can also limit growth of bluebunch wheatgrass and cheatgrass in low-nutrient soils, which is potentially useful information where these species coexist with squarrose knapweed.

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