

Pre-Dispersal Seed Predator Dynamics at the Northern Limits of Limber Pine Distribution

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Abstract—Limber pine (*Pinus flexilis*) is listed provincially as endangered in the northern part of its geographic range (Alberta) due to the high mortality caused by white pine blister rust (WPBR) (*Cronartium ribicola*) and mountain pine beetle (*Dendroctonus ponderosae*), and limited regeneration opportunities due to fire exclusion. In the case of an endangered species, seed predators may accelerate this decline, particularly when their populations are regulated by more factors than the abundance of the declining species. Red squirrels (*Tamiasciurus hudsonicus*) are a major cause of pre-dispersal seed loss in many species of conifers. Stands with varying combinations of conifer species that have different reproductive strategies (i.e., mast seeding or persistent aerial seed sources) may experience different amounts of cone predation by squirrels. With no prior studies on cone predation in the northern part of the species' range, we investigated whether: 1) squirrel cone predation differs in areas with low versus high WPBR infection rates, and 2) cone predation differs in limber pine-dominated versus mixed-conifer stands containing limber pine.

Limber pine populations in Alberta occur in the southern foothills of the Rocky Mountains at elevations typically ranging from 1300 to 1900 m. Our low WPBR study area (one percent live tree infestation in 2003; lat. 52.00°, long. -116.50°) contained nine stands ranging from pure limber pine, to limber pine mixed with Douglas-fir (*Pseudotsuga menziesii*), white spruce (*Picea glauca*), or lodgepole pine (*Pinus contorta*). Our high WPBR study area (38 percent live tree infestation in 2003; lat. 49.60°, long. -114.20°) contained stands of either pure limber pine or limber pine–Douglas-fir mixtures. All species except lodgepole pine masted in 2007 and had low cone production in 2008 and 2009. We assumed that one active midden equals one squirrel, based on previous research. Preliminary results suggest that large differences in squirrel abundance in low vs. high WPBR study areas (1.6 vs. 0.4 active middens/ha, respectively) did

not affect the proportion of cones removed. On average, red squirrels removed 85 percent of cones in low WPBR landscapes and 81 percent of cones in high WPBR landscapes. Additionally, fewer squirrels (0.25 as many) harvested the much greater cone production in high WPBR study areas (15.3. vs. 5.9 cones produced per live tree, in high vs. low WPBR areas). Cone predation was highly variable amongst all 17 stands, ranging from 0 to 100 percent. Cone predation varied less than one percent between 2008 and 2009 (averaged across all 17 stands), despite a two-fold increase in cone production in 2009.

More limber pine cones were removed in stands where lodgepole pine was present (93 percent) versus pure limber pine (77 percent). Mixed-limber and lodgepole pine stands generally supported higher squirrel populations, suggesting stands with lodgepole pine (i.e., a persistent aerial seed source) provide a more stable cone supply than stands with one or more mast seeding species (limber-fir or limber-spruce mixtures). Preliminary analyses suggest cone predation and active midden abundance increases as tree basal area increases; however, species composition, and midden proximity were not significant predictors of cone predation amongst trees within each stand. These findings suggest that limber pine may frequently escape seed predation by squirrels, by virtue of its preference for open and exposed habitats, which have fewer trees of other species and lower basal area overall.

Our results suggest that red squirrels are capable of removing most of the cones in non-mast years, even when squirrels are present in low numbers. **Seed predators may accelerate the decline of an endangered species if it is preferentially selected over other abundant species.** Conserving limber pine will require rapidly identifying populations that are most subject to seed limitation and in need of mitigation.

The content of this paper reflects the views of the author(s), who are responsible for the facts and accuracy of the information presented herein.