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### Pattern oriented modeling of Clark's Nutcracker (*Nucifraga columbiana*) in whitebark pine communities

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Whitebark pine (*Pinus albicaulis*; WBP) is an endangered tree species that inhabits high elevation ecosystems in both Western Canada and the United States. WBP communities play a central role in providing wildlife habitat and watershed protection in subalpine and tree line forests, and its seeds provide a high-fat, high-energy food source for many wildlife species. Populations of WBP are in major decline resulting from the combination of outbreaks of mountain pine beetle (*Dendroctonus ponderosae*), mortality and damage from white pine blister rust (*Cronartium ribicola*; a non-native disease), both exacerbated by climate change, and further losses from advancing ecological succession resulting from fire exclusion. Clark's nutcracker (*Nucifraga columbiana*) is the primary disperser of WBP, extracting seeds from the indehiscent cones and caching them throughout montane terrain for future use. Declines in WBP may affect the mutualistic relationship with Clark's nutcrackers, resulting in limited seed dispersal possibly leading to little or no regeneration of WBP. A critical threshold of WBP availability on the landscape may exist below which the Clark's nutcracker will choose alternative food resources. Investigating threshold conditions of WBP on the landscape and the individual behaviors of Clark's nutcrackers in response to these conditions are therefore critical in understanding the potential consequences of declining WBP populations and the cumulative effects this has on WBP communities. In this study, an agent-based modeling (ABM) approach that includes animal movement and behavioral ecology is used to simulate ecosystem dynamics within a WBP community. We focus here on key behaviors of Clark's nutcracker, including prey (seed) choice, group foraging and patch selection as a function of distance observed by nutcrackers. Empirical data from field studies are used to calibrate the model while a pattern-oriented modeling (POM) approach compares observed patterns with model outcomes for validation. The results elucidate the impact of behaviors of Clark's nutcracker on the use of WBP, and ultimately on the long term survival of the tree species based on its abundance as a food resource.

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