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## Clark's Nutcrackers of Yellowstone National Park: Conserving an Iconic Mutualism

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**Background and objectives:** Fundamental to species conservation planning is understanding important interspecific interactions. Whitebark pine (*Pinus albicaulis*), an ecologically important high elevation conifer, was listed as threatened under the Endangered Species Act in 2023. The pine is declining rangewide from several threats including exotic disease and global climate change. Clark's nutcrackers (*Nucifraga columbiana*) are primary seed dispersers for whitebark pine and key to maintaining the tree. In Yellowstone National Park (YNP), long-term monitoring confirms whitebark pine decline, but little is known about nutcracker population dynamics, seed resource use, and spatial movements. We are addressing the following questions: Which forest community types in YNP are used by Clark's nutcrackers, and does use differ between late summer and fall? Do nutcrackers have home ranges within YNP or do home ranges extend beyond park boundaries? Do home ranges vary seasonally and annually? If birds leave the park do they return (residency vs. emigration)?

**Methods:** To address forest community use, we established 11 study sites representing 5 forest community types— whitebark pine, lodgepole pine (*P. contorta*), Engelmann spruce (*Picea engelmannii*), limber pine (*P. flexilis*), and Douglas-fir (*Pseudotsuga menziesii*). Each site generated nutcracker point counts, conifer cone production indices, forest community data, and seed resource use observations. We compared models to estimate nutcracker density and its relationship to forest community type, seed harvesting time-period, year, site, and cone seed energy. To determine nutcracker spatial use, in March 2021 we placed GPS tags with limited fixes and variable intervals on 6 breeding nutcrackers. In March 2023 and 2024, 5 and 4 nutcrackers, respectively, were captured and fitted with solar-powered satellite tags.

**Results/Conclusions:** For questions about habitat use, we compared models to estimate nutcracker density and its relationship to forest community type, seed harvesting time-period, year, site, and cone seed energy. Cone production varied across years indicating annual variability in energy availability. Nutcracker density was highest in whitebark pine stands during the mid-harvesting season. Nutcracker density was comparatively low for all other forest community types. Regarding spatial use of YNP by nutcrackers, in 2021 all tagged nutcrackers were in breeding condition and remained in the vicinity of capture until late May to late June. One nutcracker repeatedly returned to the same area between trips to higher elevation forests in late summer, suggesting seed caching at lower elevations. In June, two birds left the park and overwintered outside park boundaries, providing fixes until battery failure. Three of the five nutcrackers tagged in 2023 provided sufficient locational information for annual home range analysis.

The 95% confidence intervals for Weighted Autocorrelated Kernel Density Estimation (wAKDE) for these birds ranged from 212 to 534 km<sup>2</sup>. In conclusion, the forest habitat study underscored whitebark pine's importance as a key seed resource for Clark's nutcracker in YNP. All tagged birds remained within YNP or the Greater Yellowstone Region during the period that geospatial data were available, with no emigration evident.

Diana F. Tomback is Professor of Integrative Biology at the University of Colorado Denver, with expertise in forest ecology and conservation biology. She has conducted research over many decades on Clark's nutcracker, its interaction with whitebark pine, and whitebark pine ecology. More recently, she and her students have been studying nutcracker habitat use and population and spatial dynamics in Yellowstone National Park in collaboration with park resource managers and Ricketts Conservation Foundation.