Meg and Bert Raynes Wildlife Fund Proposal December 2012
Taza Schaming tds55@cornell.edu

The impact of whitebark pine (*Pinus albicaulis*) mortality on Clark's Nutcracker (*Nucifraga columbiana*) demography and habitat use

Abstract

Whitebark pine (WBP, *Pinus albicaulis*) is an obligate mutualist of Clark's Nutcrackers (CLNU, *Nucifraga columbiana*) because WBP trees sprout almost exclusively from CLNU seed caches. This dependency leads to considerable concern for both species because WBP ecosystems are rapidly disappearing in the western United States, and anecdotal evidence suggests that declining WBP communities are leading to reduced local CLNU populations. While WBP restoration efforts are underway, these efforts will not be effective if the mutualism breaks down due to CLNU populations declining, or their habitat use changing to a degree that they are not available to disperse WBP seeds. I am characterizing the variation in the resource-utilization niches of CLNU subpopulations in areas with variable WBP mortality by documenting CLNU seasonal habitat use and foraging ecology, through occupancy abundance surveys, fledgling surveys, radio tracking individuals, and behavioral watches in which I assess diet composition. With these data, I will examine how WBP cone crop density, local conifer composition, and regional landscape composition correlate with local differences in occupancy and abundance of CLNUs in the Greater Yellowstone Ecosystem. I will then develop habitat suitability models to predict (1) which forest communities surviving within the CLNU range will be sufficient to support CLNU populations, (2) the threshold at which stability of the CLNU-WBP mutualism will begin to break down, and (3) which management actions should increase persistence of CLNUs. My results will characterize the importance of WBP to CLNUs in the Greater Yellowstone Ecosystem, allowing for better informed predictions of the impacts of current disturbances on CLNU population viability and viability of the CLNU-WBP community. CLNUs are on the cusp of a potentially drastic decline, and my ultimate goal is to design biologically informed management interventions to help ensure persistence of CLNUs throughout their range.

Statement of Objectives and Significance

In July 2011, the Fish and Wildlife Service determined that listing WBP as an endangered species was "warranted but precluded", meaning that the tree should be listed, but the funding is not currently available (United States, Department of the Interior 2011). For successful WBP restoration, it is essential that we continue to fill the gaps in our knowledge on the interactions between CLNUs and WBP, and that managers design WBP ecosystem management plans with consideration of the role of CLNUs. Managing CLNUs is important not just for the birds, but for the entire WBP ecosystem.

My results will give us a better understanding of how plastic CLNU foraging behavior and habitat use are in the face of habitat degradation. This understanding will aid us in designing management interventions that better contribute to the success of restoring these communities to maintain a healthy ecosystem. By comparing my data with Lorenz and Sullivan's (2009), the only other systematic study of CLNU habitat use, I will evaluate behavioral variability of CLNU populations, illuminating whether similar management strategies are likely to have similar effects on CLNUs in different regions. I am also developing an accurate and cost-effective method for monitoring CLNU populations in order to create, then help implement a standardized CLNU monitoring protocol for federal, state, and private organizations throughout the west. I am interacting with faculty at Cornell University and the University of Colorado, as well as with land managers at Grand Teton and Yellowstone National Parks, Bridger-Teton National Forest, and the Wyoming Game and Fish Department (including Diana Tomback, Nancy Bockino, Liz Davy and Susan Patla) to coordinate research and share information toward developing a conservation strategy for the CLNU-WBP system. My research has immediate conservation implications, but also advances theoretical understanding of niche adaptation, cascading effects of the decline of keystone species and mutualism stability. I am passionate about this work, and have demonstrated my ability to carry out this research in four previous field seasons. I will conduct my final season of dissertation field research in 2013.

Review of Relevant Literature

WBP is a critical component of treeline and subalpine ecosystems in western North America, contributing to biodiversity and performing multiple ecosystem services. It is a keystone species in some communities because many animal species, including the grizzly bear, depend on its high-fat, high-energy nuts (Tomback et al. 2001). WBP is valuable for watershed protection because it delays snowmelt which leads to decreases in spring flooding, then decreases in summer droughts (Ellison et al. 2005). Until recent declines, WBP made up 10-15% of the total forest cover in the northern Rockies (Tomback et al. 2001). Currently, WBP forest communities are rapidly disappearing range-wide due to decades of fire suppression, widespread infection by the nonnative fungal pathogen *Cronartium ribicola*, which causes white pine blister rust, and outbreaks of mountain pine beetles (*Dendroctonus ponderosae*) (Tomback et al. 2001). This high mortality may seriously reduce biodiversity and disrupt many species interactions (Resler and Tomback 2008). Even the healthiest WBP stands, located in the Greater Yellowstone Ecosystem, have severely declined since 2000, due primarily to a mountain pine beetle epidemic (Schwartz et al. 2007; L. Davys, pers. comm.) that has been worsened by favorable effects of global warming on bark beetle reproduction (Gibson 2006), and in 2009, 46% of these WBP stands were classified as "high mortality" (Macfarlane et al. 2010).

Because of the obligate dependence of WBP on CLNUs for dispersal of its wingless seeds (McKinney et al. 2009, Tomback 1978), WBP conservation efforts should consider including strategies which ensure local CLNU survival and reproductive success. CLNUs depend on fresh and stored pine seeds for their diet, and their morphology, behavior, and annual cycle are tied to these specialized food sources (Tomback 1998). CLNU population size, mortality rate, and reproductive rate *appear* to correlate with cone production of their preferred *Pinus* species (McKinney et al. 2009). Though CLNUs do live in regions south of the WBP range, these southern regions have different dominant trees and potential food sources compared to the northern WBP range (Tomback et al. 2001), and though the dependency of the CLNU population on different subalpine conifers has not been determined, they are thought to prefer WBP seeds when available (Tomback 1978). Where WBP are found, CLNUs are estimated to store up to 35,000 WBP seeds per year per bird (Tomback 1977), suggesting that the decline of WBP will have strong impacts on CLNU populations in these areas. CLNUs play an important role in forest regeneration and conifer seed dispersal for not only WBP, but for at least *ten* conifer species in western North America (Lorenz and Sullivan 2009), and a decline in CLNU populations would affect not only WBP regeneration, but long-distance dispersal of many conifer species.

The population status and habitat use of CLNUs are poorly studied, in part due to their remote range (Tomback 1998). Most previous CLNU research has been restricted to observational studies on harvesting and caching behavior (Tomback et al. 2001), and only one systematic study of habitat use has been carried out on a population in the Cascade Range, Washington (Lorenz and Sullivan 2009). Lorenz's study had a very low sample size, and the dominant habitat and WBP degradation at the site differs greatly from other regions – mortality rates of some WBP stands in the Cascades were as high as 90% (Kendall and Keane 2001, Lorenz and Sullivan 2009). The CLNU habitat use and movement patterns discovered in Lorenz's study may not reflect the behavior of all CLNU populations. Before management actions are initiated based on Lorenz and Sullivan's results, it is important to evaluate variation in CLNU populations.

Though on the cusp of a potentially drastic decline, CLNUs are currently still relatively abundant in the Greater Yellowstone Ecosystem (T. Schaming pers. observ.). No one has quantified how important WBP is to CLNUs in this region, and therefore the impact of WBP mortality on CLNU population and habitat use is currently impossible to predict. Can CLNUs survive by feeding on non-WBP seeds available in this region, where, like the Pacific Northwest, we know WBP is an important component of their diet (Lorenz and Sullivan 2009, Tomback et al. 2001)? Is it possible for CLNUs to remain local residents and breed even when WBP populations and cone crops are low? It is critical to collect more data on feeding ecology, habitat use and reproductive success of CLNUs to inform management decisions specific to the Greater Yellowstone Ecosystem, and to evaluate variability of CLNU behavior in populations across different habitats. By characterizing the variation in the resource-utilization niches (MacArthur 1968) of subpopulations in areas with variable amounts of WBP, I can evaluate if CLNUs require WBP in this region, which other conifer types CLNUs use for foraging in the absence of WBP, and overall how plastic CLNUs are in the face of WBP degradation. These data will increase our understanding of these species' interactions, and the impacts of WBP decline on CLNU demography and behavior, so that we can design biologically informed management interventions that better contribute to the success of restoring these communities to maintain a healthy ecosystem.

Current WBP restoration efforts include collecting, growing and planting blister-rust resistant seeds, and carrying out prescribed burns and silvicultural thinning to create openings which both attract CLNU caching and enhance growth of WBP's shade-intolerant seedlings (Tomback et al. 2001). A better understanding of CLNU habitat use may impact management decisions: for example, to effectively maintain CLNU populations, it may be necessary to maintain specific conifer habitats other than WBP. Alternatively, a specific minimum size of WBP stands may be required to ensure seeds survive to maturity at which point they become available to be cached.

In this proposed study, which is both hypothesis driven and discovery based, I will evaluate the following hypotheses and predictions: **(H0)** CLNUs are dependent on WBP in the Greater Yellowstone Ecosystem, and therefore negative impacts of the loss of WBP will not be overcome by adequate concentrations of other native conifers. **P1:** CLNUs cannot subsist solely on seeds of conifers other than WBP in this region. **P2:** CLNU occupancy and abundance increase with increasing WBP cone crop density, and **P3:** with proportion of the landscape composed of WBP stands at local and regional scales. **P4:** CLNUs will not breed when the WBP cone crop is low. **(HA)** CLNUs are not dependent on WBPs in the Greater Yellowstone Ecosystem, and therefore negative impacts of the loss of WBP can be overcome by sufficient concentrations and specific compositions of alternative local conifer species. **P1:** CLNU can subsist on seeds of local conifers other than WBP. **P2:** There is an adequate concentration of multiple conifer species whose seeds CLNUs eat, so that when the cone crop of one is low, the cone crop of the second can act as a buffer and provide adequate nutrition for CLNUs. **P3:** CLNU occupancy and abundance increase with increased specific dominant conifers (e.g. Douglas Fir (*Pseudotsuga menziesii*)) in areas with low or no WBP cone crops, or **P4:** with the proportion of the landscape composed of specific conifer stands at local and regional scales. **P5:** CLNUs will breed even when the WBP cone crop is low.

Methodology:

Study Area: My field site is located in Bridger-Teton and Shoshone National Forests, Wyoming, in the Greater Yellowstone Ecosystem.

Radio-tracking, Behavioral Watches: Radio tracking individuals is essential to determine home range, proportional habitat use, and to seasonally track and carry out behavioral watches on individuals. I completed this portion of the field research between 2010 and 2012.

Occupancy and Abundance Surveys: I have established 96 random points within conifer forests in my study area, and have conducted surveys at a subset of the points each year since 2009. The established points are in habitats with variable levels of healthy WBP. However, the majority of points are located within an area approximately 40km by 20km. In order to better understand the impact of WBP mortality and habitat on CLNU occupancy at higher spatial scales, I need to expand my surveys to cover a larger area. I need to carry out surveys in locations with extensive healthy stands of WBP in the southern Wind River Mountain Range (~100-200km from primary study location), and near Red Lodge, MT (~200km), as well as in locations where extensive extreme WBP mortality has occurred, such as in the Absaroka Mountains (~100km). The additional surveys will ensure I have adequate survey data in locations with variable WBP health at larger landscape scales. As CLNUs are known to move long distances (up to 32.6 km to harvest seeds (Lorenz and Sullivan 2009)), the landscape scale levels of WBP may be a driving factor in determining CLNU occupancy. It is essential that I complete these additional surveys to fill in gaps in my data.

In 2013, I will revisit all of the 96 established points and will establish an additional 75 points (minimum). Three sets of point counts will be conducted at each point between May and September, with one set consisting of three sequential ten-minute point counts. Three counts are necessary to determine variable seasonal detectability of CLNUs in different habitats (MacKenzie et al. 2006). CLNU surveys have rarely been carried out (Lorenz and Sullivan 2009), and previous studies have never corrected their CLNU counts by taking detectability into account. When a CLNU is seen or heard, I will record the time, manner of detection (visual or audio), distance to the point (exact with a rangefinder, or <50m, 50-100m, or >100m), compass bearing from the point to the bird, behavior when first detected (e.g. flying, perching, foraging), age if possible (juveniles have distinctive plumage (Tomback 1998)), whether or not sublingual pouch is full (indicating caching behavior), and flock size. During each point count sampling, I will document cloud cover, average and maximum wind speed (m/s), temperature (°C), precipitation, and time of day.

Habitat Surveys: After each point count, I will count the number of cones on (the same) four randomly chosen WBP trees within 50m of each survey point. To determine tree density, tree size and species, and number of cone-bearing WBP, I will carry out a modified point quarter method at each CLNU survey point. I will calculate basal area per species from the dbh, and will estimate number of WBP cones and cone-bearing trees per hectare with the cone counts and cone-bearing tree densities.

Fledgling Surveys: In 2012, we conducted a pilot study to evaluate feasibility of fledgling surveys. We carried out over 50 hours of surveys, and determined that CLNU fledglings are readily observable between mid-May and mid-July. In 2013, I will evaluate fledgling presence in habitats with variable levels of healthy WBPs throughout Bridger-Teton and Shoshone National Forest, through a combination of occupancy surveys (above), and time and distance standardized spot-mapping proven to work in the 2012 pilot study. These surveys would enable me to determine reproductive success (presence and number of fledglings per pair) in varying habitats without radio tracking individuals. As with the occupancy surveys (above), I would carry out fledgling surveys in a much larger area, in order to better evaluate landscape effects on CLNU reproductive success.

Data Analyses: I will use minimum convex polygons to calculate home ranges of tracked CLNUs (Lorenz and Sullivan 2009), and will determine habitat composition within home ranges and in the larger landscape using Manifold. I will analyze my occupancy data with the package "unmarked" in R (version 2.11.1), with single-season occupancy models, to evaluate detectability within differing habitats, then to tease apart CLNU occupancy and abundance, and reproductive success, in relation to WBP cone crop density, local conifer diversity, and landscape composition at local and regional scales. I will develop habitat suitability models to demonstrate which environmental variables relate to the likelihood of CLNU occurrence. I will use general linear and general linear mixed models to evaluate proportional habitat use within home ranges and diet composition.

Time frame:

Mid-May – Mid-July (1) Conduct fledgling surveys; Mid-May – Sept (1) Establish ≥ 75 new occupancy survey points, (2) carry out three sets of occupancy surveys and WBP cone counts at 96 previously established points, and ≥ 75 new points, (5) carry out modified point quarter method habitat surveys at each point.

Funding request justification:

In order to best understand the influence of landscape scale WBP mortality, it is essential that I fill in the gaps in my occupancy survey data by completing additional surveys during the 2013 field season. I request $6,000 from the Meg and Bert Raynes Wildlife Fund to support two interns' stipends and housing expenses for two and a half months each, July 15 through September 30 ($600/mo housing, $600/mo stipend; see budget below). The interns can be trained and can begin work under my supervision for the first month, then can continue carrying out research after I return to campus mid-August. With interns, I will be able to collect immense amounts more data than I can alone. And, by interns continuing to work through September, we will be able to collect data through the important fall harvest season, when CLNUs move out of their summer home ranges to harvest cones from distant WBP pine stands. Two interns are necessary so that they can work together; I would not feel comfortable sending out an intern alone in this remote terrain in grizzly bear country. I now have the equipment for two interns, so I only need to fund the interns themselves.

<u>2013 Budget:</u>	**Each:**	**Quantity:**	**Total Cost:**
Intern Expenses (for 2 interns):			
Housing (2.5mo, July15-Sept30)	600/mo	2*2.5mo	3,000.00
Stipend (2.5mo, July15-Sept30)	600/mo	2*2.5mo	3,000.00
		Total	**$6,000.00**

Current Funding 2013: NASA Harriett G. Jenkins Pre-doctoral Fellowship (Jan-Aug personal stipend); Athena Fund (travel expenses).

Funding Applied For, Results Pending: Wyoming Game and Fish (intern and travel expenses).
*I will continue to apply for funding from additional sources. If additional funding is not acquired, I will pay the additional expenses out of my living expenses stipend (listed above).
*Any redundancy in funds received will be used for daily travel at the field site and travel between Ithaca, NY and Jackson, WY or other research expenses.

Literature Cited:

Ellison, A. M., M. S.Bank, B. D. Clinton, E. A. Colburn, K. Elliott, C. R. Ford, D. R. Foster, B. D. Kloeppel, J. D. Knoepp, G. M. Lovett, J. Mohan, D. A. Orwig, N. L. Rodenhouse, W. V. Sobczak, K. A. Stinson, J. K. Stone, C. M. Swan, J. Thompson, B. Von Holle, and J. R. Webster. 2005. Loss of foundation species: consequences for the structure and dynamics of forested ecosystems. Frontiers in Ecology and the Environment 3(9): 479–486.

Gibson, K. 2006. Mountain pine beetle conditions in whitebark pine stands in the greater Yellowstone ecosystem. USDA Forest Service FHP Rpt. 06-03. Missoula, MT.

Kendall, K. C. and R. E. Keane. 2001. Whitebark pine decline: Infection, mortality, and population trends. Pages 221-242. In Tomback, D.F., S.F. Arno, and R.E. Keane, editors. Whitebark pine communities: Ecology and restoration. Island Press. Washington, DC.

Lorenz, T. and K. Sullivan. 2009. Seasonal differences in space use by Clark's Nutcrackers in the Cascade Range. The Condor 111(2): 326-340.

MacArthur, R. H. 1968. The theory of the niche. Pages 159-176. In Lewontin, R. C., editor. Population biology and evolution. Syracuse University Press. Syracuse, New York.

Macfarlane W. W, J. A. Logan and W. R Kern. 2010. Using the Landscape Assessment System (LAS) to assess mountain pine beetle-caused mortality of whitebark pine, Greater Yellowstone Ecosystem, 2009: Project Report. Prepared for the Greater Yellowstone Coordinating Committee, Whitebark Pine Subcommittee. Jackson, WY.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy Estimation and Modeling, Inferring Patterns and Dynamics of Species Occurrence. Elsevier Inc. Burlington, MA.

McKinney, S., C. E. Fiedler and D. F. Tomback. 2009. Invasive pathogen threatens bird-pine mutualism: implications for sustaining a high-elevation ecosystem. Ecological Applications 19: 597-607.

Resler, L. M. and D. F. Tomback. 2008. Blister rust prevalence in krummholz whitebark pine: Implications for treeline dynamics. Arctic, Antarctic and Alpine Research 40:161-170.

Schwartz, C. C., M. A. Haroldson, and K. West [eds.]. 2007. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team. U.S. Geological Survey. Bozeman, MT.

Tomback, D. F. 1977. The behavioral ecology of the Clark's Nutcracker (*Nucifraga columbiana*) in the eastern Sierra Nevada. Ph.D. dissertation, University of California, Santa Barbara, CA.

Tomback, D. F. 1978. Foraging strategies of Clark's Nutcracker. Living Bird 16:123-161.

Tomback, D. F. 1998. Clark's Nutcracker (*Nucifraga columbiana*). In Poole, A. and F. Gill [eds.], The Birds of North America, No. 331. The Birds of North America Inc. Philadelphia, PA.

Tomback, D. F., S. F. Arno, and R. E. Keane, [eds.]. 2001. Whitebark Pine Communities: Ecology and Restoration. Island Press, Washington, D.C.

United States. Department of the Interior. Fish and Wildlife Service. 2011. "Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition To List Pinus albicaulis as Endangered or Threatened With Critical Habitat." *Federal Register.* 76 (138): 42631. [Docket No. FWS–R6–ES–2010–0047; MO 92210–0–0008].