

What determines the distribution of Red-naped Sapsuckers in the East River Valley?

Mary Clapp

Independent Study, Rocky Mountain Biological Laboratory

Mentor: Chris Floyd

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ABSTRACT

The conservation of keystone species and their associates is of great importance due to the disproportionately large role they play in community and ecosystem structure. The Red-naped Sapsucker (*Sphyrapicus nuchalis*) is considered part of an intricate keystone species complex in the aspen forests of the Rocky Mountains, in which sapsuckers drill nest cavities in aspen infected with heartrot fungus (genus *Phellinus*) each year. Abandoned nests provide habitat for secondary nesters such as the violet-green swallow, tree swallow, and house wren. Furthermore, the sap wells they drill into aspen and willow trunks provide a high-carbohydrate meal for many species of mammal, bird, and insect. Because willow stands provide such a significant food resource to sapsuckers, previous studies have suggested that proximity to willow is correlated with sapsucker distribution, using sapsucker damage on aspen as a proxy for distribution. However, it is unknown whether other ecological variables within aspen groves shape or limit sapsucker distribution. In this study, randomly generated quarter-hectare plots within aspen groves were surveyed for a number of ecological variables (including distance to willow and extent of sapsucker damage), and multiple regression analysis was performed to determine which variables best explained variation in sapsucker damage across sites. My analysis tentatively suggests that, once differences in elevation, extent of infection by *Phellinus*, and distance to meadow edge are taken into account, proximity to willow does not explain variation in sapsucker damage. This study provides more information about the ecological requirements of this keystone species complex, which is integral to its preservation.

Key Words: *Sphyrapicus nuchalis*, *Phellinus tremulae*, *Populus tremuloides*, red-naped sapsucker, trembling aspen, heartrot fungus, keystone species, community structure

INTRODUCTION

The concept of the keystone species is critical to our understanding and preservation of complex community structures, yet was not explicitly defined until 1996. It refers to a species whose role in the ecosystem is disproportionately large relative to its abundance (1996).

Keystone species receive much attention from scientists and conservationists alike because they fill ecological niches upon which the rest of the community depends for some aspect of its livelihood, and without which, the structure of the community would unravel. Because of the keystone species' disproportionate role in its ecosystem, it is imperative to understand both direct and indirect links to its community in order to prevent the loss of biodiversity in these systems.

The Red-naped Sapsucker (*Sphyrapicus nuchalis*; Family Picidae) is a well-studied bird that is considered a keystone species of the aspen woodland in the western United States (Ehrlich and Daily 1988). They are primary cavity nesters, excavating aspen trees (*Populus tremuloides*) every year to provide habitat for themselves. Old cavity nests are used by up to eight different bird species, including the violet-green swallow and the house wren. These secondary cavity nesters are more abundant in groves where sapsuckers also reside (Daily et al. 1993). Sapsuckers also drill wells into willows (*Salix* spp.) to harvest sap, an important food resource for the sapsucker during the breeding season, and many bird, mammal, and insect species take advantage of these sap wells for a high-carbohydrate meal (Ehrlich and Daily 1988). Because sapsuckers provide both habitat and food to many different species, they are considered a double keystone species.

It seems that many ecological factors limit the distribution of the Red-naped Sapsucker in aspen woodland. It has been shown that sapsuckers nest almost exclusively in aspen infected with the heart rot fungus (*Phellinus tremulae*), which softens the inner wood (Daily et al. 1993). The method by which the fungus spreads is unknown, but it seems likely that fungus distribution plays a large limiting role in the distribution of the sapsuckers, which depend upon the soft heartwood for efficient cavity drilling. Also, cavity nests are more common in aspen groves with sparse distribution and that border meadow instead of forest (Lawler and Edwards 2002), suggesting that edge habitat is most suitable for nest site location.

Although these ecological factors contributing to the distribution of cavity nesters and associated species have been investigated in the past, it is unclear which variables are primarily responsible for distribution (i.e., cause and effect are unclear). Is sapsucker distribution dependent on the reproductive and dispersal mechanisms of the fungus, without which it would

be impossible to excavate the hard wood of the aspen? This is likely, as aspen hardwood is much too dense for efficient excavation by sapsuckers (Jackson and Jackson 2004). The few studies that have been done on the fungus posit that its spores are wind-dispersed, and that fungus is more likely to infect trees near the edge of a grove than further inward (Jackson and Jackson 2004). What else limits sapsucker distribution, since sapsuckers do not colonize every tree infected with fungus? Is the nearby presence of willows necessary for a sapsucker choosing a nest, or is the fact that sapsucker nests are commonly found near willow stands just a coincidence of similar habitat needs (mesic soil, open space) of aspen and willow?

Daily et al. (1993) described Red-naped Sapsuckers as “double keystone” birds because their old nest cavities provide homes for a number of secondary nesters, and the sap wells they drill into willows (*Salix* spp.) provide a high-carbohydrate meal for a number of birds, mammals, and insects. The investigators concluded that the presence of willows was important to sapsucker distribution from their finding that sapsucker damage to aspen was significantly more prevalent in groves close (<50 meters) to willow stands than in groves far away from willows. However, aspen in the East River Valley are distributed continuously and over a large elevational gradient, so defining discrete groves with similar spatial and topographical characteristics is problematic. It is possible that the association that Daily and Ehrlich found between willow proximity and sapsucker distribution is due to any number of confounding ecological variables such as elevation or heartrot fungus distribution patterns. If the correlational pattern that Daily and Ehrlich reported still exists after controlling for these variables, we can say with greater confidence that the presence and proximity of willows limits sapsucker distribution. If the trend disappears, then sapsucker distribution—and the distribution of its associated obligate secondary cavity nesters—is independent of willow proximity.

It is clear that this keystone species complex is extremely important to the biodiversity of the region, and thus it is important to make our observations and studies of it as accurate and direct as possible. By understanding what drives these interactions, we are less likely to run the risk of tampering with the delicate system and causing it to unravel.

MATERIALS AND METHODS

I studied the association between sapsucker damage and proximity to willow in aspen stands across the East River Valley in Gothic, Colorado, six miles north of Crested Butte, controlling for the following ecological variables: elevation, aspen density, distance to nearest willow, distance to edge habitat, distance to nearest sapsucker cavity, and prevalence of fungus-infected trees. I used ArcGIS to define my study region as a circle with centerpoint: 38°57'30.414" N, 106°59'17.76" W and radius = 2642.3 m, making my study area a total of 21,933,947.03 square meters that spanned the Gothic Townsite, Copper Creek, and North Gothic areas. Within that circle, I generated an excess of random points across the East River Valley. Using either a GeoXT or a GPS eXplorer, I navigated to 14 random points that fell below 3070 m in elevation and established circular plots with radius = 28.2 m (0.25 hectare) and area = 2497.05 m². Within each plot, I counted every standing aspen over 5 cm DBH and recorded the following variables for each: size (large trees ≥ 17 cm DBH, small trees < 17 cm DBH); infection by *Phellinus* (determined by the presence of visible conks on trunk); infection by orange rot (determined by softness and/or orange blotches on trunk); presence/absence of sapsucker damage (determined by the presence of horizontal rows of rectangular scars; and presence/absence of cavity nests. I marked each aspen with a tree crayon to prevent counting it twice. I also counted every conifer and snag over 5 cm DBH and recorded the aforementioned variables for each. I divided each plot into quarters using measuring tape and collected data quarter by quarter,

estimating by eye the arc of my circular plot. At each plot, I also recorded GPS coordinates and elevation. I used ArcGIS to measure the distance of the center of my plots to nearest willow and nearest meadow edge. I also measured the distance from the center of my plot to the nearest sapsucker cavity nest, occupied or not, using data collected by Chris Floyd over 2006-2008.

Data analysis. Using JMP, I performed a stepwise multiple regression on my data in order to determine which, if any, of the following ecological variables (elevation, aspen density, distance to nearest willow, distance to edge habitat, distance to nearest sapsucker cavity, and prevalence of fungus-infected trees) best explained the variance in the extent of sapsucker damage (transformed as the arcsine square root of proportion of aspen with sapsucker damage) within my plots.

RESULTS

Sapsucker damage was found in only half of 14 quarter-hectare plots.

A linear regression of distance from the center of a plot to nearest willow on the proportion of aspen with sapsucker damage showed that distance to willow does not explain variation in proportion of sapsucker damage at any random point within an aspen grove (Figure 1; $R^2 = 0.0176$, $p = 0.65$). In a linear regression of distance to willow on the distance to nearest cavity nest, there was a significant effect ($R^2 = 0.403$, $p = 0.0146$).

In a stepwise multiple regression incorporating the aforementioned ecological variables, three variables significantly explained such variation: elevation ($p = 0.0490$), distance to edge ($p = 0.0423$), and the proportion of aspen infected with *Phellinus* fungus ($p = 0.0045$), with the latter explaining the most of the variation (Figure 2). When distance to willow was included in the regression as an independent variable along with the first three, it did not exhibit a significant relationship with the response variable ($p > 0.5$), both the R^2 - and whole-model p-values

decreased, and the effect of elevation became insignificant ($p = 0.1417$). Power analysis revealed that a sample size of $n > 168$ was necessary for the effects of willow proximity on extent of sapsucker damage to be significant, indicating that distance to willow has a small, if any, effect on sapsucker distribution.

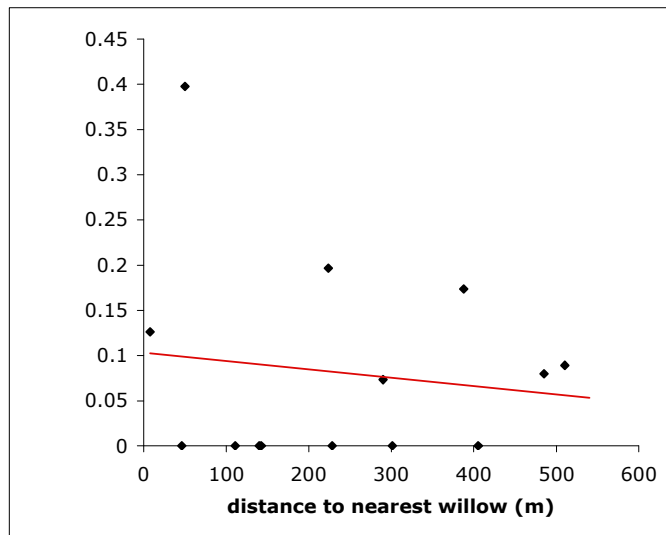


Figure 1. There is no significant relationship between the distance to the nearest willow and the extent of sapsucker damage in random 0.25-hectare plots of aspen (linear regression; $y = 0.1031303 - 0.0000922x$; $R\text{-squared} = 0.01$; $p = 0.56$).

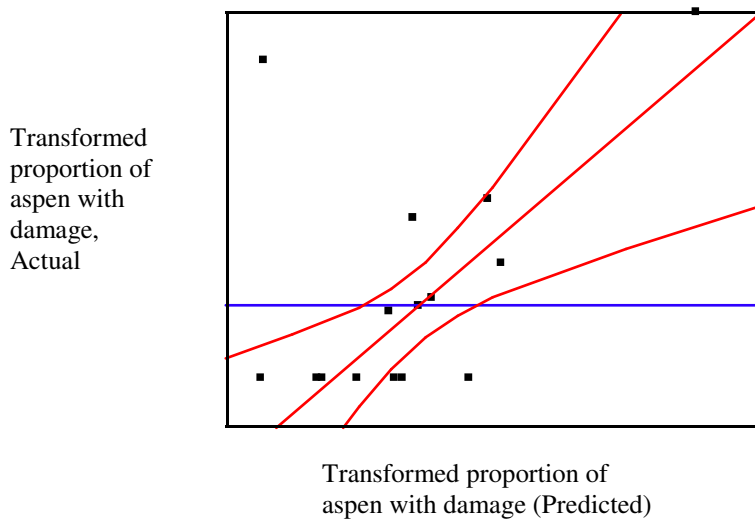


Figure 2. Predicted vs. actual proportions of aspen with sapsucker damage from a multiple regression analysis. Elevation, distance to edge (m), and proportion of aspen with fungus, and all significantly predicted the variation in proportion of aspen with sapsucker damage ($p < 0.05$ for all three variables).

DISCUSSION

My results suggest that a number of ecological variables shape suitable sapsucker habitat. The finding that sapsucker damage is more prevalent in aspen closer to the edge of the grove supports Lawler and Edwards' research (Lawler and Edwards 2002) that cavity-nesting birds prefer sparsely populated aspen groves close to meadows, and the lack of correlation between damage and distance to willow suggests that it is the spatial properties of the forest edge that the sapsuckers prefer, rather than an increased proximity to willow associated with edge habitat. Prevalence of sapsucker damage was largely explained by prevalence of fungus-infected trees—this link is plausible because fungus-infected trees are necessary for colonization by sapsuckers, and it is probable that sapsuckers optimize foraging during the beginning of the season by drilling sap wells in aspen close to a suitable nest location, as cavity excavation is a costly behavior, diverting time away from activities like vigilance and foraging (Jackson and Jackson 2004), and keeping a food source close would decrease search time and handling time, later in the season.

However, there was no correlation between extent of damage and distance to the nearest cavity nest, suggesting that sapsucker damage may not be a good proxy for sapsucker nesting territory. At a number of my sites, I observed sapsuckers flying overhead, perching on aspen, and sometimes pecking at the trunk but not leaving the characteristic horizontally aligned scars on the trees that were the measurement of “sapsucker damage.” This suggests that damage may not define their home range very accurately. Also, it is uncertain whether the damage scars are temporally correlated with cavity sites. It is possible that some damage may be tens of years older than the nearest cavity nest, and that the nest tree that was associated with that damage, if

there was one, has already rotted and fallen, leaving the damaged trees as a relic of its presence there.

It is possible that sapsucker distribution changes over time due to changes in environmental and behavioral factors. The site location at which sapsucker damage and cavity nests were most prevalent (NG13), no sapsuckers were observed within the plot or around the vicinity. House wrens and tree swallows occupied all of the cavity nests and defended their cavities vigilantly, raising persistent alarm calls as I approached. Dobkin et al (1995) noted that nest cavities are a limiting resource due to the potential for high interspecific competition for nest locations. It is possible that sapsuckers are competed out of suitable habitat that they have established in previous years by secondary nesters. An investigation of relative arrival times for the migratory birds involved in this system, as well as a year-by-year census of sapsucker cavities, and a study of cavity-nesting bird behavior may provide insight into the possibly successional structure of this community.

It is also possible that distance to willow does indeed play a role in determining sapsucker habitat, but one that was not perceived by my study for a number of reasons. First, I visually determined distance to willow, cavity nest, and edge using aerial photos on ArcGIS, which is a less accurate method (but far less time-consuming) than physically measuring that distance. At a few sites, I found willow stands with sapsucker damage in closer proximity to my site than was indicated by my aerial estimate. In these cases, I physically measured that distance to improve my accuracy, but it is unknown whether there are willow stands closer to my other sites that I simply did not see during data collection. Also, not all stands of willow contain sapsucker damage, indicating that not all willows are suitable for drilling by sapsuckers. I suggest a more accurate and meaningful method of measuring distance to willow in order to get a

more honest metric of the importance of willow proximity. I also suggest at least a two-fold increase in sample size in order to survey a wider, more comprehensive range of the ecological variables present in aspen groves. While my results suggest that ecological variables other than distance to willow are at play in determining sapsucker distribution, they are not exclusive of Daily's (1993) results, and instead suggest that more sophisticated study be done on this system to gain a comprehensive understanding of this ecological system.

Proximity to willow may in fact be important to sapsucker distribution, and undoubtedly to sapsucker fitness and survival, as it is such an important food source. Doing a time-budget analysis of sapsucker behavior to determine how often sapsuckers spend at aspen sap wells and willow sap wells is important to our understanding of their relative importance to sapsucker fitness. During fledgling season, I observed a parent and offspring sapsucker pair in a willow stand every morning for approximately two weeks in mid- to late July, and after fledging, observed one to two fledglings foraging alone on new sap wells in the same aspen stand. It is possible that proximity to willow is not strongly correlated with sapsucker distribution, but the effects of willow proximity to fledgling success are unknown. While brooding, adult sapsuckers must forage for much of the day in order to provide food for their offspring, and distance to food source may have consequences for the successful rearing of a brood. Previous studies use fledgling success as a metric for understanding habitat suitability in cavity nesting birds (Tobalske 1992), so a study examining the relative reproductive/fledgling success of nesting sapsuckers at different distances from willow would be another way to understand the importance of willow to this keystone species system.

As aspen forests and surrounding riparian habitat are increasingly logged for livestock use, commercial sprawl and agriculture (Dobkin et al. 1995), it is important to understand the

dynamics and requirements of this keystone species system in order to make informed policy on sustainable development. The preservation of keystone species complexes such as this one is key to understanding community structure dynamics and the effects of keystone species complexes on their ecosystem.

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