

**Red-naped sapsucker nest tree selection and effects on the willow breeding bird
community**

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Abstract

The Red-naped sapsucker creates a nest cavity in aspen woodlands each year, required by other bird spp. for nesting, and spends much of its foraging time in willow wetlands. This study attempted to determine a) how does proximity of potential nest trees to forest edge and willows affect the sapsucker's choice of nest tree b) is there an edge effect on insect abundance and c) what are the effects of sapsucker presence on the willow breeding bird community? Sapsucker nest trees are significantly closer to the edge of the forest than unoccupied trees, but not closer to willows. Insect abundance increases towards the forest edge; this could help explain the preference for sapsucker edge-nesting. An increased density of sapsucker-drilled sap wells in the willows acts to increase willow breeding bird diversity.

Introduction

Red-naped Sapsuckers (*Sphyrapicus nuchalis*), excavate a new nest hole every breeding season; the choice of a nest tree in which to place this is one of the most important decisions they face all season. Placed in a tree closer to a food supply, the potential for a greater number of healthier young increases. However, the more exposed the nest is, the more likely it is to be preyed upon by any of a number of animals that relish in doing so, such as the black bear (*Ursus americanus*; Franzreb and Higgins 1975, Walters and Miller 2001), raccoon (*Procyon lotor*; Kilham 1971), and weasel (*Mustela* spp.; Daily 1993, Walters and Miller 2001). As *S. nuchalis*' foraging areas lie outside the nesting area, the two factors of a ready food supply and a safe nest site are tradeoffs; bird

nests that lie on the forest edge (and thus closer to foraging areas) are more susceptible to predation than those on the forest interior (Fenske-Crawford et al. 1997).

These choices that face *nuchalis* are vital not only to their own reproductive success but to that of other birds as well. This sapsucker has been identified as a keystone species by Daily et al. (1993) in that their nest holes, abandoned after a single breeding season, are used by a number of secondary cavity nesters in subsequent years. Most notable among these are the obligate secondary cavity nesters, which actually require an old cavity to nest in, as opposed to facultative secondary cavity nesters, which benefit from but do not require old cavities.

When the quaking aspen (*Populus tremuloides*) is present in the breeding territory of sapsuckers, they choose it for nesting purposes over all other species of trees, especially when it is infected with the heartwood fungus *Fomes igniarius* (Crocket and Hadow 1975, Li and Martin 1991, Daily et al. 1993, Dobkin et al. 1995, Walters 1996, Martin et al. 2004). The East River valley, in which the Rocky Mountain Biological Laboratory is located and in which I conducted my studies (Gunnison county, CO), is no exception to this rule; aspen woodlands are plentiful and *nuchalis* nests almost exclusively in them.

S. nuchalis' diet includes two main food groups: insects and sap. Insects are obtained by fly-catching and gleaning; sap, on the other hand, is taken from wells drilled into the xylem of various plant species. Early in the year *nuchalis* concentrates its wells on quaking aspen and Douglas-fir, while later in the year, during most of the breeding season, the sapsucker utilizes willows for the this purpose; it thus spends much of its foraging time in willow wetlands tending and feeding off of its wells. Sapsuckers are not

the only animals that benefit from the sap wells they drill; Kilham (1953) observed Ruby-throated Hummingbirds (*Archilochus colubris*), Black-throated Blue Warblers (*Dendroica caerulescens*), and Cape May Warblers (*Dendroica tigrina*) feeding off of sapsucker-drilled wells in a birch. Specifically in willows, Orange-crowned (*Vermivora celata*), Nashville (*Vermivora ruficapilla*), and Wilson's (*Wilsonia pusilla*) warblers, Broad-tailed Hummingbirds (*Selasphorus platycercus*), and an array of small mammals are known to commonly feed off the sapsucker's bounty (Sutherland et al. 1982, Ehrlich and Daily 1988). Because of the obvious benefits these animals reap from having sapsuckers around, it has been postulated by Ehrlich and Daily (1988) that *S. nuchalis* could be considered a keystone species not only in the aspen woodlands in which it nests but in the willows in which it feeds as well.

In my first study I examined the nest tree choice of *nuchalis* as determined by two factors: the proximity of the nest tree to the forest edge and its proximity to willows. My predictions for the proximity of sapsucker nests to the forest edge were based on risk of predation, proximity to foraging areas, and insect productivity at the edge of the forest vs. its interior. As *nuchalis* spends very little time foraging in the interior of aspen groves, the first two factors mentioned here are somewhat of a tradeoff. As to the former, the risk of predation, some of the aspen forests in the East River valley span vast hectares, and it would seem that to be situated in the middle of such a forest as opposed to ten meters from its edge would provide little more safety to the sapsucker; as long as the nest closer to the edge of the forest is suitably within the forest's confines and not overtly exposed, both nests should have roughly the same potential for survival. However, the costs to the

sapsucker nesting in the center of the forest would be great in terms of energy and time spent merely to make it to its feeding grounds; a nest which necessitated flying between trees for eighty meters just to get to the edge of the forest would surely not be very successful. An additional bonus may be had by edge-nesting birds; Cody et al. (1972) showed the size of wren territories to shrink with greater food availability; correspondingly, the territory size of Ovenbirds shrinks when their habitat is edge-type (lower canopy, more ground vegetation) (Stenger and Falls 1959), suggesting an increase in insect resources in edge habitats. Finally, *S. nuchalis* is attracted to habitat with a good deal of open space (Lawler et al. 2002). Based on all this, my hypothesis was that the nest trees of *S. nuchalis* should be closer to the edge of aspen forests than other trees that it could have chosen to nest in.

Willow wetlands represent pretty much ideal foraging locations for *nuchalis*, as not only is willow sap present in large quantities but so are insects. *S. nuchalis* damage in aspens increases with increasing proximity to willows (Daily et al. 1993), and the Williamson sapsucker (*Sphyrapicus thyroideus*) nests exclusively in areas that offer it easy access to its preferred foraging habitat (Crockett and Hadow 1975). As *nuchalis* spends a large amount of time in the willows every day, it seems that it would be preferential to the sapsuckers to have nests located as close as possible to willows so as to minimize both time and energy spent traveling between them; hence, my hypothesis for this part of the experiment was that *S. nuchalis* nests should be located in trees closer to willows than other trees in the same general area.

My second study looks at the forest-edge effect on insect abundance. Stenger and Falls' (1959) study indicated that there was greater insect density with an increase in

edge-type habitat; I decided to look at this more directly, by analyses of the insects themselves. With this experiment I expected to find an increase in insect abundance with an approach to the edge of the forest from the interior. Additionally, if the edge was strictly aspen/meadow, I expected density to drop further from the edge, whereas if the edge was aspen/willow, I expected a further increase in insect abundance as the willows were entered.

For my final study I examined the direct effects of *S. nuchalis*' presence on the breeding bird community. If *nuchalis* really is to be considered a keystone species in willow wetlands, then there should be some measurable effect on the species composition, diversity and density, of the willow breeding bird community. The sap wells that *nuchalis* drills into willow provides direct nourishment to a number of bird species; additionally, insects are attracted to feed at the wells, and the resulting increase in insect density should act to nourish the birds present further. With a greater number of sap wells present, there will be greater food supply in the form of insects and sap available thus and more niches open for different bird species to fill; hence, I expected to see an increased bird diversity with an increase in active sap well density.

Methods

Sapsucker nest tree selection

I searched aspen woodlands of the East River valley for active sapsucker nests, and from these trees I measured the distances to the forest edge and to the nearest willows suitable for sap wells (defined as the nearest willow bearing some sapsucker damage). To

compare distances to edge and willows for trees in use and suitable trees not in use, I defined a suitable tree as being infected with *Fomes igniarius* and of a size reasonable for sapsuckers to raise a brood inside; this reasonable size I called the size of the smallest aspen I found with an active *nuchalis* nest in it, or of a DBH of 0.2 m. Having defined suitable trees, I went back through the forests that I had searched for active sapsucker nests, found all the suitable nest trees that were present, and measured the distances from these trees to the nearest edge and nearest suitable willow. I then compared the means for distances to edge and willows of the occupied and unoccupied trees.

Edge effects on insect abundance

I placed four transects of fifty meters each running from twenty five meters within aspen forests to twenty five meters out of them. I deployed six flypapers along each of these transects, starting at one end and every ten meters thereafter. Two of these transects I ran across an aspen/meadow boundary and two I ran across the transition from aspens to willows. After leaving the flypapers out for 48 hours I counted the insects on each, scoring each insect as XS to XL[why didn't you just pick them off or use Goo Gone and weigh them to get biomass in g/m². Maybe next time]. From these data I determined an insect score for each flypaper, based on the number and sizes of insects present, by counting each XS insect once, each S twice, and so forth; this gave a rough estimate of insect biomass present. Given these data, I was able to compare the means of the edge insect scores (at five meters out of and into the aspens) with the means for the interior of the aspen woodlands (25 meters within).

Sapsucker effects on willow birds

I established thirteen points of radius thirty meters in large willows suitable for sap wells and conducted three point counts at each within three hours of dawn. I recorded the presence or absence of fifteen common willow birds; from the three censuses, for each species I dropped the lowest count obtained and averaged the top two. From the resulting bird community compositions for each point, I used Simpson's index to determine the bird diversity.

To determine sap well density for each point, I ran four 30 x 1 meter transects at random compass directions, radiating out from the center. Along these transects I recorded the number of willow stems with active sap wells. Because the area of the willow points were so much greater than the area that I actually looked at with these transects, I dropped the high and low sap well counts and averaged the remaining two in order to procure an average sap well density for each point. Finally, I ran a regression between the bird diversity and sap well densities thus procured.

Results

Sapsucker nest tree selection

I found 21 active *nuchalis* nests, all of which were located in *Fomes*- infected quaking aspens, and 238 unoccupied yet suitable trees. The mean distance to the forest edge for the occupied trees was 10.07, with a high of 42 meters, low of 0 meters, and variance of 86.17. The mean edge distance for the unoccupied trees was 21.43 meters, with a high of 82 meters, low of 0, and variance of 326.78. Using univariate analysis of variance (ANOVA) to compare the mean edge distances, I procured a p-value of

0.0048 when you report P values at least report the F statistic and numerator and denominator degrees of freedom, e.g., $F_{1,19}$ so the reader can see how many replicates the test is based on, or more appropriately what error the effect was tested over. On a similar but more important point, never report a p-value without some indicate of the size of the difference. For example, with lots of replicates you can show a small difference (e.g., 2%) and low probability that the difference it do to chance. However, a p-value of $P = 0.03$ and a difference among means of 80% means a lot more. (see Fig. 1). *S. nuchalis* is a fairly territorial bird intraspecifically; there is a minimum distance of 100 meters between *nuchalis* nests, generally speaking (Walters 1996). Because of this, trees within 100 meters of an active sapsucker nest that I deemed suitable merely based on size and stage of rot would not be suitable after all. When I drop trees from my list of suitable trees that are within 15 meters of an active nest tree, the mean distance for the 229 remaining trees to the forest edge rises to 21.92, and the p-value for the comparison drops to 0.0036.

The original idea for analyzing these data was to compare the mean distances to edge of unoccupied and occupied trees within the same patch of aspen; the question addressed in that case would have been, given a certain aspen grove, which tree is the sapsucker going to choose? The problem with this analysis was that of all the places where I found sapsucker nests, only one aspen grove had enough nest trees and unoccupied trees in it to make such an analysis possible; for the rest of the places, there were either too few occupied trees, too few unoccupied trees, or too few of both to contemplate running ANOVA on. In one case where it was possible to compare the means of trees within only one contiguous patch of aspen the results were good: for the

four occupied trees the mean distance to edge was 5.13 meters, and for the 101 unoccupied trees mean edge distance was 29.88 meters. Comparing these two values via ANOVA produces a p-value of 0.026.

The proximity of the nest trees to willows vs. the proximity of unoccupied trees to willows tells a different story. The mean distance to willows for occupied trees was 108.36 meters with a maximum of 203 meters, minimum of 10.5 meters, and variance of 3770.11; the mean for unoccupied trees was 113.23 with a maximum of 288.4 meters, minimum of 1 meter, and variance of 4174.08. Comparing these means gives a p-value of 0.74. Dropping the trees within 15 meters of an active nest tree from the unoccupied tree list improves this p-value slightly to 0.70.

Edge effects on insect abundance

The 24 flypapers gave insects scores for points along the four transects ranging from a low of 26, in the middle of a dry meadow, to a high of 486, corresponding to a point 15 meters within a patch of willows (see fig. 2). The scores for the edge points on the transects ranged from 104 to 302, while the scores for the points 25 meters within the aspens ranged from 55 to 112. Any way that the means of the edge points are compared with that for the interior points gives significantly higher insect biomass near the edges. When the mean for all the edge point scores is compared with the mean of the interior points, $P = 0.0129$; when the mean for the points five meters out of the aspens is compared with the mean of the interior points, $P < 0.001$.

Sapsucker effects on willow birds

In the thirteen points, the Broad-tailed Hummingbird was present in all cases and the Cordilleran Flycatcher (*Empidonax occidentalis*) was the only bird that failed to appear across the board. Between these two extremes, the Fox Sparrow (*Passerella iliaca*) was present most often, followed by very common Yellow Warbler (*Dendroica petechia*), Song Sparrow (*Melospiza melodia*), and MacGillivray's warbler (*Oporornis tolmiei*). Lincoln's Sparrow (*Melospiza lincolnii*) was present at seven points, Swainson's Thrush (*Catharus ustulatus*) at five, Lazuli Bunting (*Passerina amoena*) at four, Dusky flycatcher (*Empidonax oberholseri*) at three, and the White-crowned Sparrow (*Zonotrichia leucophrys*) and Wilson's Warbler at two; the Willow Flycatcher (*Empidonax traillii*) was present at only one point. Simpson's index gave diversity ratings for each of the willow points ranging from 3.46 to 6.21 (out of a maximum 15), and sap well densities ranged from 0.017 to 0.333 stems/m². When the sap well densities are plotted against the diversities for each point, the resulting regression gives $R^2 = 0.30$, $P = 0.054$ (see fig. 3).

Discussion

The Red-naped Sapsucker obviously greatly prefers nest sites that lie near to the forest edge. The first and foremost reason to account for this is that the aspens are used by the sapsucker for shelter and not much else during the breeding season. Earlier in the year, before nest sites are established, the aspens are drilled for sap, but for the vast majority of the breeding season, willow sap wells are used preferentially over those in

aspens. As this is the case, placing a nest in a tree that lies deeper within the forest can offer only one benefit, that being increased protection from predation. It is not documented how risks of predation change over a continuum running from forest edge to interior; Fenske-Crawford et al.'s 1997 study showed only that nests immediately on the forest edge were hit much harder than nests placed 50 or 100 meters within the forest. I would imagine, however, that as soon as nests are removed by only a few meters from the forest edge, predation risks will drop dramatically as does the degree of exposure to the wandering predator. Only two of the active nests that I found were directly on the edge of the forest, most being removed by at least a few meters; presumably most sapsuckers were discerning enough to place nests at least slightly removed from the forest edge.

The benefits to sapsuckers living on the edge must be great. Because the interior of aspen groves are used for virtually nothing by sapsuckers for most of the year, those that nest on the edge will have a competitive advantage over those that are obligated by their nest site location to fly between trees for eighty meters before making it to their first potential foraging location. This period of slow flight could well double overall foraging time, especially if all the birds are doing is picking up a couple of insects for their chicks, as opposed to foraging in the willows. Obviously, a doubled foraging time could mean a clutch size cut in half. Additionally, as there is significantly higher insect abundance at the edge of aspens, having a nest on the edge could mean having no travel time whatsoever to get to a foraging location; were the interior of aspen forests to have the sort of insect density that is present on the edge, perhaps living on the interior would not be so unthinkable. As it is, however, the insect abundance at the edges could well be one of the factors contributing to *nuchalis*' choice to nest in those locations.

S. nuchalis' choice to nest near forest edges benefits not only itself but the host of birds that nest in its holes in the years after their abandonment by the original owner. Having the choice of all old nest holes, which are already situated close to the forest edge, secondary cavity nesters will preferentially choose those that are closest to the edge (Aitken et al. 2002), presumably for much the same reasons that sapsuckers choose edge habitat in the first place. Were sapsuckers to stop nesting on the edge, numerous species could potentially suffer reductions in population.

That *S. nuchalis* does not choose to nest as close to willows as possible is a bit of an aberration from the general emerging pattern of sapsucker behavior. At first thought, it seems that a bird that nests based more on proximity to foraging habitat than anything else and is known not to nest farther than a kilometer from willows (Daily et al. 1993) *would* choose to nest close to willows, perhaps their most lucrative foraging location. However, the sapsucker is an extremely fast flying bird, and in Gothic's East River valley, it is virtually impossible to find a stand of aspens that are even close to being removed from willows by 1000 meters. The distances we are dealing with here are thus more on the order of 200 or 300 meters maximum; and the difference in time for *nuchalis* to travel 150 vs. 50 meters through open spaces will be absolutely minimal, on the order of a couple of seconds. In addition to this, foraging time once the sapsucker is in the willows, tending its sap wells, is extended; average duration for these visits is 50 seconds for adult individuals (Ehrlich and Daily 1988). This amount of time spent in the willows makes the travel time even more insignificant in comparison. Taking this travel distance to an extreme, a radio-tagged individual in British Columbia was noted to maintain sap wells 1.4 kilometers from its nest (Walters 1996). In light of this, it is not surprising that

S. nuchalis does not discern between distances of 20 and 200 meters to willows when choosing a nest tree suitable to its purposes.

Willow bird points

The regression (fig. 3), that plots sap well density against willow breeding bird diversity presents an interesting picture of *nuchalis* effects on the willow breeding bird diversity. There is a triangular array of data points, the three groups being those with high sap well density and correspondingly high bird diversity, those with low sap well density and low bird diversity, and then those with low sap well density and yet high bird diversity. The thing that most readily jumps out of this picture is the effect that high sap well density has on bird diversity, namely, when the sap well density is high, bird diversity will not drop below a certain point. This is exhibited by the rightmost four points of the regression with sap well densities over 0.125, which do not drop below a diversity of four.

The points with low sap well density, however, do not have such a clear pattern. Without high sap well density to drive bird diversity, it seems that diversity can fall very low or can be fairly high. The low diversity points are understandable; there will be some willows that are less productive than others, and without the added benefits that a high sap well density provides, bird diversity will suffer lacking the resources of more productive willows. As for the willow points with high bird diversity yet low sap well density, there are of course innumerable factors that I did not measure in my study. Some bird species will of course not be troubled one way or another whether sap well density is high or low; additionally, if insect productivity is high in an area regardless of the

presence or absence of sap wells, then this will act to boost the bird diversity of the area. In summary, sap wells act merely to provide extra resources to the willow breeding bird community; high sap well densities will thus set a minimum for bird diversities of the area, yet low sap well densities will not necessarily limit the bird diversities of willows, as many other factors can contribute to increase or decrease the maximum stable bird diversity for these areas.

Even without making excuses for the high diversities at low sap well densities, however, the data are mildly significant at $P = 0.054$; the R^2 value of 0.30 is very decent. As my sample size was only 13 points, I do not doubt that were I to double this sample size to enable a more encompassing study, I would see a great increase in significance of sap well densities driving willow bird diversity. Ehrlich and Daily (1988) suggested that *S. nuchalis* should be considered a keystone bird in willow wetlands based on the added nutrition they secure for other bird and mammal species; these data would seem to support that conclusion.

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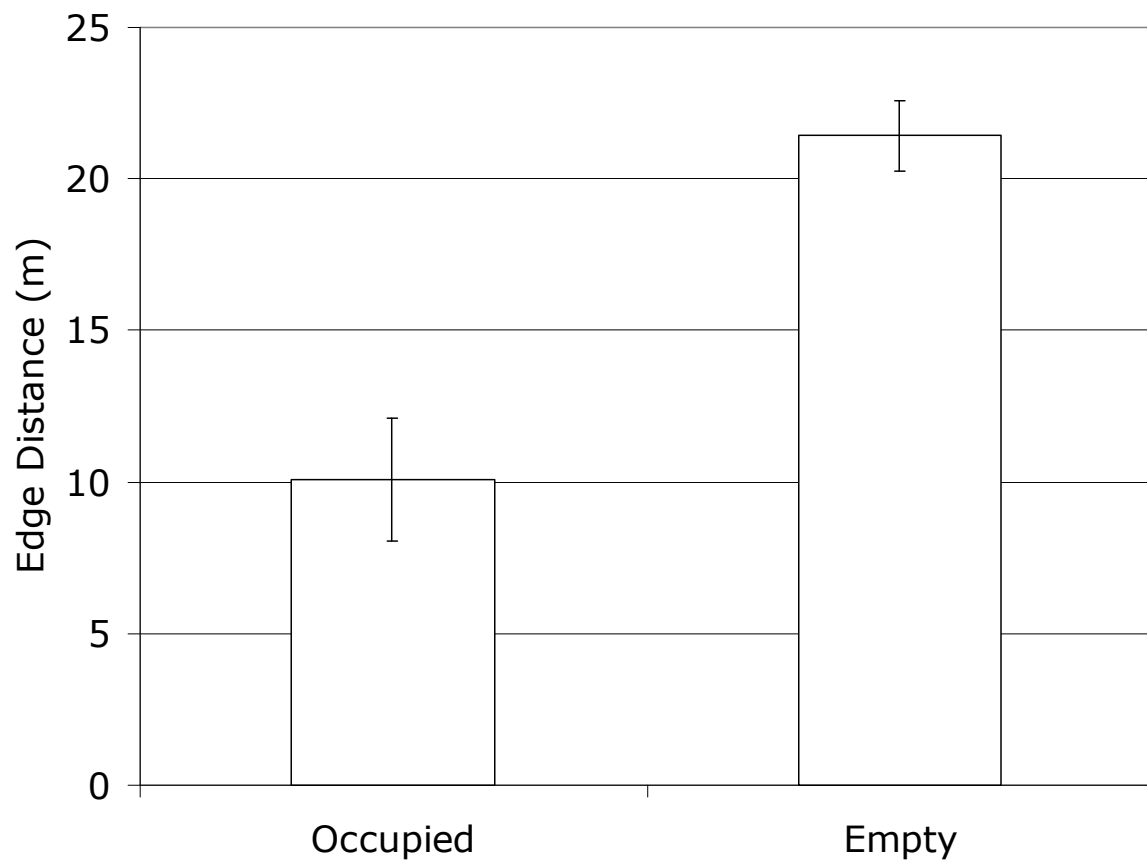


Figure 1: Relative edge distances for occupied and empty suitable nest trees. Occupied trees are closer to the edge ($P = 0.0048$). Note that when you submit the paper the figure legends go on a separate page by themselves.

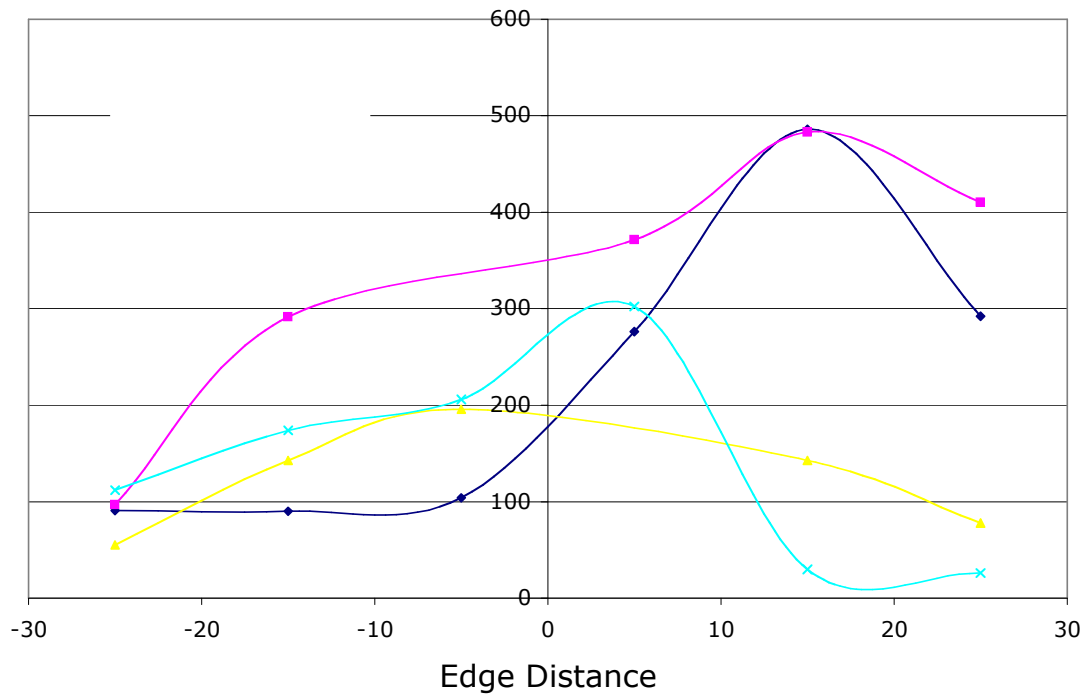


Figure 2: Insect scores along transects running from 25 meters within aspen groves (-25) to 25 meters outside them (25). Insect biomass is higher near the edges ($P \approx 0.015$).

Sap Well Density Increases Bird Diversity

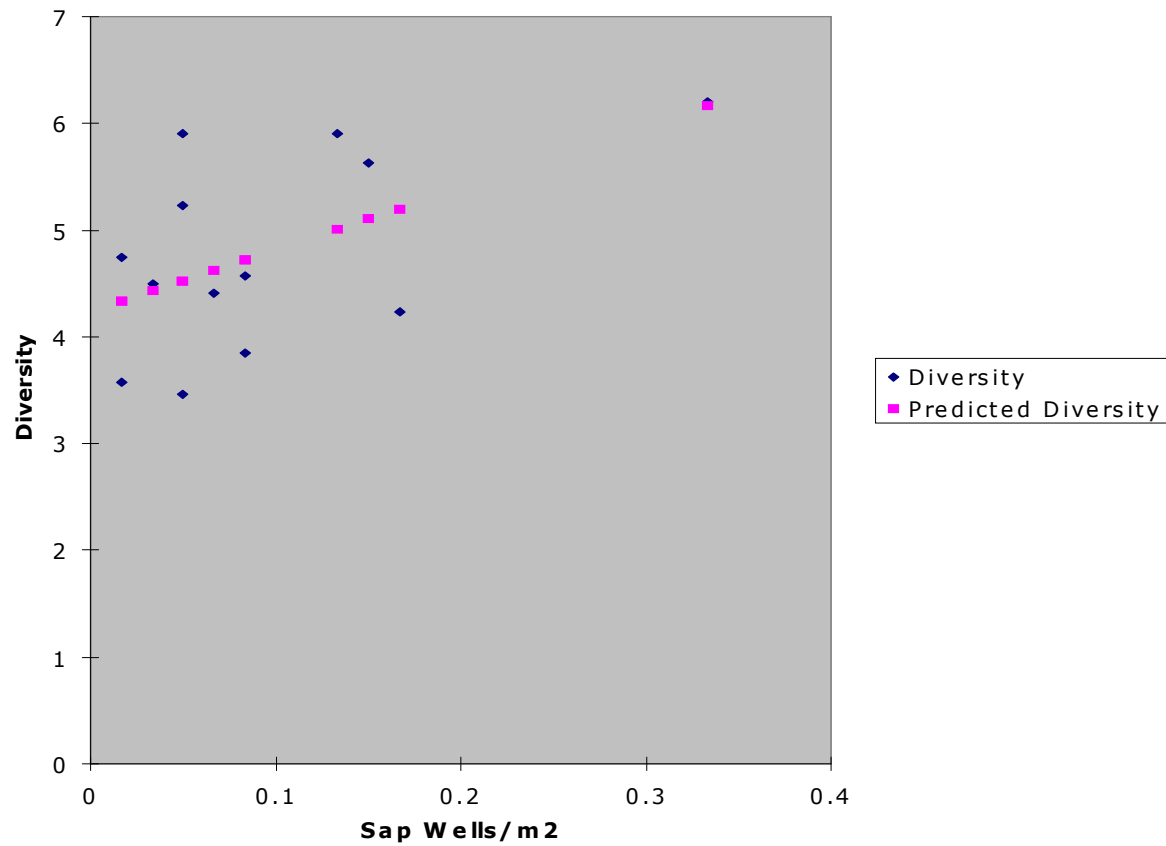


Figure 3: A regression plotting active sap well density vs. willow breeding bird diversity.

$R^2 = 0.30$; $P = 0.054$.