AN ABSTRACT OF THE THESIS OF

Eric M. Johnson for the degree of Honors Baccalaureate of Science in Wildlife Science and Bioresource Research presented on June 7, 2002. Title: Granary-Site Selection by Acorn Woodpeckers in Benton County, Oregon.

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The acorn woodpecker (*Melanerpes formicivorus*) is among the most common primary cavity nesters of the Oregon white oak (*Quercus garryana*) woodlands. Understanding their selection of granary sites is important in evaluating habitat quality and management actions. I hypothesized that granary locations would be consistent with the optimal foraging theory. Site characters were selected that were hypothesized to affect granary profitability. I compared site characteristics of granaries and non-granaries within the home ranges of 20 colonies in Benton County, Oregon during the winter of 2001. Granaries had greater oak basal area ($\chi^*=104 \pm 16$ dm^2), shorter brush height ($\chi^*=-26 \pm 7$ cm), larger diameter at breast height (dbh) ($\chi^*=11 \pm 4$ cm). Of 14 *a priori* models considered, I determined that the Forage Model was the best predictor of granary presence. This model is based solely on the oak basal area variable, a measure of potential acorn production. Increased acorn production in the vicinity of granaries is likely beneficial to the birds because minimal effort is expended in caching maximum forage.

Granary-Site Selection by Acorn Woodpeckers in Benton County, Oregon

By

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I understand that my project will become part of the permanent collection of Oregon State University, University Honors College. My signature below authorizes release of my project to any reader upon request.

Eric M. Johnson, Author

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Introduction

The range of the acorn woodpecker (*Melanerpes formicivorus*) stretches from Colombia through northern Oregon (Winkler *et al* 1995). This species is highly specialized for living in oak (*Quercus* spp.) communities, and its range is limited by the distribution of oak woodlands and diversity of oak species (Bock and Bock 1974). Prudent habitat selection in the northern fringe of their range is likely important to insure colony survival.

The central feature of acorn woodpecker territories is the storage tree, or granary. Typically, each home range will contain one primary granary tree, and often one or more secondary granaries with fewer storage holes (Koenig *et al.* 1995). Acorn woodpeckers drill small holes in granaries in which to store individual acorns for the winter (Koenig and Mumme 1987). Acorns are gathered directly from the tree and placed in a granary for storage (MacRoberts 1970, MacRoberts and MacRoberts 1976). The granary holes are reused each fall. Additionally, the birds create new holes so that as holes accumulate, the granary takes on a "Swiss cheese" appearance (Koenig and Mumme 1987).

Acorn woodpecker territories tend to have larger diameter oaks, more dead limbs, and lower density of trees than oak woodlands lacking the birds (Doerge 1979). These characters are likely indicators of habitat quality. Why specific trees are chosen as granaries is unknown. It is probably energetically beneficial for the birds to center their activities, and consequently their granaries, on the highest quality microhabitats within their home range (Pyke *et al.* 1977). Proximity to acorn production may be important to granary-site selection due to increased caching efficiency and acorn quantity. Location of granaries in areas with low ground cover height may be indicative of a safer site with lower terrestrial competition and predation. Canopy closure may by indicative of lower aerial predation. Larger diameter trees may provide many advantages including greater mast production, limbs and bole, and canopy. These large trees may also have more dead and decaying wood which may be beneficial for the construction of granaries and cavities. Oak trees are unique in their growth form and characteristics, which may make them more attractive granary-sites than non-oaks. This may be especially true among living oaks which produce mast, while dead-oaks and non-oaks do not.

Productive and safe granary-sites seem particularly important because acorn woodpeckers rely upon them for survival through the winter months, and spend a great deal of time in close proximity to these while stocking and consuming the mast. As large expanses of suitable habitat decline (Ryan and Carey 1995), more attention on subtleties such as granary-site preferences may be necessary to ensure viable acorn woodpecker and dependant populations in this region.

My objectives were to report on the selection of granary-sites and provide a basis for within-stand site prediction. I predicted granaries would be located (1) in areas with greater acorn production; (2) in areas with lower brush height; (3) in larger diameter trees; and (4) in living oak trees.

Methods

Study Sites

I conducted my study within Benton County of western Oregon. This portion of the Willamette Valley is mostly flat, low elevation (~100 m) land dominated by agricultural and suburban uses. The climate is mild with wet winters and warm, dry summers (Franklin and Dyrness 1973). I investigated historic acorn woodpecker sites identified by Doerge (1979) and unpublished Oregon Department of Fish and Wildlife survey data. I also searched oak woodlands for the birds and their granaries by viewing from nearby roads with binoculars. I identified a pool of 27 sites in which the acorn woodpecker was present. Seven sites were excluded due to restricted access; a total of 20 accessible sites were sampled (Figure 1). All sites were dominated by Oregon white oak (*Quercus garryana*) and near grasslands. Douglas-fir (*Pseudotsuga menziesii*), giant sequoia (*Sequiadendron giganteum*), and bigleaf maple (*Acer macrophyllum*) were the only other trees present in at least one site.

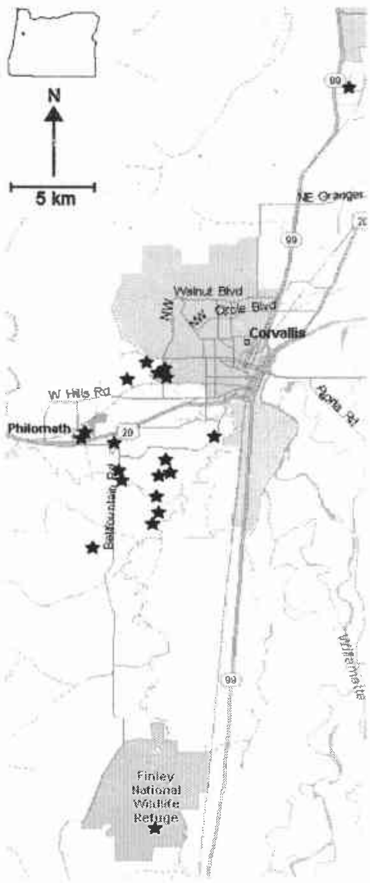

FIGURE 1. Location of the study site within Benton County, Oregon, sampled January – April 2001. Acorn woodpecker sites (n=20) are indicated by star (★).

Sampling

I located granaries by walking through acorn woodpecker sites and searching with binoculars for the birds and their granaries. This search was done during the winter months (January-April) of 2001 while the trees lacked leaves and the woodpeckers were actively feeding upon cached acorns. To locate the birds, I used the "Swiss cheese" appearance of their granaries as well as visual and aural detectors. I recorded the position of the main granary, or the center of activity when there was no clear main granary. Positions were recorded on a global positioning system (Garmin GPS 12; Olathe, Kansas) to aid with mapping and sampling. Locations were typically accurate within 6 m.

I defined the home range of each woodpecker group by the location of the main granary. Following Koenig and Mumme (1987), I defined the main granary as the largest consistently guarded cache, and a home range as the area within a 50 m radius from the main granary. I considered 50 m to be optimal because it contained all granaries in most sites, while including minimal unoccupied territory. Three non-granary trees and three granary trees were selected for measurement by randomly selecting a universal transverse mercator (UTM) within the bounds of the home range. The random UTM was selected using a random distance (δ) weighted towards the exterior (to give equal probability for the entire home range) according to

$$\delta = 50\sqrt{\chi_1}\text{, and}$$

a random angle (α) was generated according to

$$\alpha = 360\chi_2,$$

where χ_1 and χ_2 are randomly generated numbers between 0 and 1. Therefore, δ is the distance in meters from the main granary, and α is the bearing (in degrees west of true north) from which the distance is measured. The nearest tree or snag ≥20 cm diameter at breast height (dbh) was selected if within 5 m of the random UTM. I continued to select random locations until I had located exactly three granary and three non-granary trees. I proceeded to the next location when the current one did not contain a qualifying tree, or the selected tree would increase the count of granaries or non-granaries to four.

I recorded location, and estimated dbh, basal area density of oaks, and brush height for selected granary and non-granary trees. Basal area of oaks was estimated by measuring the dbh of all oak trees ≥20 cm dbh within 12 m (452 m^2) of the reference tree (granary or non-granary). I used 12 m because acorns are usually gathered from within that distance of the granary (Nicpon 1995, personal observation). I chose 20 cm dbh as the minimum size to include because oaks rarely produce mast until achieving this size (Goodrum *et al* 1971, personal observation). Brush height was estimated by measuring the maximum height within four 1 m diameter circles, with each center 3 m from the reference tree in each of the four cardinal directions (Higgins and Barker 1982).

Model Development

Prior to data analysis, I hypothesized potential relationships between the probability of granary occurrence and each of the hypothesized explanatory variables. These models related a variable to a hypothesized response (e.g. survival, reproductive success, or probability of extinction) and therefore depended on the assumption that these responses were related to granary location. I developed 14 *a priori* models of the relationship between site characteristics and the likelihood of a granary being present (Table 1). Each model was included because it was deemed biologically reasonable. This reduced the probability of spurious inference (Burnham and Anderson 1998).

The variables in each model were so assigned to embody specific hypotheses. The Global Model included all of the variables explored in this study (Table 1). The eight single-variable models include each of these variables in some permutation. The Cover-Forage Model includes the hypothesis that proximity to acorn production is attractive and that ground cover has a negative influence. This model accounts for both forage and terrestrial competition and predation. To account for tree characteristics associated with large diameter, the Cover-Forage-DBH Model also includes diameter. The Central Cover-Forage Model combines all of the variables from the Cover-Forage, Quadratic DBH, and Oak models. This model focuses on the forage resources around the tree, and especially those produced in the granary tree itself. It also includes the brush variable to account for cover which may hide potential competitors and predators. The Oak Global Model, is identical to the Global Model except that it does not include the conifer and live tree variables. This model assumes that non-oak species are equally unattractive and that whether of not the tree is alive is not important. The Diameter-Forage Model assumes that acorn production and tree size are most important.

I thought that all taller brush (e.g. >20 cm) may have a similar influence. Differences between tall patches were thought to be minimal compared to shorter patches. For example, 3 cm high brush will not hide a predator or competitor, while a 13 cm patch may. The natural logarithm of brush height was used to describe this hypothesis because it accentuates differences between short patches.

I thought that differences between large trees may be more important than between smaller trees. This is because total tree volume increases exponentially as diameter increases. The squared dbh was used to describe this hypothesis because it accentuates differences between large trees. Converting diameter to basal area would have achieved a similar result.

TABLE 1. List of *a priori* models relating habitat characteristics associated with acorn woodpecker granaries in Benton County, Oregon.

Model	Model Structure[1]	Expected Results[2]
Global	$\beta_1(OBA)+\beta_2(B)+\beta_3(D)+\beta_4(L)+\beta_5(O)+\beta_6(C)$	$\beta_1>0, \beta_2<0$ $\beta_3>0, \beta_4>0$ $\beta_5>0, \beta_6<0$
Cover	$\beta_1(B)$	$\beta_1<0$
Logaithmic Cover	$\beta_1(\ln B)$	$\beta_1<0$
Conifer	$\beta_1(C)$	$\beta_1<0$
Live Tree	$\beta_1(L)$	$\beta_1>0$
Forage	$\beta_1(OBA)$	$\beta_1>0$
DBH	$\beta_1(D)$	$\beta_1>0$
Quadratic DBH	$\beta_1(D^2)$	$\beta_1>0$
Oak	$\beta_1(O)$	$\beta_1>0$
Cover-Forage	$\beta_1(B)+\beta_2(OBA)$	$\beta_1<0, \beta_2>0$
Cover-Forage-DBH	$\beta_1(B)+\beta_2(OBA)+\beta_3(D)$	$\beta_1<0, \beta_2>0$ $\beta_3>0$
Central Cover-Forage	$\beta_1(B)+\beta_2(OBA)+\beta_3(D^2)+\beta_4(O)$	$\beta_1<0, \beta_2>0$ $\beta_3>0, \beta_4>0$
Oak Global	$\beta_1(B)+\beta_2(OBA)+\beta_3(D)+\beta_4(O)$	$\beta_1<0, \beta_2>0$ $\beta_3>0, \beta_4>0$
Diameter-Forage	$\beta_1(OBA)+\beta_2(D^2)$	$\beta_1>0, \beta_2>0$

[1] OBA= oak basal area, B= brush height, D= dbh, L= living, O= oak, C= conifer; all variables are the difference between granaries and non-granaries.

[2] Expected direction in regression coefficients, assuming that the hypothesized model reflects reality.

I analyzed the frequency of the binary explanatory variables (live, oak, conifer, and non-oak deciduous) and discovered that while each had some variation within the non-granary sub-set, there was no variation within the granary sub-set (Figure 2). Due to this lack of variation, I discarded all models that included any of these binary variables because matched-pairs logistic regression requires variation.

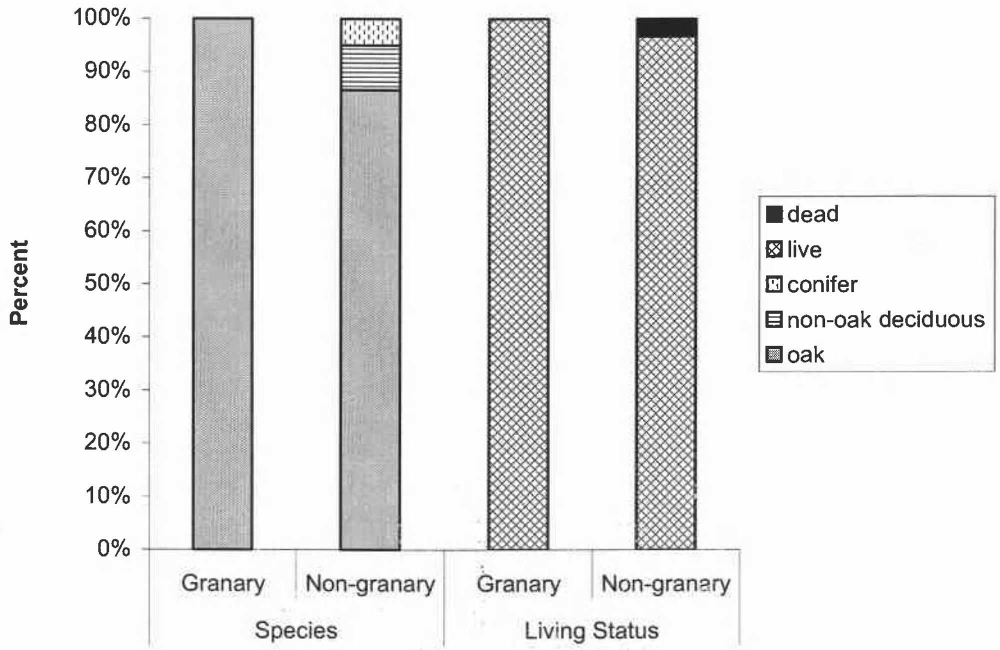

FIGURE 2. Frequency of binary explanatory variables within granary and non-granary sub-sets for acorn woodpecker sites (n=20) in Benton County, Oregon, January – April 2001.

I examined correlations between variables using Pearson correlation coefficients (Table 2). Oak basal area and brush height were highly correlated (r=–0.62). Due to this collinearity, I discarded models that included both of these variables. Models that contained only one of these variables were retained.

TABLE 2. Pearson correlation coefficients for continuous variables.

	Oak Basal Area	Brush Height	Dbh
Oak Basal Area		-0.62	0.24
Brush Height	-0.62		-0.18
Dbh	0.24	-0.18	

I used 1:1 matched-pairs logistic regression to estimate the association between site characteristics and the probability of the presence of a granary (Allison 1999). The constant term in the logistic regression model was set equal to zero, β_0=0, and the data vector equal to the value of the granary (y = 1) minus the value of the non-granary (y = 0), $x^* = x_g - x_{ng}$, yielding

$$\mu = \frac{e^{\beta'(x^*)}}{1 + e^{\beta'(x^*)}}$$

This allowed me to use Proc Logistic (SAS Institute 1994) to obtain parameter estimates and their associated standard errors of the estimated coefficients. The sample size was the number of sites (n=20), used the differences, χ^*, as covariates, set the values of the response variable equal to 1, and excluded the constant term from the model (Hosmer and Lemeshow 2000).

I used an information-theoretic approach, ranking the models against each other. The relative ranking allowed me to determine what model(s) best approximated the data. I used Akaike's Information Criteria adjusted for small-sample bias (AICc) to select the best approximating model of those considered (Burnham and Anderson 1998). I ranked the models based on the difference in AICc value from the best model (ΔAICc). Akaike weights (Burnham and Anderson 1998) were also used to compare models. I used the Akaike weights to estimate weighted parameter estimates for the variables in the best logistic regression model(s) as the sums of the products of the estimate and weight from each model that included a particular variable. I computed an unconditional squared variance in accordance with Burnham and Anderson (1998). I reported means ± standard error.

Results

Living Oregon white oaks were by far the most abundant tree in my sites (~85%). Other tree species were relatively uncommon (<20%) in all sites, and absent in several. Of these, Douglas-fir and bigleaf maple were the most common, while giant sequoia only occurred at one site. While all sampled granaries were in oak, a few granaries were observed in bigleaf maple and giant sequoia. Granaries were also observed in a utility pole and on the side of a house. My tree counts cannot be used to calculate the relative abundance of tree types in home ranges due to sampling method. Consequently, selection of tree species relative to abundance cannot be estimated.

The mean (± SE) oak basal area was greater (χ^*=104 ± 16 dm^2, P<0.001) at granary sites ($\bar{x}$=227 ± 19 dm^2) than at non-granary sites ($\bar{x}$=123 ± 14 dm^2) (Figures 3 & 4). The mean average brush height was shorter (χ^*=-26 ± 7 cm, P=0.001) at granary sites ($\bar{x}$=18 ± 4 cm) than at non-granary sites ($\bar{x}$=45 ± 10 cm). The mean average dbh was greater (χ^*=11 ± 4 cm, P=0.008) at granary sites ($\bar{x}$=65 ± 5 cm) than at non-granary sites ($\bar{x}$=53 ± 5 cm).

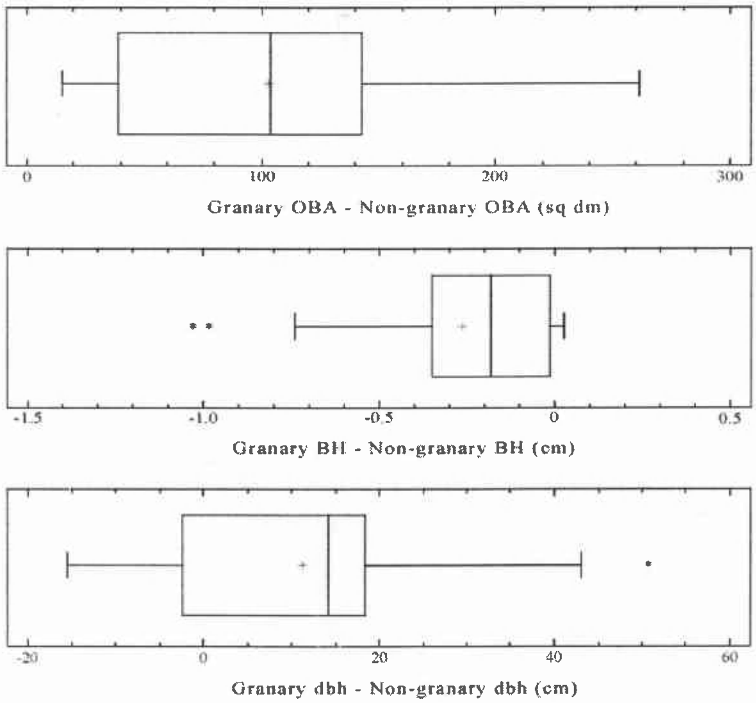

FIGURE 3. Box-and-whisker diagrams of difference between granary and non-granary site variables (oak basal area, brush height, and diameter at breast height) for acorn woodpecker sites (n=20) in Benton County, Oregon, January – April 2001.

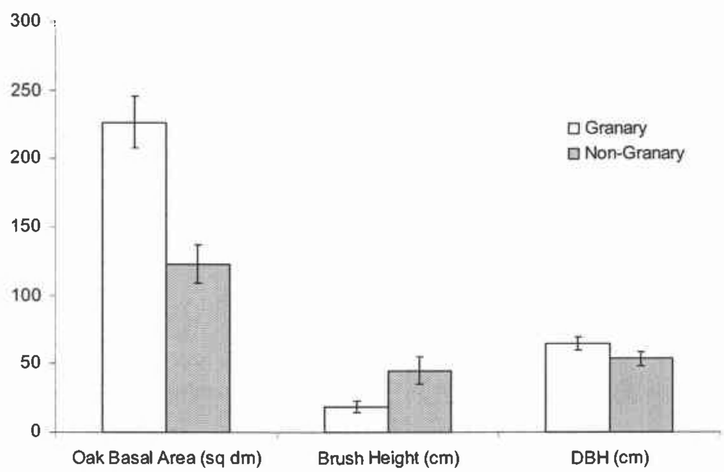

FIGURE 4. Mean averages and standard error of site variables among acorn woodpecker sites (n=20) in Benton County, Oregon, January – April 2001. This figure does not reflect the matching of granaries and non-granaries within each site.

Of the 14 models considered, six were eliminated due to lack of variation in the binary variables (Figure 2), and an additional two were eliminated due to collinearity (Table 2). Of the remaining six models, the Forage Model was the best approximating model based on ΔAICc (Table 3). The Diameter-Forage Model had a ΔAICc value of <3 and may be a competing model to the Forage Model, however Akaike weights suggest that the Forage Model is more than three times as likely as the Diameter-Forage Model. The other four remaining models appear to poorly approximate the data (Table 3). The dbh^2 variable in the Diameter-Forage Model has a high standard error and does not appear to be contributing (Table 4). The oak basal area variable is the reason this model is ranked so highly, despite being punished by the AICc statistic for containing an additional explanatory variable.

TABLE 3. Comparison of *a priori* acorn woodpecker granary site-selection models.

Model	**Model Variables**[1]	**ΔAICc**[2]	**Weight**[3]
Forage	oba	0.00	0.76
Diameter-Forage	oba, dbh^2	2.44	0.23
Cover	brush	10.13	0.00
Logarithmic Cover	ln (brush)	10.14	0.00
DBH	dbh	19.40	0.00
Quadratic DBH	dbh^2	22.83	0.00

[1] oba = oak basal area, dbh = diameter at breast height; all variables are the difference between granaries and non-granaries.

[2] Akaike's Information Criteria with a small sample size correction, difference between the model with the lowest AICc and the respective model. Lower AICc (and ΔAICc) indicates a better model from which to make inferences.

[3] Akaike's Information Criteria weights estimate the relative likelihood of the given model being the best within the set considered (Burnham and Anderson 1998).

The relationships shown in the best models were consistent with my hypotheses (Table 1). The parameter estimates for oak basal area, dbh, and dbh^2 are positive; while cover and logarithmic cover parameters are negative (Table 4).

TABLE 4. Parameter estimates for *a priori* acorn woodpecker granary-site selection models.

Model	Variable[1]	Estimated Coefficient	SE	Squared Variance	Weight
Cover	brush height (cm)	-0.2751	0.2207	0.028976	0.00
Forage	oak basal area (dm^2)	0.2300	0.3000	0.000008	0.76
DBH	dbh (cm)	0.0982	0.0471	0.000000	0.00
Quadratic DBH	dbh^2 (cm)	0.0005	0.0003	0.000006	0.00
Diameter-Forage	oak basal area (dm^2)	0.1400	0.2400	0.000008	0.23
Diameter-Forage	dbh^2 (cm)	0.0032	0.0106	0.000006	0.23

[1] All variables are the difference between granaries and non-granaries.

The estimated coefficient (Table 4) yields the Forage Model:

$$\mu = \frac{e^{0.23 \cdot oba^*}}{1 + e^{0.23 \cdot oba^*}}$$

where *oba** is granary oak basal area minus non-granary oak basal area and μ is the model output. The output is a number between 0 and 1, which can be cut off at an arbitrary point to separate the granary predictions from the non-granary predictions. When a cutoff point (λ) of 0.995 ($\mu < \lambda$: non-granary, $\mu > \lambda$: granary) is used, 81% of the predictions made by the Forage Model were correct (Figure 5). This estimation is based on the data from which the Forage Model's coefficient was generated. Since this data was composed of half granaries and half non-granaries, a model with no predictive capability would predict correctly 50% of the time.

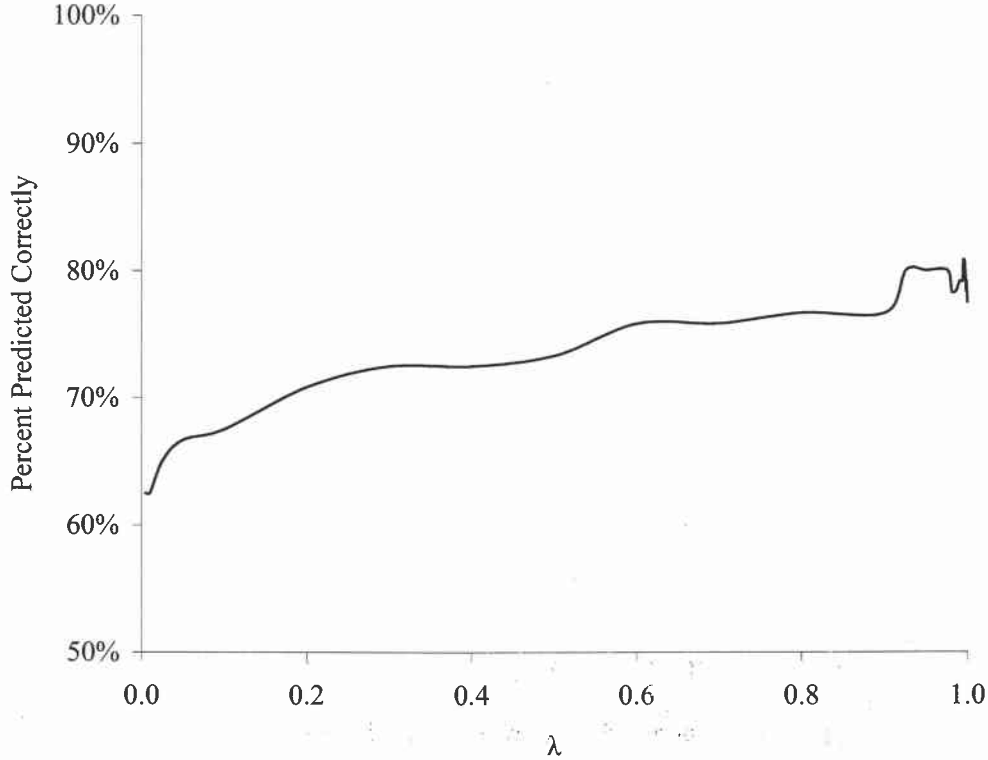

FIGURE 5. Relationship between cutoff point (λ) and percent predicted correctly by Forage Model. Prediction of granary or non-granary tested against acorn woodpecker site data (n=20) from which the model was developed.

Discussion

If acorn woodpeckers are behaving in a manner consistent with the optimal foraging theory, granaries should be located centrally in the major acorn-producing area within the home range (Pyke *et al.* 1977). This would allow for minimal expenditure of energy per acorn. If this is true, habitat directly around the granaries is expected to have greater acorn production relative to other portions of the home range. Acorn production increases as basal area increases (Goodrum *et al.* 1971), and acorn woodpeckers should select areas of high oak density. In northwestern California, Raphael (1987) demonstrated this association with tanoak (*Lithocarpus densiflora*) canopy volume, which is also associated with mast production.

Proximity of granaries to available nesting and roosting sites would minimize energy expended in commuting. Frequency of feeding of chicks can be greater than one feeding per minute and much of this activity is focused on acorns (Weathers *et al.* 1990). It can be assumed that a considerable portion of the total energy expended by adults in rearing the young is spent retrieving acorns from the granary. I observed an abundance of unoccupied cavities, but did not estimate abundance at sites. It is likely that cavity site-selection is dependant upon granary sites. This is because many more caching flights between acorn-source and granary are taken than flights between cavity and granary. Consequently, we would expect to see cavities near granaries which are near the acorn-source.

While canopy cover is likely reduces the risk of predation, the lack of leaves during the winter months precluded this measurement. It is also likely that acorn production is correlated with canopy cover in pure-oak stands. I would predict a preference for granary-sites with greater canopy cover.

Although a predominant aspect of acorn woodpecker ecology, acorns are actually a supplemental food source. Insects are the preferred food and are eaten when available (Koenig and Mumme 1987). In addition to consuming insects from tree surfaces, insect-foraging acorn woodpeckers usually sit at the top of trees and make short flycatching flights above the canopy (Doerge 1979, Koenig *et al.* 1995). Doerge (1979) found that insect production is linked to acorn woodpecker presence. Granary use and significant insect consumption do not occur simultaneously for most of the year (Koenig *et al.* 1995). Consequently, it is likely that home ranges are partially chosen based on insect abundance. However, I would consider it unlikely that the location of granaries within the selected home range would be affected significantly.

According to Bock and Bock (1974), oak diversity limits the distribution of acorn woodpeckers. This is due to downward fluctuations in production by some oak species being mediated by upward fluctuations in other species in any given year. Consequently, acorn production is more consistent in areas of greater oak species diversity. Acorn production by Oregon white oak is cyclical (Sudworth 1967, Coblentz 1980), with high yields of acorn crops occurring every 3-6 years (Ryan and Carey 1995). Acorns tend to be produced by trees that are ≥20cm in diameter. As the tree grows, it tends to produce more acorns. Since the Oregon white oak is the only native oak species in Benton County, these birds experience a great deal of fluctuation in forage availability. Hannon *et al* (1987) showed that poor acorn crops adversely affect acorn woodpecker populations. During years of low acorn production, Benton County acorn woodpeckers likely experience a great deal of winter-kill. Consequently, acorn production probably limits population size in Benton County, as it does in other regions (Koenig and Mumme 1987). The granaries in successful colonies are likely located in close proximity to trees which produce enough for survival during poor years. This is what I observed, and is supported by my conclusion that the Forage Model is the best predictor of granary-sites.

Competition and predation may also be an important influence in granary-site selection. Competition for nesting cavities and acorns, as well as predation comes from both terrestrial and aerial sources (Neff 1928, Troetschler 1976, Koenig *et al.* 1995, Nicpon 1995). This may lead to the selection of sites which are more defendable, less desirable for competitors and predators, and have greater escape opportunities.

My data do not contain any granaries located in tree species other than Oregon white oak. However, in southwestern Oregon the use of coniferous species as granaries is quite common. Dillingham and Vroman (1997) noted that in Curry County most granary trees were Douglas-fir, with a few sugar pine (*Pinus lambertiana*) and Jeffrey pine (*Pinus jeffreyi*), and in Josephine County mostly ponderosa pine (*Pinus ponderosa*) were utilized along with a few Douglas-fir. In that region, acorn woodpeckers are commonly associated with residual coniferous trees in clearcuts adjacent to tanoak, California black oak (*Quercus kelloggii*), and Oregon white oak (Jobanek 1995, Dillingham and Vroman 1997). This suggests that the woodpeckers in Benton County may not be discriminating against the use of non-oaks, but that my sample (60 granaries) was of insufficient size to detect such granary trees.

Matched-pair models, such as the Forage Model, utilize data from both a case and control (granary, non-granary). To make a prediction, the model requires the input of the oak basal area from the vicinity of non-granary trees in the home range as well as the tree in question. The difference between the granary and non-granary variables (oba^*) is input into the model and the output (μ) is compared to the cutoff value (λ) and a prediction is made. To use this model, one should take the difference between the oak basal area in a 12 m radius of several non-granaries in a stand and the oak basal area of the tree in question. Such a model is useful for determining which trees in a stand have the potential of being used as a granary. This is a useful guide to consider when managing oak woodlands for acorn woodpeckers and dependant species.

I identified three factors that may be responsible for differences in granary-site selection. It appears that acorn woodpeckers select large oak trees with low brush height and good acorn production potential.

My results were most consistent with the hypothesis that the occurrence of acorn woodpecker granaries in Benton County is best explained by the quantity of nearby acorn production, measured by oak basal area. This is likely due to the great dependence upon acorns for winter survival and spring reproduction. Based on observation, brush height and dbh did appear to be correlated with acorn woodpecker presence at the landscape level; however they were not useful predictors of the location of granaries within stands.

Further research is required to understand the population dynamics of the acorn woodpecker on the fringe of its range, especially in regards to how these populations cope with fluctuating acorn abundance. How this affects colony persistence, abundance, distribution, home range size, colonization, connectivity, and possible migration is unknown.

Management Implications

Because the acorn woodpecker is highly dependant upon the presence of fruiting oaks, management actions upon these trees is likely to greatly affect the birds which depend upon them. Most of the oak woodlands in Benton County are tightly spaced and produce very little mast, resulting in relatively few beneficial granary locations. Thinning these stands to create larger diameter, heavier fruiting trees will likely benefit acorn woodpeckers by creating potential granary-sites with high acorn production. Stands that are producing an adequate quantity of acorns should be maintained and not allowed to become overcrowded. The addition of another oak species such as California black oak to Oregon white oak stands may also be beneficial to acorn woodpeckers due to dampening of the fluctuations in acorn production. However, such an introduction may have many unforeseen effects and would likely be less beneficial than the management of existing native stands for acorn production.

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