AN ABSTRACT OF THE THESIS OF

Craig A. DeMars for the degree of Master of Science in Wildlife Science presented on July 7, 2008.
Title: Conserving Avian Diversity in Agricultural Systems: the Role of Isolated Oregon White Oak Legacy Trees.

Abstract approved:

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Over one third of the earth's land surface has been modified to some extent for agricultural purposes. The large global footprint of agriculture, combined with the knowledge that existing reserve networks are likely insufficient for long-term conservation of native biodiversity, has necessitated that agricultural systems contribute to conservation of native biota. Current research paradigms have taken a landscape-level view of conservation in agricultural systems, assessing the relative contribution that various habitat elements make in conserving biodiversity in the agricultural matrix. Within this context, I investigated the potential role that individual Oregon white oak (*Quercus garryana*) trees play in conserving avian diversity in the agricultural systems of the Willamette Valley, Oregon, U.S.A. Retained by landowners primarily for cultural reasons, many of these trees pre-date Euro-American settlement of the Willamette Valley and thus are biological legacies from historic white oak habitats. I compared avian use of isolated white oak trees in three different site contexts - croplands, pastures, and oak savanna reserves - and used an information-theoretic model selection approach to determine the relative importance of site-specific and landscape-level factors thought to influence avian use of these individual trees. Specifically, I tested whether avian species presence on Oregon white oak legacy trees could best be explained by: (i) tree architecture; (ii) the distance of the tree to the nearest tree or patch; (iii) the density of trees in the surrounding landscape; or (iv) the matrix in which the tree was embedded. I evaluated species-specific responses as well as four community-level responses: (i) total bird species richness; (ii) species richness of native birds associated with oak savanna; (iii) species richness of tree foraging birds; and (iv) the combined species richness of aerial- and ground-foraging birds. I sampled 35 individual white oak trees and recorded 47 avian species using these individual trees, including a high number of oak savanna-associated species such White-breasted Nuthatch (*Sitta carolinensis*) and Chipping Sparrow (*Spizella passerina*). For the majority of these species, the frequency of use of individual oak trees was similar among crop, pasture and reserve sites. The most important factors for predicting avian use were tree size and tree density in the surrounding landscape. In general, avian use increased with increasing tree size and decreasing tree density. My findings suggest that individual white oak legacy trees have the potential to positively contribute to landscape-level conservation of a wide range of avian species within the Willamette Valley. Due to the declining abundance of white oak legacy trees on the landscape, the conservation of existing legacy trees and the recruitment of younger replacement trees should be a management priority.

Conserving Avian Diversity in Agricultural Systems: the Role of Isolated Oregon White Oak Legacy Trees

by
Craig A. DeMars

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

Craig A. DeMars, Author

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CONSERVING AVIAN DIVERSITY IN AGRICULTURAL SYSTEMS: THE ROLE OF ISOLATED OREGON WHITE OAK LEGACY TREES

CHAPTER 1: INTRODUCTION

Agricultural conversion of natural environments is a major factor in the current global decline of biodiversity (Krebs et al. 1999, Tilman et al. 2001, Foley et al. 2005). Approximately half of the earth's habitable land has been modified to some degree for agricultural purposes (Clay 2004) and current trends suggest that the global agricultural footprint could increase by a further 18% by 2050 (Tilman et al. 2001). This high degree of agricultural impact on the world's terrestrial ecosystems suggests that conservation of global biodiversity can no longer be solely focused on nature reserves and protected areas (Fischer et al. 2006, Vandermeer & Perfecto 2007). Moreover, in many highly modified landscapes, existing reserve networks may be insufficient for long-term conservation of native biodiversity (Brooks et al. 2004, Rodrigues et al. 2004). Consequently, an emerging research theme in conservation biology has been the assessment of factors thought to be important for conserving biodiversity in agricultural systems (e.g. Harvey et al. 2006, Sekercioglu et al. 2007, Billeter et al. 2008, Haslem & Bennett 2008).

Since agricultural conversion of natural landscapes results in habitat loss and fragmentation, early research paradigms applied island biogeography theory to assess the role of habitat remnants in conserving native biodiversity in human-modified ecosystems (Saunders et al. 1991, Andrén 1994). This initial pattern-based approach focused on the spatial distribution of habitat remnants and employed a binary system of "habitat" and "non-habitat", thus assuming the intervening matrix to be inhospitable to native biota. Subsequent research has recognized that this initial fragmentation model is often too simplistic for explaining species distribution patterns in human-modified landscapes. Rather than sharp distinctions between habitat and non-habitat, human-modified landscapes often consist of habitat gradients that are dependent upon the intensity of land-use in the surrounding matrix (McIntyre & Hobbs 1999). These habitat gradients exist at multiple spatial scales with patch-level and landscape-level patterns of habitat heterogeneity and structural complexity affecting species assemblages in small habitat remnants (Tscharntke et al. 2002, Tews et al. 2004). Species distribution patterns are further influenced by species-specific biological processes (e.g. foraging behavior, dispersal ability) and broader ecological processes (e.g. changes in climate and disturbance regimes), both of which can interact with the spatial pattern of habitat remnants (Lomolino 2000, Fischer & Lindenmayer 2006, Kupfer et al. 2006). Consequently, current research paradigms explicitly incorporate spatial pattern, matrix composition and ecological processes into a more holistic "continuum" model (Manning et al. 2004b, Fischer & Lindenmayer 2006). Within this holistic landscape-level view, a primary research theme is the assessment of the relative contribution that various landscape elements make in conserving biodiversity in agricultural systems (Daily 2001).

Within this context, I investigated the potential role that isolated legacy trees play in conserving avian diversity in a North American agricultural system. In many agricultural areas, biological legacies from historic habitats exist in the form of scattered large trees which have often been retained by landowners for cultural reasons (Harvey & Haber 1999, Fischer & Bliss 2008). Although there is a paucity of studies within the U.S., previous studies in tropical and Australian agricultural systems demonstrate that isolated legacy trees provide numerous ecological functions that are important to avian populations in agricultural systems including landscape connectivity for woodland species (Fischer & Lindenmayer 2002b), foraging sites (Luck & Daily 2003), and nesting sites for cavity-dependent species (Manning et al. 2004a). When assessing the entire range of ecological functions provided by scattered trees, Manning et al. (2006) further suggests that isolated trees be considered keystone structures in human-modified landscapes because their ecological influence is disproportionate to their actual physical footprint on the landscape. A critical management issue in scattered tree landscapes is to determine an appropriate spatial pattern of trees that best maintains landscape-level biodiversity and characteristics of trees that best provide wildlife habitat.

In this study, I compared avian use of isolated Oregon white oak (*Quercus garryana*) legacy trees in three different landscape contexts within the agricultural matrix of the Willamette Valley, Oregon, U.S.A. Further, I evaluated the relative importance of site-specific and landscape-level factors thought to influence avian use of these individual trees. Specifically, I tested whether avian use could best be explained by: (i) the architecture of the tree itself, (ii) the distance of the tree to the nearest tree or patch, (iii) the density of forest or oak-specific vegetation in the landscape surrounding each tree, or (iv) the matrix in which the tree is embedded. I investigated species-specific responses and four community-level responses: (i) total bird species richness; (ii) species richness of native birds associated with oak savanna; (iii) species richness of tree foraging birds; and (iv) species richness of birds foraging away from the tree (aerial and ground foragers).

CHAPTER 2: METHODS

Study Area

I conducted the study in the southern half of the Willamette Valley, which lies between the Cascade and Coast Ranges in western Oregon. The Valley (elevation 70 – 120 m) has a Mediterranean temperate climate characterized by long wet winters (mean annual precipitation = 110.9 cm) and short dry summers (OCS 2006). The Valley contains the state's three largest cities and is home to ~70% of its human population (Baker et al. 2004). Outside of urban development, the predominant land uses in this part of the Valley are grass seed production and, to a lesser extent, livestock grazing.

Prior to Euro-American settlement in the 1850's, white oak open-canopy woodland and savanna habitats were prominent vegetation types in the landscape mosaic of the Willamette Valley, occupying xeric sites above riparian bottomland forests but below higher elevation conifer stands (Thilenius 1968, Johannessen et al. 1971). In the last century, the extent of the Valley's white oak savanna has declined to less than 1% of its historic range, making it one of the most imperiled ecosystems in North America (Noss et al. 1995, Vesely & Tucker 2004, ODFW 2006). Agricultural conversion, urban expansion, and conifer invasion from the cessation of historic fire regimes have been cited as primary factors in this precipitous decline (Johannessen et al. 1971, Towle 1983, Vesely & Tucker 2004). Much of the Valley's remaining white oak savanna habitats are now found on private lands, occurring in small, fragmented patches or in the form of scattered large trees (ODFW 2006). Many of these large trees pre-date Euro-American settlement of the Valley and thus are biological legacies from historic white oak habitats.

I sampled individual white oak legacy trees in three different landscape types that represent the current rural landscape mosaic of the Willamette Valley: croplands, pastures, and oak savanna reserves. Study sites were located on both private and public lands. Criteria for site selection therefore included the ability to gain access to sites on private lands. The sites selected encompassed a geographic area that extended from Salem in the north to just south of Eugene ($43^{o}56'$ - $44^{o}54'$, $122^{o}53'$ - $123^{o}22'$; Fig. 1).

Cropland sites were predominantly grass seed production fields with the main crop species being annual ryegrass (*Lolium multiflorum*), perennial ryegrass (*Lolium perenne*) and tall fescue (*Festuca arundinacea*). Four of the cropland sites were nursery operations where small saplings (<1.5 m high) of maple (*Acer* spp.), Douglas fir (*Pseudotsuga menziesii*), and noble fir (*Abies procera*) were grown. Pasture sites were either sheep or cattle grazed with the predominant forage species being perennial ryegrass, tall fescue, orchard grass (*Dactylis glomerata*), and clover (*Trifolium* spp.). Savanna reserves consisted of sites that were actively managed to replicate historic oak savanna conditions. Reserve sites were characterized by a diverse understory of grasses and forbs interspersed with shrubs of Himalayan blackberry (*Rubus discolor*), poison oak (*Toxicodendron diversilobum*) and wild rose (*Rosa* spp).

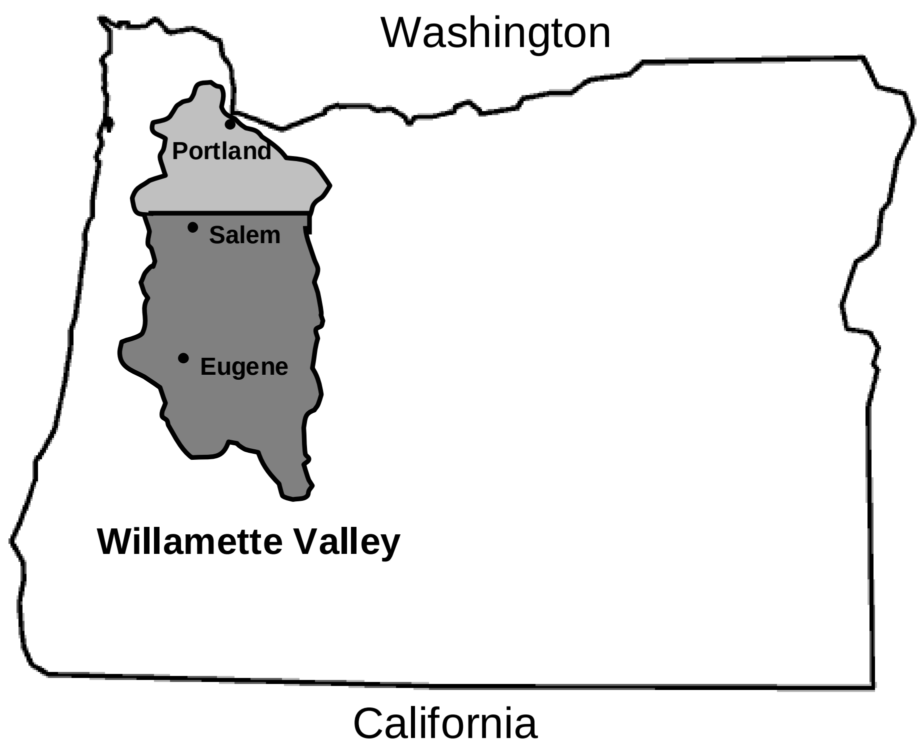

Figure 1: Location of the Willamette Valley in the state of Oregon. Dark grey area represents geographic extent of study area.

Within each site type, I identified white oak legacy trees as those trees whose morphology is characterized by an open-grown "mushroom"-shaped canopy with thickened lateral limbs (Peter & Harrington 2002). All potential trees within a site were evaluated for their structural characteristics (e.g. height, basal area, and canopy structure) and relative isolation in an effort to select a final sample that represented the variation in these attributes within the study area. For cropland and pasture sites, only one tree was selected per site. For reserve sites, the limited number of oak savanna reserves within the Valley necessitated the selection of multiple trees per site. To prevent double counting of birds within reserve sites with multiple study trees, I selected individual trees that were separated by at least 250 m. The mean distance between all pairs of trees was 39.73 km (range 0.38-303.03 km). In total, 35 trees were selected with 13 trees situated in croplands, 13 in pastures and 9 in reserves.

Avian Surveys

I conducted avian surveys between 15 May and 1 July 2008. Within this time period, I surveyed each tree five times. Sites were grouped into six routes that allowed between four to seven trees to be surveyed each day. After completion of the first survey of all trees, the order in which routes were surveyed was randomized. Additionally, the direction of routes was reversed on subsequent surveys so that sites were not always surveyed at the same time of day.

Surveys took place on calm weather days (i.e. no rain and wind < 15 kph) between 0600-1000 when birds are most active and more easily detected. Each survey consisted of observing the tree for five minutes in each of the four cardinal directions at a distance of approximately 30 m. I recorded all bird species that physically landed on the tree. In an attempt to describe how birds are using individual legacy trees, I documented the primary behavior for each bird detected, recording singing, foraging, perching and nesting behaviors. At the end of the 20 minute observation period, I visually inspected the inner canopy of the tree for two minutes from the base of the tree and recorded any previously undetected birds.

Tree Architecture

To capture variation in tree architecture, I developed two structural indices: a tree size index and a tree complexity index. For tree size, I used an index similar to Fischer & Lindenmayer (2002a) by multiplying tree height (m) by basal area (m^2) and canopy volume (m^3). This product was divided by 10,000 to rescale the initial values to smaller numbers for convenience in later data analysis. For each tree, I estimated tree height using a hand-held laser range finder and measured diameter-at-breast height to calculate basal area. I estimated canopy volume using a program called Tree Analyser (Phattaralerphong & Sinoquet 2006). The program computes canopy volume for isolated trees by creating a virtual 3-D reconstruction of the canopy from multiple binary digital photographs. Canopy volume is then estimated by the proportion of voxels (3-D pixels) that contain canopy vegetation. I used four photographs per tree taken in each of the four cardinal directions where possible. The program, however, does allow for geographic variation in picture location in situations where a suitable background could not be achieved in a true cardinal direction. Photographs were processed into black-and-white bitmap files for input into Tree Analyser using program GIMP version 2.2.17 (GNU Image Manipulation Program, http://www.gimp.org).

I developed the tree complexity index to capture variation in structure beyond the tree's physical size. This complexity index is the summation of three categorical variables each scored on a scale of one to four: number of dead limbs (0-5 deadlimbs = 1; 5-15 = 2; 15-20 = 3; 20+ = 4), number of mistletoe patches (0-5 patches = 1; 5-15 = 2; 15-20 = 3; 20+ = 4), and lichen cover (none = 1; sparse = 2; abundant = 3; superabundant = 4). In general, this complexity index yields higher scores for older trees that have developed increased structural diversity and thus may have an increased number of foraging niches (Mazurek &Zielinski 2004).

Because Oregon white oak trees are an important source of cavities for cavity-nesting birds (Gumtow-Farrior 1991; Viste-Sparkman 2005), I also recorded the number of cavities visible on each tree.

Landscape Variables

To determine how the spatial context of an individual tree affected avian use, I measured two landscape factors: the distance of each study tree to the nearest tree and patch (defined as >5 contiguous trees); and the densities of forest and oak-specific vegetation in the surrounding landscape. To estimate the distance to the nearest tree and patch, I used a hand-held laser range finder in the field for distances ≤ 150 m. For distances beyond 150 m, I used the ruler function in ArcGIS to estimate distances from digital orthophoto quad maps taken from the year 2000 (1-m resolution; OGEO 2007).

Within ArcGIS, I estimated both forest and oak-specific vegetation densities surrounding each study tree at multiple spatial extents using recent Willamette Valley vegetation maps (1:24,000 scale; NHI 2007). When calculating forest vegetation density, I included all polygons classified as forest regardless of tree species composition. Because the avian community composition of conifer-dominated forests can differ markedly from the avian community associated with oak woodlands (Hagar and Stern 2001), I calculated oak-specific vegetation densities by excluding polygons that had an oak component of <25%. In both forest and oak vegetation density estimation, I used 50-m buffer increments for the first 1000-m, 100-m increments for the next 1000-m, and then 500-m increments to a maximum buffer of 5000-m. For community-level responses, I used program Focus (Holland et al. 2004) to determine the spatial scale at which each community most strongly responded to each vegetation variable. Program Focus iteratively samples subsets of spatially independent (e.g. non-overlapping) data points and fits a regression line to each subset to create a distribution of model fit statistics. I considered the spatial scale with the highest mean R^2 value to be the characteristic scale of response for each community. I used a similar approach for species-specific responses by selecting the spatial scale that had the lowest deviance from repeated logistic regression analyses.

Data Analysis

For the initial phase of data analysis, I evaluated whether the probability of detecting a bird on an individual tree varied among sites. The main variable thought to affect avian detection probabilities among sites was the relative size of the tree's canopy (e.g. large-canopied trees would have a lower detection probability). Given the uniqueness of surveying a single tree for avian use, I used a novel approach to test for heterogeneity in detection probabilities between large- and small-canopied trees. Recently developed methods for assessing detection probabilities (e.g. MacKenzie et al 2006) could not be used because a single tree represents a small proportion of a typical passerine bird's home range; therefore, temporary absences by birds that otherwise might use these individual trees would violate the closed-population assumption of these methods. I pooled the data of the five smallest-canopied trees and the five largest-canopied trees and used EstimateS (Colwell 2006) to generate sample-based rarefaction curves of species accumulation for each tree type. Rarefaction curves are created by repeatedly re-sampling the pool of individual detections at a given site type to create a smooth curve, or statistical expectation, of species accumulation (Gotelli & Colwell 2001). A difference in the slopes of the rarefaction curves between the two tree types could thus be interpreted as a difference in detection probabilities. For example, if small-canopied trees allowed for increased visibility of birds using these trees, then this increased detection probability should be reflected in a steeper rarefaction curve for small-canopied trees.

For species-level analyses, I assessed only those species that were detected at a minimum of five sites. For each of these species, I used Fisher's Exact test to compare the proportional use of trees situated in agricultural sites versus trees in oak savanna reserves. For community-level analyses, I considered all species detected with no minimum site detection threshold. Species were assigned to each community group *a priori* from a list of potential birds thought to use Willamette Valley oak habitats based on Altman et al. (2001) and Marshall et al. (2003). I assessed four community responses: (i) total species richness; (ii) species richness of native birds associated with oak savanna; (iii) species richness of tree foraging birds; and (iv) the species richness of birds that predominantly forage away from the tree ("non-tree foraging species"). Native oak savanna species richness excluded invasive species such as European Starling as well as generalist species such as American Robin (see Table 1 for species assignments and scientific names). Tree foraging species included species that are either foliage gleaners (e.g. Black-headed Grosbeak) or bark gleaners (e.g. White-breasted Nuthatch). Western Wood-pewee was also included in the tree foraging group since having a tree in which to perch is integral to its short sally fly-catching strategy. Non-tree foraging species included aerial foragers (e.g. Tree Swallow), ground foragers (e.g. Savannah Sparrow) and generalist species (e.g. Western Scrub Jay).

For comparing community-level responses to the three site types, I used EstimateS to calculate Mao Tau expected species richness functions for each site type (Colwell 2006). The Mao Tau species richness estimator creates rarefaction curves of species accumulation analytically without re-sampling the data thus allowing estimates of unconditional variance. The resulting rarefaction curves allow comparison of species richness estimates at a similar sampling effort when sample sizes are unequal or when the number of individuals encountered is uneven (Gotelli & Colwell 2001).

I pooled the data from the five visits for each site and considered each site as a sample, thereby creating nine reserve samples, 13 pasture samples and 13 crop samples.

To evaluate how the explanatory variables influenced avian use of these individual trees, I used a two-stage information-theoretic model selection approach (Burnham & Anderson 2002). Prior to model development, I used Pearson's correlation coefficient to evaluate for potential correlation ($r \geq 0.70$) among the variables within the four explanatory factors of tree architecture, distance, vegetation density, and site type. The variables describing the density of forest vegetation and the density of oak vegetation in the landscape were highly correlated ($r = 0.89$) and thus these two variables were not included in the same model. None of the other variables were strongly correlated. I therefore developed the following *a priori* models describing the tree architecture, distance and vegetation density factors using Poisson log-linear regression for the community-level species richness responses and logistic regression for the species-level presence / absence responses:

i. Tree architecture

Avian use = tree size index + foraging complexity index + cavities

ii. Distance

Avian use = distance to nearest tree

and

Avian use = distance to nearest patch

iii. Vegetation density

Avian use = forest vegetation density at characteristic scale of response and

Avian use = oak vegetation density at characteristic scale of response

I evaluated each model using Akaike's Information Criterion with a small sample size correction factor (AIC_c). In the first stage of model selection, I selected the model with the lowest AIC_c value as the most parsimonious model for each factor. For tree architecture, I evaluated all subsets of the full three-variable model. For the distance and density factors, I assessed the two competing models within each of these factors.

In the second stage of model selection, I combined the top model for each factor along with an indicator variable for the site (or matrix) type and fit this model to the data:

Avian use = top tree architecture model + top distance model + top vegetation density model + matrix indicator variable

For this model, the matrix indicator variable was categorical with the reference variable being oak savanna reserve. I ran all subsets of this model to arrive at an overall best model for each species-specific and community-level response. Following Burnham and Anderson (2002), I considered for inference those models that were within 2 AIC units of the top model and compared model weights (ω) among this set of top models. Model weight can be considered to represent the relative probability that the model under consideration is the best approximating model:

$$\text{Model weight } (\omega) = e^{-0.5*\Delta i} / \sum e^{-0.5*\Delta i}$$

Where Δi is the number of AIC units model *i* is away from the top model.

Given my small sample size, I report 90% confidence intervals for parameter estimates to further assess the weight of evidence for a given model and the likely values of its explanatory variables.

During this stage of analysis, I also assessed the relative importance of the four factors (tree architecture, distance, vegetation density and matrix). A relative importance value ($\omega_+(i)$) for each factor can be calculated by summing the Akaike weights of all the models that contain a particular factor:

Relative factor importance ($\omega_+(i)$) = $\sum \omega_i$ for all models that contain factor *i*

CHAPTER 3: RESULTS

I recorded 47 avian species using the selected individual trees from 528 detection incidents during surveys conducted between 15 May and 30 June 2007 (Table 1). European Starling (n = 20 sites) was the most frequent species encountered followed by American Robin (n = 18) and American Goldfinch (n = 17). Among native oak savanna associates, American Goldfinch and Lazuli Bunting (n = 11) were observed at the largest number of sites. Bullock's Oriole (n = 10) was the most frequent tree foraging species. The majority of species individually were detected at less than 10 sites (Table 1). Of the 23 species detected using at least 5 sites, only 8 species occupied a higher proportion of reserve sites than agricultural sites with Lazuli Bunting, Spotted Towhee and House Wren most strongly associated with reserves.

The most prominent behavior recorded for birds using these individual trees was perching or roosting (n = 266 observations) followed by foraging (n = 105) and singing (n = 73). Eight species were using these individual trees for nesting including American Goldfinch, American Robin, Cedar Waxwing, European Starling, House Wren, Tree Swallow, Violet-green Swallow, and Western Tanager. Evidence for nesting was either direct observation of the nest itself or repeated observations of adult birds bringing nesting material into the tree.

Table 1: Avian species detected using isolated white oak legacy trees in the 3 matrix site types and proportional reserve site use versus agricultural site use in the southern Willamette Valley, OR between 15 May and 30 June 2007. Species are presented in taxonomic order. An (*x)* in the first three columns indicates the community group(s) to which a species was assigned. Numbers under the Site Type heading indicate the number of sites where detected. Numbers in the last two columns refer to the proportion of reserve sites or agricultural sites (combined crop and pasture) used.

				Site Type					
Species	Oak Savanna Associate	Tree Forager	Non-tree Forager	Reserve (n=9)	Pasture (n=13)	Crop (n=13)	Total Sites	Reserve Use [a]	Ag Use [a]
Turkey Vulture (*Cathartes aura*)			*x*	0	2	0	2	0.00	0.08
Red-tailed Hawk (*Buteo jamaicensis*)			*x*	0	3	2	5	0.00	0.19
American Kestrel (*Falco sparverius*)			*x*	0	1	3	4	0.00	0.15
California Quail (*Callipepla californica*)			*x*	1	1	1	3	0.11	0.08
Mourning Dove (*Zenaida macroura*)	*x*		*x*	0	1	2	4	0.00	0.12
Acorn Woodpecker (*Melanerpes formicivorus*)	*x*	*x*		0	1	0	1	0.00	0.04
Hairy Woodpecker (*Picoides villosus*)		*x*		1	0	1	2	0.11	0.04
Northern Flicker (*Colaptes auratus*)	*x*		*x*	0	0	1	1	0.00	0.04

Continued

Table 1 (continued)

Species	Oak Savanna Associate	Tree Forager	Non-tree Forager	Site Type: Reserve (n=9)	Pasture (n=13)	Crop (n=13)	Total Sites	Reserve Use [a]	Ag Use [a]
Western Wood-pewee (*Contopus sordidulus*)	*x*	*x*		3	3	3	9	0.33	0.23
Western Kingbird (*Tyrannus verticalis*)	*x*		*x*	0	1	0	1	0.00	0.04
Western Scrub Jay (*Aphelcoma californica*)	*x*		*x*	3	2	1	6	0.33	0.12
Common Raven (*Corvus corax*)			*x*	0	1	0	1	0.00	0.04
American Crow (*Corvus brachyrhynchos*)			*x*	0	1	3	4	0.11	0.15
Violet-green Swallow (*Tachycineta thalassina*)	*x*		*x*	0	1	0	1	0.00	0.04
Tree Swallow (*Tachycineta bicolor*)	*x*		*x*	0	1	1	2	0.00	0.08
Black-capped Chickadee (*Poecile atricapilla*)		*x*		3	2	2	7	0.33	0.15
Bushtit (*Psaltiparus minimus*)		*x*		0	1	0	1	0.00	0.04
Red-breasted Nuthatch (*Sitta canadensis*)		*x*		1	0	0	1	0.11	0.00

Continued

Table 1 (continued)

Species	Oak Savanna Associate	Tree Forager	Non-tree Forager	Site Type Reserve (n=9)	Pasture (n=13)	Crop (n=13)	Total Sites	Reserve Use [a]	Ag Use [a]
White-breasted Nuthatch (*Sitta carolinensis*)	*x*	*x*		0	3	5	8	**0.00**	**0.31**
House Wren (*Troglodytes aedon*)		*x*		4	1	0	5	**0.44**	**0.04**
Western Bluebird (*Sialia mexicana*)	*x*		*x*	0	1	0	1	0.00	0.04
American Robin (*Turdus migratorius*)			*x*	3	9	6	18	0.33	0.58
Swainson's Thrush (*Catharus ustulatus*)			*x*	0	1	0	1	0.00	0.04
European Starling (*Sturnus vulgaris*)			*x*	4	10	6	20	0.44	0.62
Cedar Waxwing (*Bombycilla cedrorum*)		*x*		0	2	3	5	0.00	0.19
Orange-crowned Warbler (*Vermivora celata*)		*x*		0	1	0	1	0.00	0.04
Yellow Warbler (*Dendroica petachia*)		*x*		3	1	0	4	**0.33**	**0.04**
Common Yellowthroat (*Geothlypis trichas*)			*x*	4	2	1	7	**0.44**	**0.12**

Continued

Table 1 (continued)

Species	Oak Savanna Associate	Tree Forager	Non-tree Forager	Site Type: Reserve (n=9)	Site Type: Pasture (n=13)	Site Type: Crop (n=13)	Total Sites	Reserve Use [a]	Ag Use [a]
Wilson's Warbler *(Wilsonia pusilla)*		*x*		0	2	0	2	0.00	0.08
Western Tanager (*Piranga ludoviciana*)		*x*		1	2	2	5	0.11	0.15
Black-headed Grosbeak (*Pheucticus melanocephalus*)		*x*		0	3	4	7	0.00	0.27
Lazuli Bunting (*Passerina amoena*)	*x*		*x*	7	2	2	11	**0.78**	**0.15**
Spotted Towhee (*Pipilo maculatus*)			*x*	4	1	1	6	**0.44**	**0.08**
Chipping Sparrow (*Spizella passerina*)	*x*		*x*	2	3	5	10	0.22	0.31
Savannah Sparrow (*Passerculus sandwichensis*)			*x*	0	4	3	7	0.00	0.27
White-crowned Sparrow (*Zonotrichia leucophrys*)			*x*	1	2	5	8	0.11	0.27
Song Sparrow (*Melospiza melodia*)			*x*	1	2	2	5	0.11	0.15
Dark-eyed Junco (*Junco hyemalis*)			*x*	0	1	1	2	0.00	0.08

Continued

Table 1 (continued)

Species	Oak Savanna Associate	Tree Forager	Non-tree Forager	Site Type: Reserve (n=9)	Pasture (n=13)	Crop (n=13)	Total Sites	Reserve Use [a]	Ag Use [a]
Brown-headed Cowbird (*Molothrus ater*)	*x*		*x*	0	0	1	1	0.00	0.04
Red-winged Blackbird (*Agelaius phoeniceus*)			*x*	0	0	2	2	0.00	0.08
Brewer's Blackbird (*Euphagus cyanocephalus*)	*x*		*x*	0	4	3	7	0.00	0.27
Bullock's Oriole (*Icterus bullockii*)		*x*		2	4	4	10	0.22	0.31
Purple Finch (*Carpodacus purpureus*)		*x*		0	1	0	1	0.00	0.04
House Finch (*Carpodacus mexicanus*)		*x*		0	2	5	7	0.00	0.27
Lesser Goldfinch (*Carduelis psaltria*)	*x*		*x*	2	3	2	7	0.22	0.19
American Goldfinch (*Carduelis tristis*)	*x*		*x*	2	8	7	17	0.22	0.58
House Sparrow (*Passer domesticus*)			*x*	0	0	1	1	0.00	0.04

[a] Bold indicates difference in proportions is significant ($p \leq 0.10$ from Fisher's Exact test).

Sample-based rarefaction curves for assessing variation in avian detection probabilities suggest that the rates of species accumulation between large- and small-canopied trees were approximately equal (Fig. 2). Moreover, the species found on small canopied trees were simply a subset of those found on large canopied trees. I therefore inferred that avian detection probabilities were similar among sites.

Observed site-specific values of total species richness varied from 3 to 14 (mean = 6.9, SE = 2.9). Comparing cumulative species richness between the three site types, pasture sites (n = 42 species) had the highest total species richness followed by crop sites (n = 34) and reserve sites (n = 20). Evidence for differences between the three site types was weak, however, as the 90% confidence intervals of the sample-based rarefaction curves generated for each site type all overlap at a similar sampling effort (Fig. 3). For oak savanna associates, species richness was highest on crop sites (n = 15 species) and pasture sites (n = 15) and lowest on reserve sites (n = 6). Again, evidence for differences between the site types was weak as the 90% confidence intervals of the rarefaction curves for oak savanna associates all overlapped at a similar sampling effort (Fig. 4).

Species richness results for the two foraging guilds followed a similar pattern, each having higher observed cumulative species richness in agricultural sites compared to reserve sites but with weak evidence for differences due to overlapping 90% confidence intervals at similar sampling efforts (Figs. 5-6). Tree foraging species richness was highest on pasture sites (n = 16 species) followed by crop sites (n = 9) and reserve sites (n = 8). Richness of non-tree foraging species was highest on pasture (n = 25 species) and crop sites (n = 25) and lowest on reserve sites (n = 12).

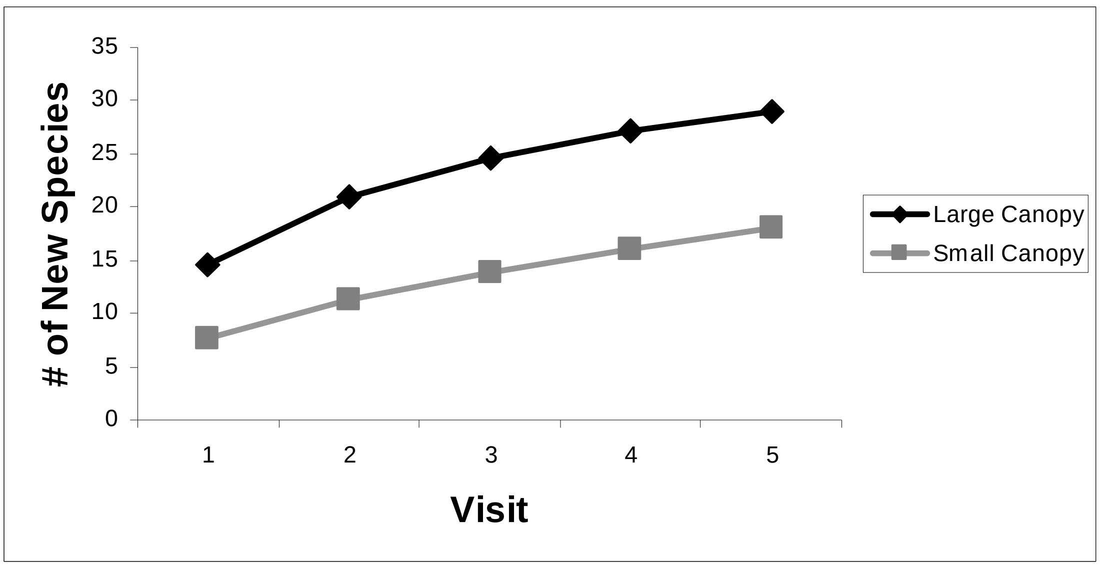

Figure 2: Sample-based rarefaction curves depicting species accumulation rates for large and small canopied trees in the southern half of the Willamette Valley, OR. I pooled data for the five smallest-canopied trees and five largest-canopied trees. The roughly parallel curves indicate that rates of species accumulation between the two tree types are approximately equal. Similar rates of species accumulation suggest that avian detection probabilities did not vary significantly between the two tree types.

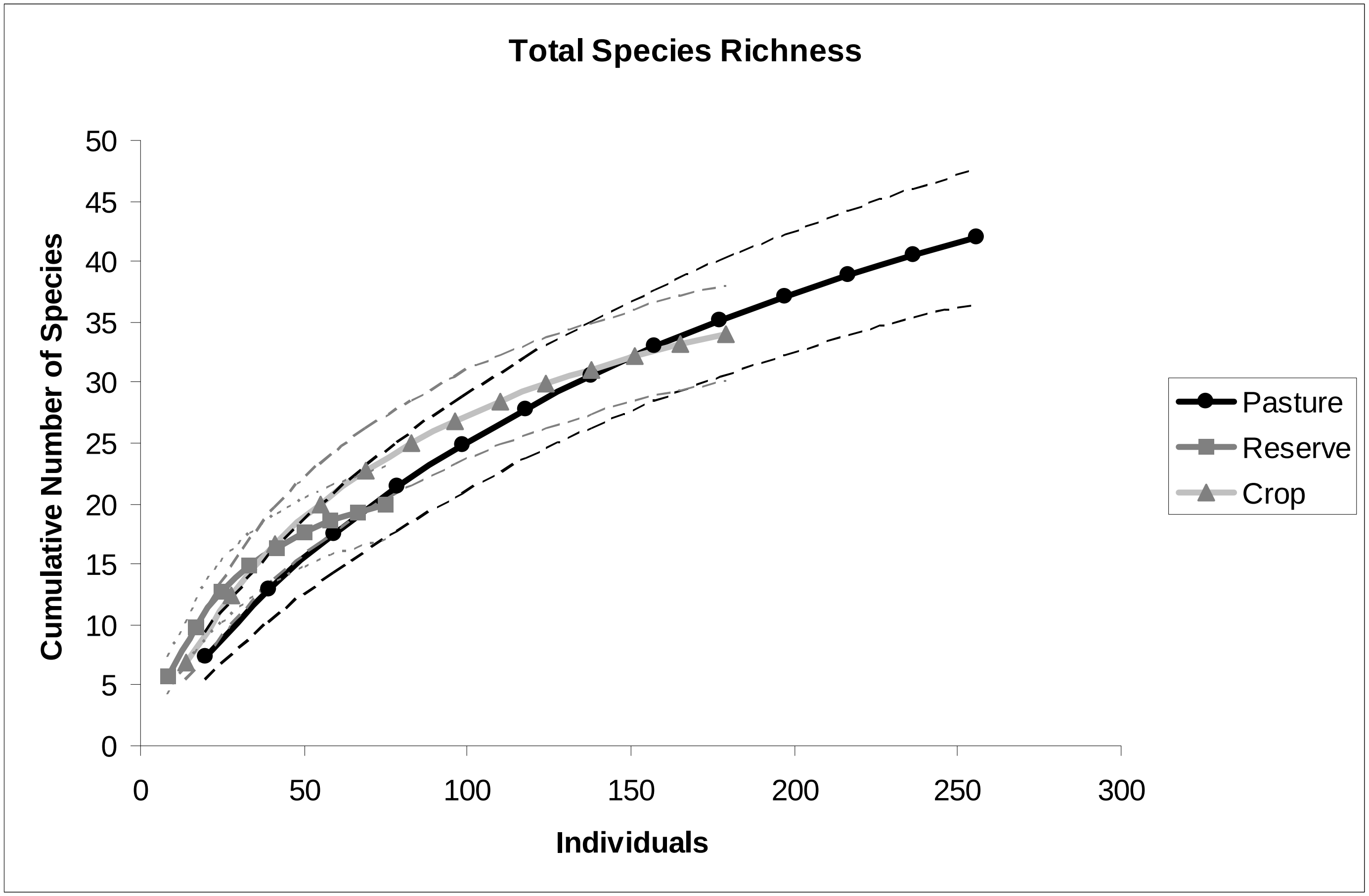

Figure 3: Sample-based rarefaction curves of total avian species richness for the three site types in the southern half of the Willamette Valley, OR. The x-axis has been re-scaled to the number of individuals encountered. Dotted lines represent 90% confidence intervals for each curve.

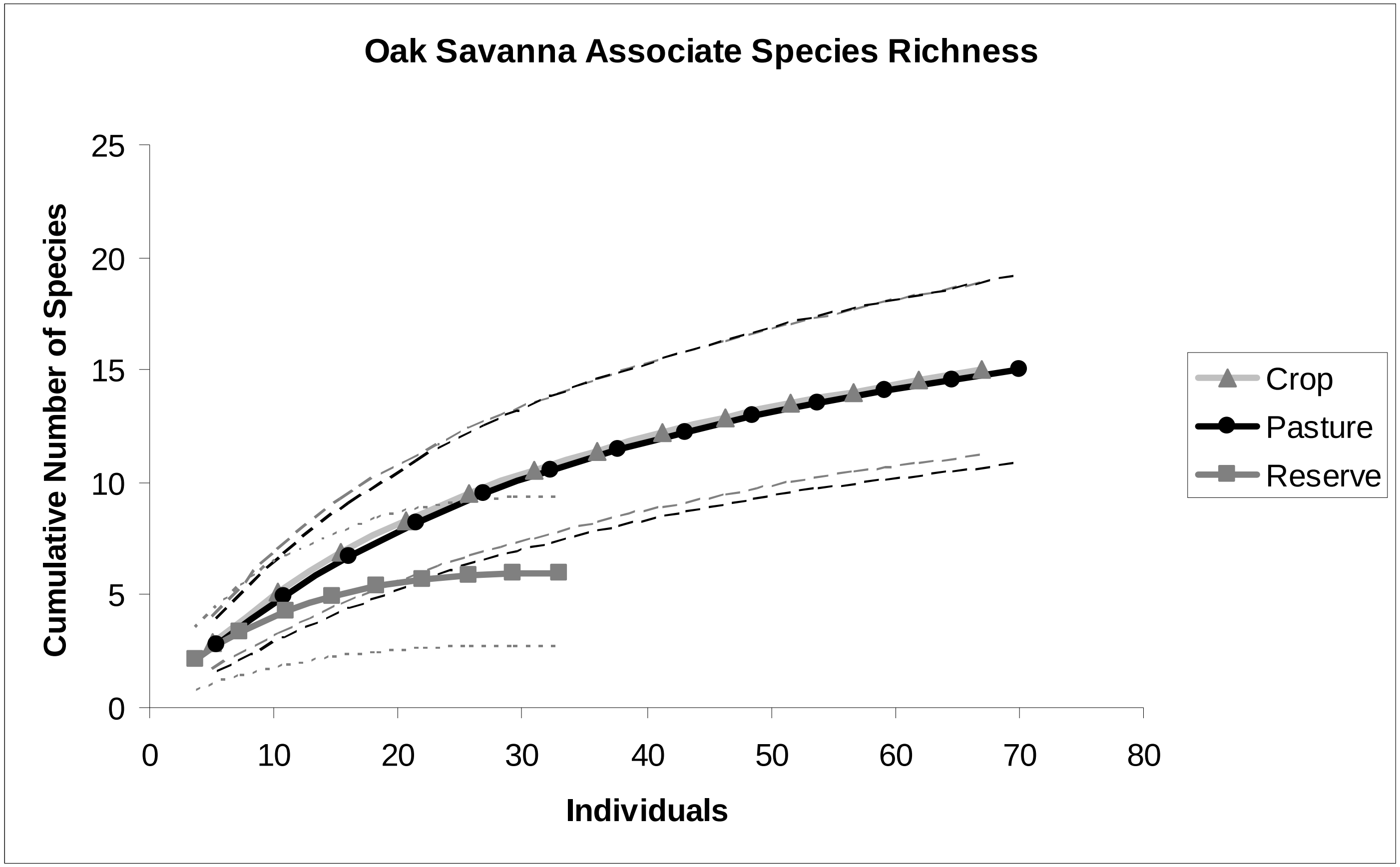

Figure 4: Sample-based rarefaction curves of oak savanna associate species richness for the three site types in the southern half of the Willamette Valley, OR. The x-axis has been re-scaled to the number of individuals encountered. Dotted lines represent 90% confidence intervals for each curve.

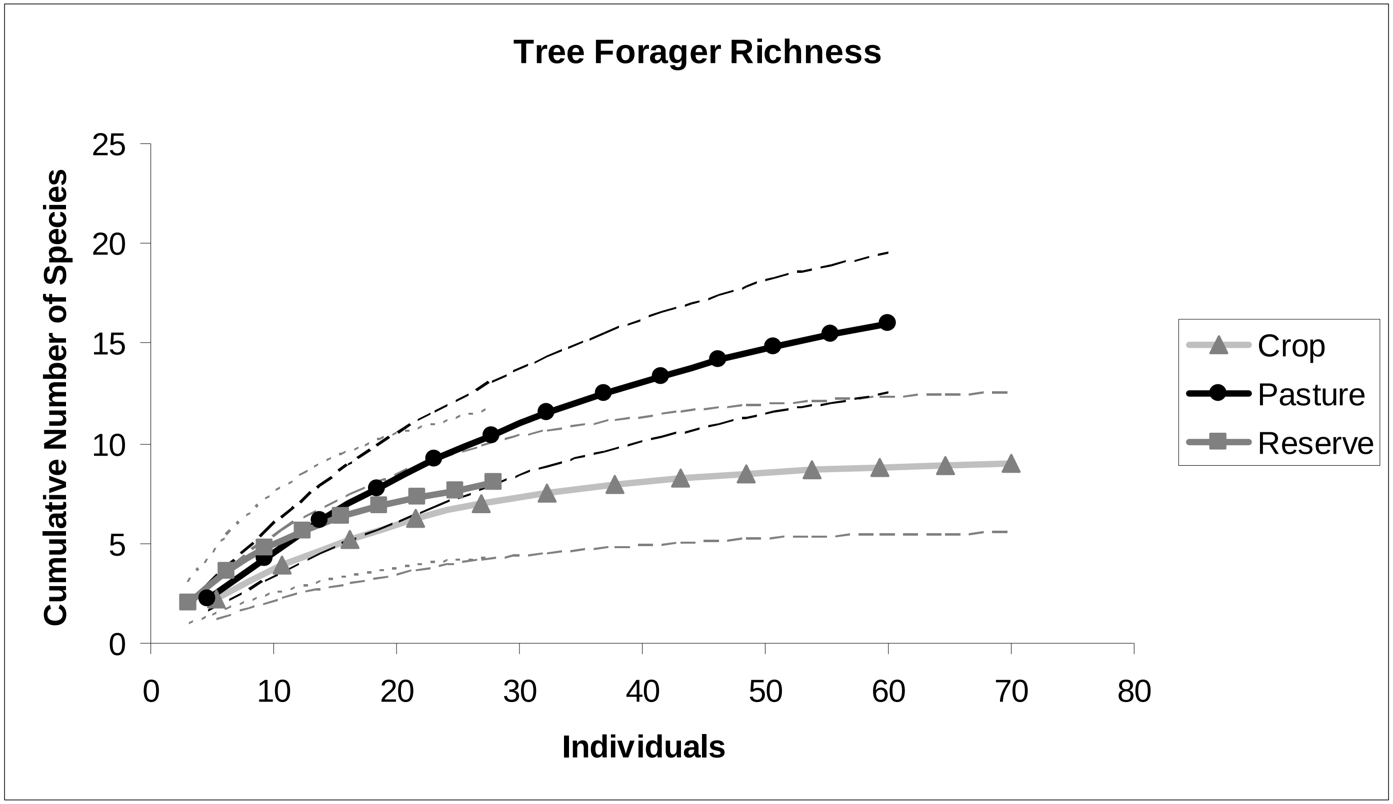

Figure 5: Sample-based rarefaction curves of tree foraging species richness for the three site types in the southern half of the Willamette Valley, OR. The x-axis has been re-scaled to the number of individuals encountered. Dotted lines represent 90% confidence intervals for each curve.

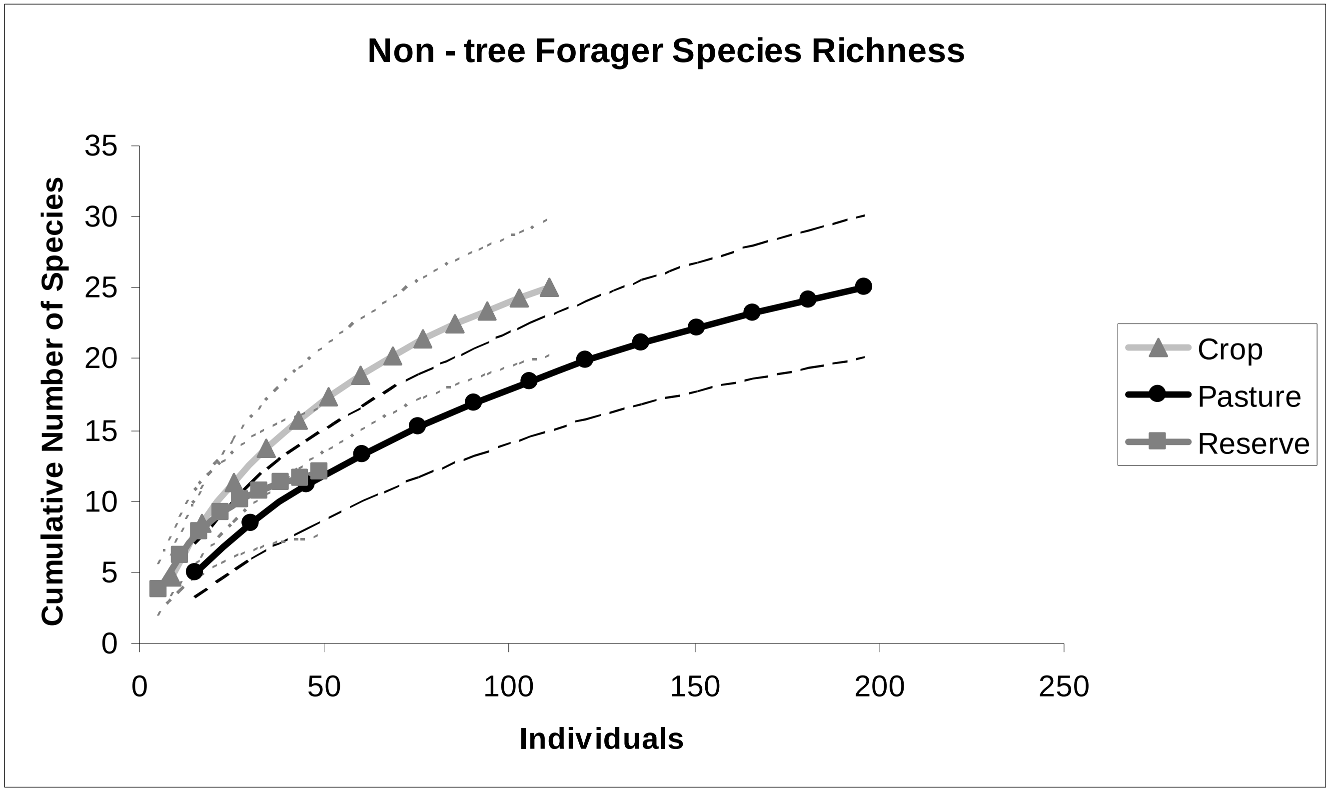

Figure 6: Sample-based rarefaction curves of non-tree foraging species richness for the three site types in the southern half of the Willamette Valley, OR. The x-axis has been re-scaled to the number of individuals encountered. Dotted lines represent 90% confidence intervals for each curve.

Model Selection

Species Level

I evaluated 23 species to determine the relative influence of the explanatory variables on species-specific use (Tables 2-3). When the explanatory variables in the top models for the 23 species are grouped by factor (e.g. tree size and number of cavities are considered tree architecture factors), the top models represented in Table 3 can be condensed into seven factor-related models (Fig. 7). Two of these models, DENSITY and TREE + DENSITY, were the top models for over half of the species analyzed. Fifteen species included a density variable in their respective top models while a tree architecture variable was included the top model of 11 species. A distance variable was included in the top model of seven species. Only one species, Lazuli Bunting, had a top model influenced by the matrix variable. Assessing the relative importance of the four factors, density was selected as the most important variable for 12 species, tree characteristics for seven species, distance for four species and the matrix type was selected for only one species (Table 4).

Table 2: Descriptive statistics for site and landscape variables collected from 35 isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Variable	Code[a]	Mean	SE	Min.	Max.
Tree Architecture					
Tree size index	SIZE	9.37	8.69	0.57	45.15
Height (m)		18.70	2.85	13.32	25.78
Basal area (m^2)		1.02	0.39	0.31	1.85
Canopy Volume (m^3)		4193.59	1797.13	685.57	9780.74
Tree complexity index	COMP	5.11	1.43	3	9
Mistletoe clumps		7.49	8.22	0	31
Dead limbs		8.89	5.00	1	21
Lichen (bin class 1 - 4)		1.63	0.49	1	2
Tree cavities	CAVI	1.91	3.05	0	16
Distance					
Distance to nearest tree (m)	DIST.T	92.39	56.93	21.25	278.88
Distance to patch (m)	DIST.P	152.59	128.00	21.25	555.00
Density					
Forest (across all buffers)	FOR	0.14	0.18	0	0.99
Oak vegetation (across all buffers)	OAK	0.11	0.15	0	0.99

[a] Variable code name in regression models.

Table 3: Top models (≤ 2 AIC units) for 23 species detected at a minimum of 5 study sites in the southern Willamette Valley, OR between 15 May and 30 June 2007. Species are presented in taxonomic order. Regression coefficients for each model are presented sequentially. For the variable TYPE, two coefficients are given: the first is for pasture sites; the second is for crop sites. Reserve sites serve as the reference for this variable.

Species	Model [a]	ω_i [b]	β_1 [c]	β_2	β_3	β_4
Red-tailed Hawk	SIZE	0.23	**0.13**			
			(0.06)			
	SIZE + TYPE	0.19	**0.18**	9.35	6.90	
			(0.09)	(37.64)	(37.66)	
	SIZE + FOR(150)	0.15	**0.11**	-27.20		
			(0.06)	(41.75)		
Western Wood-pewee	CAVI + OAK(5000)	0.24	0.27	-20.72		
			(0.20)	(14.38)		
	OAK(5000)	0.22	-23.62			
			(14.39)			
	CAVI	0.18	0.27			
			(0.17)			
	intercept	0.09				
Western Scrub Jay	CAVI + FOR(800)	0.57	-10.17	**8.87**		
			(37.72	(4.67)		
Black-capped Chickadee	DIST.T	0.29	**-0.040**			
			(0.018)			
	DIST.T + OAK(500) + TYPE	0.18	**-0.068**	**15.68**	**5.84**	**6.70**
			(0.034)	(8.56)	(3.25)	(3.53)

Continued

Table 3: Continued

Species	Model [a]	ω_i [b]	β_1 [c]	β_2	β_3	β_4
	DIST.T + OAK(500)	0.12	-0.030	2.84		
			(0.020)	(3.20)		
White-breasted Nuthatch	SIZE + COMP	0.17	**0.11**	-0.59		
			(0.06)	(0.37)		
	TYPE	0.17	8.36	9.10		
			(24.16)	(24.16)		
	SIZE + COMP + TYPE	0.11	0.090	-0.60	8.21	8.73
			(0.060)	(0.37)	(22.96)	(22.96)
	intercept	0.09				
	SIZE + COMP + FOR(1000)	0.09	**0.097**	-0.57	-4.07	
			(0.054)	(0.37)	(3.98)	
House Wren	FOR(100)	0.52	**5.60**			
			(1.93)			
American Robin	DIST.P	0.67	0.00076			
			(0.0027)			
European Starling	OAK(1600)	0.26	**-11.65**			
			(5.95)			
	SIZE + OAK(1600)	0.12	-0.046	**-12.71**		
			(0.046)	(6.07)		
Cedar Waxwing	FOR(750)	0.66	**-140.78**			
			(85.00)			
Common Yellowthroat	COMP + OAK(500)	0.50	**-1.17**	**7.68**		
			(0.55)	(3.27)		

Continued

Table 3: Continued

Species	Model [a]	ω_i [b]	β_1 [c]	β_2	β_3	β_4
Western Tanager	SIZE	0.34	**0.011**			
			(0.06)			
	SIZE + OAK(3000)	0.28	**0.14**	15.02		
			(0.07)	(10.52)		
Black-headed Grosbeak	SIZE + FOR(100)	0.65	**0.033**	**-7586.03**		
			(0.016)	(3184.71)		
Lazuli Bunting	TYPE	0.23	**-2.96**	**-2.96**		
			(1.11)	(1.11)		
	DIST.T	0.13	**-0.030**			
			(0.013)			
	OAK(50)	0.12	**3.70**			
			(1.62)			
	DIST.T + TYPE	0.10	-0.013	**-2.34**	**-2.29**	
			(0.014)	(1.25)	(1.25)	
	DIST.T + OAK(50)	0.10	-0.018	2.30		
			(0.014)	(1.80)		
Spotted Towhee	DIST.P	0.23	-0.015			
			(0.009)			
	OAK(800)	0.19	**6.67**			
			(3.32)			
	TYPE	0.10	**-2.26**	**-2.26**		
			(1.24)	(1.24)		
	DIST.P + OAK(800)	0.10	-0.0092	3.96		
			(0.0100)	(4.04)		

Continued

Table 3: Continued

Species	Model [a]	ω_i [b]	β_1 [c]	β_2	β_3	β_4
Chipping Sparrow	SIZE + DIST.P + OAK(1600)	0.52	**0.17**	**-0.012**	**-29.98**	
			(0.08)	(0.007)	(17.07)	
Savannah Sparrow	SIZE + DIST.P + FOR(150)	0.56	**-0.81**	0.019	-812.99	
			(0.38)	(0.014)	(1235.27)	
	SIZE + DIST.P	0.27	**-1.0**	**0.035**		
			(0.5)	(0.017)		
White-crowned Sparrow	FOR(150)	0.34	-103.66			
			(123.85)			
	SIZE + FOR(150)	0.30	-0.11	-109.33		
			(0.09)	(125.59)		
Song Sparrow	COMP + FOR(100)	0.25	-0.61	-6309.29		
			(0.43)	(30200.55)		
	FOR(100)	0.25	-5896.63			
			(31668.43)			
Brewer’s Blackbird	DIST.P	0.32	**0.0092**			
			(0.0038)			
	DIST.P + FOR(450)	0.16	0.0069	-6.31		
			(0.0042)	(7.04)		
Bullock’s Oriole	intercept	0.21				
	FOR(150)	0.19	-3.17			
			(2.87)			
	DIST.P	0.15	0.0038			
			(0.0029)			

Continued

Table 3: Continued

Species	Model [a]	ω_i [b]	β_1 [c]	β_2	β_3	β_4
	CAVI	0.12	-0.20			
			(0.20)			
House Finch	SIZE + OAK(400)	0.27	0.083	-15.81		
			(0.054)	(10.83)		
	OAK(400)	0.21	-16.77			
			(10.50)			
Lesser Goldfinch	DIST.P + FOR(50)	0.30	**-0.0092**	-98.33		
			(0.0068)	(499.26)		
	FOR(50)	0.22	-87.33			
			(313.18)			
American Goldfinch	FOR(1400)	0.41	**-7.38**			
			(3.42)			

[a] Variable codes are listed in Table 2. For OAK and FOR variables, the buffer size selected for is listed in parentheses.
[b] Model weight representing the relative probability that the model under consideration is the best approximating model.
[c] Bold indicates that 90% confidence interval for parameter estimate does not overlap zero. Standard errors are listed in parentheses below parameter estimates.

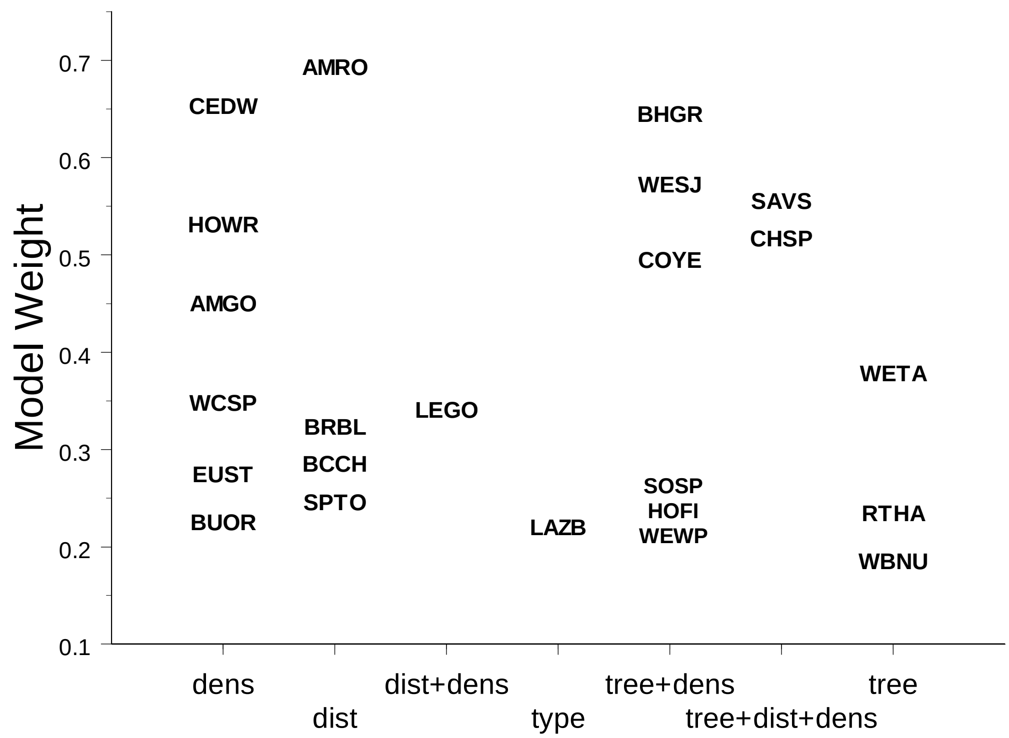

Figure 7: Model weights of the top factor-related models of the 23 species analyzed. For this graph, explanatory variables from the top models in Table 2 have been grouped according to factor type (tree = tree architecture; dist = distance to nearest tree or patch; dens = forest or oak vegetation density; type = site type). Species in this analysis occurred at a minimum of 5 sites.

* Species codes in taxonomic order: RTHA = Red-tailed Hawk; WEWP = Western Wood-pewee; WESJ = Western Scrub Jay; BCCH = Black-capped Chickadee; WBNU =White-breasted Nuthatch; HOWR = House Wren; AMRO = American Robin; EUST = European Starling; CEDW = Cedar Waxwing; COYE = Common Yellowthroat; WETA = Western Tanager; BHGR = Black-headed Grosbeak; LAZB = Lazuli Bunting; SPTO = Spotted Towhee; CHSP = Chipping Sparrow; SAVS = Savannah Sparrow; WCSP = White-crowned Sparrow; SOSP = Song Sparrow; BRBL = Brewer's Blackbird; BUOR = Bullock's Oriole; HOFI = House Finch; LEGO = Lesser Goldfinch; AMGO = American Goldfinch

Table 4: Comparison of top factors by species. Species are listed under their respective top factor based on comparing the relative importance of the four general explanatory factors. See Figure 6 for species codes.

Tree Characteristics	Distance	Density	Type
CHSP	AMRO	AMGO	LAZB
COYE	BCCH	BHGR	
RTHA	BRBL	BUOR	
SAVS	SPTO	CEDW	
WBNU		EUST	
WESJ		HOFI	
WETA		HOWR	
		LEGO	
		SOSP	
		WCSP	
		WEWP	

Among birds that were detected at a minimum of five sites, White-breasted Nuthatch and Chipping Sparrow have been identified as oak-associated species of concern by the Oregon Conservation Strategy (ODFW 2005) and are thus further highlighted. Both species had top models that suggested a positive correlation to increasing tree size (Table 3) although the relationship between probability of use and tree size was somewhat weak and variable for both species, perhaps being influenced by the data point of the largest tree (Fig. 8). However, repeating the analysis with this data point removed did not substantially affect parameter estimates (e.g. Chipping Sparrow: $\beta = 0.17$, SE = 0.08 for tree size with largest tree included; $\beta = 0.17$, SE = 0.09 with largest tree excluded). For White-breasted Nuthatch, the SIZE variable ($\beta = 0.11$, SE = 0.06 from the top model) was the only variable that had a 90% confidence interval that did not overlap zero. For Chipping Sparrow, the top model included negative correlations with distance to the nearest patch (β = -0.012, SE = 0.007) and oak density within a 1600 m buffer (β = -29.98, SE = 17.07) in addition to tree size, suggesting that the spatial pattern of trees was important for predicting use.

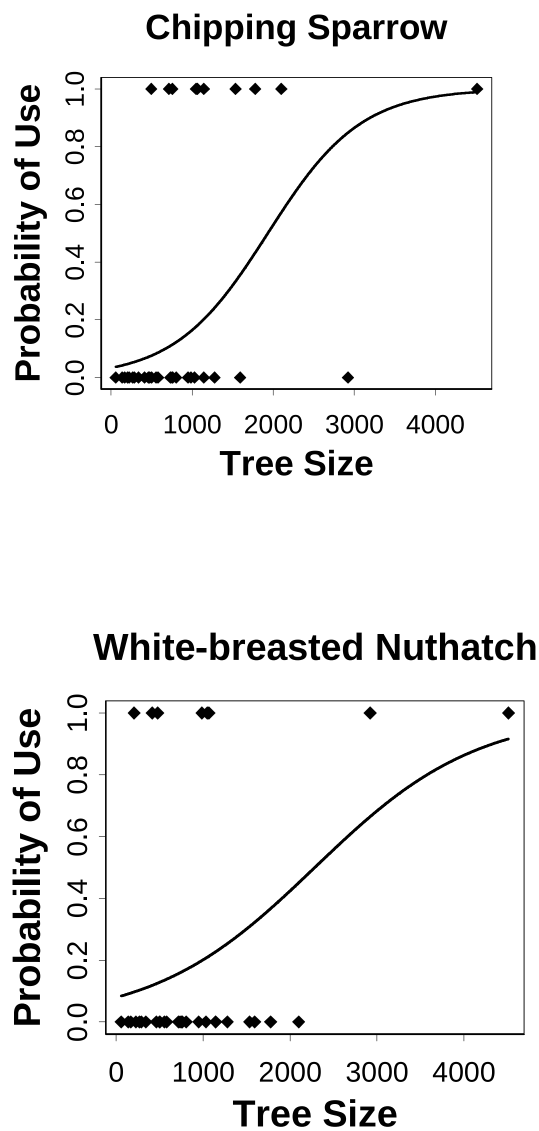

Figure 8: Estimated probability of use of isolated white oak legacy trees in the southern Willamette Valley in relation to tree size by Chipping Sparrow (top) and White-breasted Nuthatch (bottom).

Community Level

The top model for predicting total species richness was a single variable model describing a negative correlation with the density of forest vegetation in an 800-m buffer centered on each tree (β = -0.78, SE = 0.41; Table 5; Fig. 9). This forest vegetation variable was also represented in the second ranked model along with variables describing tree size and the number of cavities. The evidence for tree size and cavity effects, however, was relatively weak as both variables had 90% confidence intervals that overlapped zero. The strength of evidence for the single variable forest vegetation model is further supported by this model being over twice as likely as the remaining two models in the model set, models that do not contain the forest vegetation variable.

For species associated with oak savannas, the top model for species richness was a two-variable model that included a positive correlation with tree size (β = 0.018, SE = 0.010) and a negative correlation with the density of oak vegetation in a 1400-m buffer (β = -2.49, SE = 1.61). The second and third ranked models were single variable models describing tree size and oak vegetation respectively. All three of these models had model weights within 0.03 of each other, indicating similar strengths of evidence for these two variables in explaining oak savanna associate richness. The other model in the model set, the intercept model, was less than half as likely as the top model.

Species richness of tree foragers was best predicted by a single variable model describing a positive correlation with tree size (β = 0.024, SE = 0.010). Assessing model weights, this top model was almost twice as likely as the only other model within 2 AIC units. The top model for species richness of non-tree foragers was a single variable model describing a negative correlation with the density of forest vegetation in a buffer of 150 m ($\beta = -0.97$, SE = 0.40). This model had a high model weight ($\omega = 0.49$) and no other models were within 2 AIC units of this top model.

Table 5: Parameter estimates of top models (<2 ΔAIC_c) predicting community level responses on isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Response		Parameter Estimates [a, b]			
Model	ω [c]	β_0	SIZE	CAVI	Density Variable
Total species richness					
FOREST (800)	0.25	2.05 (0.08)			**-0.83** (0.41)
SIZE + CAVI + FOREST (800)	0.18	2.01 (0.12)	0.010 (0.007)	-0.041 (0.026)	**-0.76** (0.41)
SIZE + CAVI	0.12	1.89 (0.10)	**0.012** (0.007)	-0.042 (0.026)	
Intercept	0.09	1.94 (0.06)			
Oak savanna associate richness					
SIZE+ OAK (1400)	0.21	1.00 (0.21)	**0.018** (0.010)		-2.49 (1.61)
SIZE	0.21	0.76 (0.15)	**0.021** (0.010)		
OAK (1400)	0.18	1.22 (0.16)			**-2.83** (1.56)
Intercept	0.10	0.98 (0.10)			
Tree foraging species richness					
SIZE	0.33	0.54 (0.17)	**0.024** (0.010)		
SIZE + OAK(150)	0.18	0.44 (0.19)	**0.027** (0.011)		0.49 (0.41)
Non-tree foraging guild richness					
FOR (150)	0.49	1.64 (0.08)			**(-0.97)** (0.40)

[a] Standard errors of estimates are in parentheses
[b] Bold indicates 90% confidence interval of parameter estimate does not include zero
[c] Model weight representing the relative probability that the model under consideration is the best approximating model

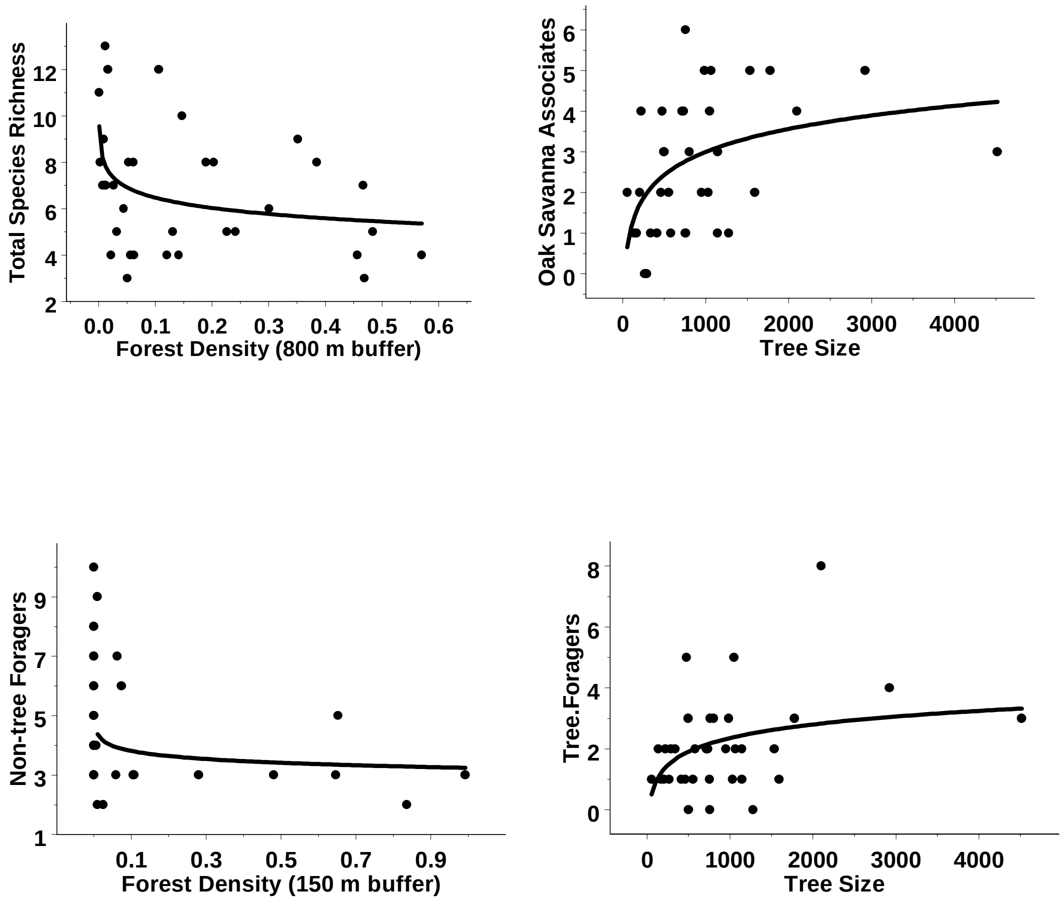

Figure 9: Model predictions for the top model for each of the four community level responses: total species richness (top left); oak savanna associate richness (top right); non-tree forager richness (bottom left); and tree forager richness (bottom right).

Assessing the relative importance of the four general explanatory factors (Table 6), tree architecture, in particular tree size, was the most important factor in explaining the richness of oak savanna breeding associates and tree foraging species. For tree foraging species, tree architecture ($\omega_+(i)$ = 0.74) was twice as important as oak vegetation density in a 150-m buffer ($\omega_+(i)$ = 0.35), the second ranked factor. For oak savanna associates, tree architecture ($\omega_+(i)$ = 0.59) ranked slightly ahead of forest density in the surrounding landscape ($\omega_+(i)$ = 0.54). Overall species richness and non-tree foraging species richness were best explained by forest density. For non- tree foraging species, forest density ($\omega_+(i)$ = 0.87) was over three times as important as tree architecture ($\omega_+(i)$ = 0.23) and distance ($\omega_+(i)$ = 0.23). For overall species richness, forest density ($\omega_+(i)$ = 0.62) ranked ahead of tree architecture ($\omega_+(i)$ = 0.44). The matrix in which the tree is embedded had little impact in explaining the four community-level responses.

Table 6: Relative importance values ($\omega_+(i)$)of the four explanatory factors for each of the community level responses.

	Species richness	Oak savanna associates	Tree foragers	Non-tree foragers
Tree Architecture	0.44	0.59	0.74	0.23
Distance	0.25	0.23	0.23	0.23
Density	0.62	0.54	0.35	0.87
Matrix	0.13	0.09	0.11	0.09

CHAPTER 4: DISCUSSION

Results of this study indicate that a high number of avian species use isolated white oak legacy trees in the Willamette Valley's agricultural matrix. Importantly, a high number of oak savanna-associated species use these trees, including species of concern such as White-breasted Nuthatch and Chipping Sparrow. For the majority of avian species observed in this study, there was little evidence that the frequency of use of individual oak trees differed among crop, pasture and reserve sites. Moreover, none of the species detected were confined only to reserve sites, indicating the potential for agriculturally-situated trees to positively contribute to landscape-level conservation of a wide range of avian species within the Willamette Valley.

Behavioral observations of avian use suggest that individual isolated trees are focal habitat structures for roosting, foraging, singing and nesting. For many oak savanna-associated species, an agriculturally-situated legacy oak tree may provide the critical resources necessary for persistence in what otherwise might be an inhospitable matrix. For tree foraging species in particular, isolated trees may provide foraging opportunities that would not exist in treeless landscapes. Further, isolated trees may act as important stopover points for tree foraging species moving among woodland patches (Fischer & Lindenmayer 2002b). For aerial and ground foraging species, individual isolated trees likely provide safe refuges for roosting (Dean et al 1999) and prominent perches for singing (Slabbekoorn 2004). The notion that isolated trees provide safe havens was supported anecdotally in the field when I observed two

Savannah Sparrows, a ground foraging and nesting species, fly up into an isolated oak tree at the approach of a Sharp-shinned Hawk (*Accipiter striatus*).

The importance of scattered remnant trees to the conservation of landscape-level avian biodiversity has been identified by previous research in tropical agricultural systems (Dean et al 1999, Luck & Daily 2003, Harvey et al 2006). The current study is the first that I am aware of to corroborate these findings in North American agricultural systems. A number of factors have been proposed to account for the disproportionate contribution of isolated trees to the conservation of biodiversity. First, scattered trees add vertical and horizontal structural diversity to otherwise treeless landscapes. Increasing habitat structural heterogeneity has long been associated with patterns of increased species richness in a number of taxa (Atauri & de Lucio 2001, Bennett et al 2006). Second, increasing the proportion of a vegetation type within a region increases the probabilities of occurrence of native species dependant on the vegetation type, translating into an expected increase in species richness in the region under consideration (Bennett et al 2006). A third factor is that scattered trees increase landscape-level tree cover thereby increasing the prevalence of forest-dependent species (Luck & Daily 2003, Harvey et al 2006).

In the current study, two factors had the most influence on avian use of white oak legacy trees: tree size and the density of forest vegetation in the surrounding landscape. In general, increasing tree size was associated with higher per capita use, particularly among tree foraging species and oak savanna associates. With all else being equal, larger legacy-type trees likely provide more and higher quality resources for birds than smaller, younger trees (Dean et al 1999, Fischer & Lindenmayer 2002a, Mazurek &Zielinski 2004). Previous studies within the Willamette Valley have illustrated the importance of large oak trees to cavity-nesting species (Gumtow-Farrrior 1991, Hagar & Stern 2001) and individual species (Viste-Sparkman 2005) but my findings give evidence that large oak trees are potentially important to the Valley's oak savanna-associated avian community as a whole. This broader applicability is exemplified by selection of tree size in the top model of the savanna-associated Chipping Sparrow, a species that is neither a cavity-nester nor a tree forager. As noted earlier, for ground foraging and nesting species like Chipping Sparrow, large isolated oak trees may provide important sites for perching and singing, a finding corroborated by frequent aural detections of Chipping Sparrows singing from some of the individual trees I studied.

The density of forest or oak vegetation in the landscape surrounding each tree was a primary factor in predicting overall species richness on individual trees. Interestingly, I found that overall avian species richness generally increased with decreasing tree density. This result is in contrast to other studies in agricultural systems where avian species richness was positively correlated to increasing tree cover (Luck & Daily 2003, Harvey et al 2006, Posa & Sodhi 2006, Sekercioglu et al 2007). These other studies, however, generally focused on how forest birds responded to agricultural conversion of previously forested landscapes. In my study area, agricultural conversion primarily affected oak savanna and prairie habitats and their associated bird communities. The overall avian community that I documented using individual oak trees was dominated by species associated with more open habitats. I recorded relatively few forest obligates using these individual trees. Consequently, it is not surprising that the overall avian community using individual oak trees might respond as a whole to decreasing tree cover.

Increasing avian use of isolated trees with decreasing tree cover suggests that the role of isolated trees as focal habitat structures increases as trees become rarer on the landscape. For many avian species, particularly tree foraging and tree nesting species, the presence of a single tree likely provides critical resources necessary for persistence in an otherwise treeless landscape. Thus, an isolated tree becomes a "habitat magnet", concentrating tree-dependent species around this focal habitat structure on the landscape and resulting in higher avian use. Conversely, as tree density increases, tree-associated resources are more abundant and dispersed on the landscape, likely resulting in lower per capita avian use of individual trees.

The current spatial configuration of oak habitats in the Willamette Valley may also have influenced the negative correlation between species richness and tree density, particularly for oak savanna associates. Historically, oak savanna habitats within the Willamette Valley were characterized by widely spaced open-grown oak trees with an estimated tree density of 5-17 trees/ha (Day 2005, ODFW 2005). Habitat patches containing this historical spatial pattern of trees are now rare within the Willamette Valley. Most agricultural fields are devoid of trees with residual oak trees confined to dense woodland strips bordering these fields. Further, in the periphery of the Valley where savannas were historically most abundant, fire suppression and conifer invasion have turned savannas into denser oak and mixed-conifer woodlands (Johannessen et al 1971, Towle 1983). To savanna species, this current spatial configuration of trees presents patches where the amount of tree cover is either too dense (the woodlands) or not dense enough (treeless fields). At a fine scale, oak savanna birds may simply be attracted to isolated agricultural trees because the presence of a single tree in a field represents a small patch that has a tree density that is intermediate between the extremes typically found within the Valley and closer to the estimated spatial configuration of historic oak savanna habitat.

The relative isolation of an oak tree, as measured by the distance to the nearest tree or patch, ranked behind tree size and forest density in terms of predicting avian use of these individual trees. In general, the number of species using individual oak trees increased with increasing tree isolation. This finding is consistent with results from a study on African savanna trees where increasing tree isolation was associated with greater intensity of utilization by birds and mammals (Dean et al 1999). It is also supportive of the hypothesis that a single isolated tree is an important and focal habitat feature in an otherwise treeless landscape.

Perhaps the most surprising finding from my study was the relatively small influence that the surrounding matrix had on avian use of isolated oak trees. Overall species richness was similar between trees located in agricultural fields and trees situated in savanna reserves. Importantly, this relationship also held true for species richness of oak savanna associates. At the species level, the only species for which the matrix was selected as the most important factor was Lazuli Bunting, a species associated with shrubby understories that are more commonly associated with savanna reserves (Greene et al 1996). The relatively high use of agriculturally-situated trees suggests that these individual trees are important habitat components to many savanna species occupying agricultural fields during the breeding season. Moreover, the high use of agriculturally-situated trees highlights the importance of off-reserve conservation of habitat remnants, even at the scale of a single tree, for conserving native biodiversity within anthropogenically-modified landscapes (Franklin 1993, Schwartz & van Mantgem 1997).

Taken collectively, my results support the hypothesis that isolated trees are keystone structures in human-modified landscapes, particularly when it comes to preserving native biodiversity (Tews et al 2004, Manning et al 2006). Further, my findings suggest that use of a large individual oak tree seems to intensify with both increasing isolation and decreasing tree density. This intensification of use with increasing isolation and decreasing tree density runs contrary to traditional fragmentation theory where species use of habitat fragments is predicted to decline with increasing isolation and decreasing habitat density (Andrén 1994, Fahrig 2003). My findings are perhaps better explained by the resource concentration hypothesis (Root 1973). More commonly applied to invertebrate populations, the resource concentration hypothesis states that animal densities will be highest in areas where critical resources can be found. In simplified agricultural systems, large isolated trees are focal habitat elements for many avian species, providing foraging, nesting and perching sites - resources that are critical for persistence in otherwise treeless landscapes.

The Influence of Oregon White Oak as a Species

If individual isolated trees provide habitat for many avian species in agricultural systems, the species of these individual trees is likely important in determining the quality of avian habitat that these individual trees provide. For avian species, Oregon white oak trees likely provide higher quality resources relative to other Willamette Valley hardwood species such as big leaf maple (*Acer macrophylum*). For cavity-nesting birds, the trunk and thickened lateral limbs of large Oregon white oak trees provide ideal sites for the creation of cavities (Gumtow-Farrior 1991). For bark-gleaning avian species such as the White-breasted Nuthatch, the bark complexity and abundant lichen cover of Oregon white oak trees support a rich fauna of bark-dwelling invertebrates (Merrifield 2000). For foliage-gleaning birds, Oregon white oak hosts an abundance of caterpillars with over 75 species recorded compared to only 17 species on big leaf maple (Miller & Hammond 2003). Oregon white oak trees also provide year-long foraging opportunities for birds, with acorns being an important food source for Western Scrub Jays and Acorn Woodpeckers in the fall and mistletoe berries for Western Bluebirds and House Finches in the winter (Marshall et al. 2003). A further consideration is that Oregon white oak is a relatively stable resource temporally, being a long-lived species that is uniquely adapted to the xeric conditions found between the Willamette Valley's riparian corridors and upland conifer forests (Thilenius 1968).

CHAPTER 5: CONCLUSIONS

Management Implications

The most immediate management issue regarding white oak legacy trees in the Willamette Valley is their declining abundance on the landscape due to current land use practices and the senescence of existing trees (Thysell & Carey 2001). Although the role that these individual trees might play in the demography of Willamette Valley avian populations is yet to be assessed, the continued decline in abundance of these individual trees has the potential to negatively impact a wide array of oak savanna-associated species, particularly those species that would not be found in agricultural fields without these trees. Thus, land managers interested in preserving oak habitats at a landscape-level should work with willing landowners to conserve existing individual legacy trees and foster the recruitment of younger replacement trees.

My findings have further implications with respect to current Willamette Valley oak restoration efforts (Campbell 2004, Vesely & Tucker 2004). Clearly, the ultimate goal of many oak savanna restoration projects is to not only conserve or restore large savanna-form trees but also to restore the native herbaceous understory with the hope of restoring habitat for a broad complement of oak-associated wildlife species. The rarity of this habitat type on the North American continent necessitates that this type of restoration should be a high priority wherever possible (Ricketts et al 1999, Brawn 2006). However, in agriculturally-dominated systems such as the Willamette Valley, this type of restoration is likely not feasible at a large scale. My results suggest that oak savanna restoration in agricultural systems does not necessarily need to be an all-or-none proposition. Large savanna-form oak trees scattered in agricultural fields have wildlife value, particularly for many oak-associated avian species. Moreover, these individual trees have a relatively small physical footprint on the landscape thus allowing minimal impact on agricultural production.

Finally, my findings have broader implications when considering habitat management strategies for conserving wildlife in agricultural systems. Traditional paradigms developed in the late twentieth century for conserving wildlife in agricultural systems focused on the use of hedgerows, fencerows, shelterbelts and other strip-cover habitats (Pimentel et al 1992, Best et al 1995). These types of management strategies, however, may not be the most appropriate ones for all agro-ecosystems. More recently developed paradigms suggest that agricultural systems that attempt to incorporate the ecological patterns and processes of the underlying historical natural system may be more successful at conserving native biodiversity (Blann 2006, Fischer et al 2006, Vandermeer & Perfecto 2007). In the context of the Willamette Valley's agricultural matrix, scattered large white oak trees should therefore be considered part of a landscape-level management strategy for improving conservation of the Valley's native avian populations.

Limitations

The results of this study are limited to simple detections of birds using isolated Oregon white oak trees in agricultural systems. Although isolated white oak trees are clearly used by a wide variety of avian species, my results do not give insight as to how these individual trees affect species-specific demography. Specifically, my results give no indication as to whether isolated oak trees function as source or sink habitats for the avian species using them. This study also did not account for the potential effect of inter-specific interactions on avian use of these individual trees. Based on field observations, this factor may be influential, particularly with regard to European Starlings. At one study site with low total species richness (n = 4 species), I observed at least four starling nests in the study tree and antagonistic interactions between the resident starlings and an Acorn Woodpecker.

Results of this study also do not shed light on the appropriate number or spatial distribution of isolated trees required for conserving oak-associated avian species at the population level (e.g. are multiple trees in a field significantly better than one?). Moreover, my finding that increasing tree isolation correlates with increasing avian use does not suggest that oak trees within a particular field should be thinned to increase the isolation of the remaining trees.

A final consideration is that the results of this study are confined to avian use during the breeding season. Avian use of these trees may vary temporally, with acorn production in the fall and mistletoe in the winter potentially providing important foraging resources for resident species. Thus, future directions for research into the role of scattered trees for avian conservation in agricultural landscapes include:

1. Species-specific demographic studies to determine whether isolated trees positively contribute to population persistence.

2. Assessing the impact of European Starlings on avian species using white oak legacy trees, particularly cavity-nesting birds.
3. Spatially-explicit studies to determine an appropriate number and spatial pattern of individual trees within agricultural fields.
4. Assessing temporal variation in avian use of isolated trees and the potential role these trees might play in sustaining resident bird populations during the non-breeding season.

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APPENDIX A: Study site geographic information.

Table A1: Study site UTM coordinates of 35 isolated white oak legacy oak trees in the southern Willamette Valley, OR [Datum: NAD 1983].

Site ID	UTM_Easting	UTM_Northing	Matrix Type
1	473333	4935291	Reserve
2	470269	4911970	Pasture
3	473610	4884897	Pasture
4	472571	4895377	Pasture
5	473973	4884656	Pasture
6	473585	4918195	Reserve
7	473404	4918603	Reserve
8	473005	4918258	Reserve
9	476635	4888734	Pasture
10	469715	4928287	Crop
11	484529	4934350	Crop
12	491205	4910713	Crop
13	471551	4927943	Crop
14	471280	4925350	Crop
15	479082	4908545	Pasture
16	498518	4959357	Reserve
17	486482	4928409	Crop
18	500199	4870588	Pasture
19	501619	4872449	Reserve
20	503841	4871144	Reserve
21	501808	4873342	Reserve
22	501760	4871388	Reserve
23	494760	4896646	Pasture
24	490112	4917051	Crop
25	490290	4933074	Pasture
26	476094	4934622	Pasture
27	483738	4942666	Crop
28	474219	4937599	Pasture
29	482442	4879239	Pasture
30	509181	4970794	Crop
31	508394	4971726	Crop
32	504485	4970422	Crop
33	473833	4883482	Crop
34	485221	4931528	Crop
35	478279	4865546	Pasture

APPENDIX B: Response data collected on 35 isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Table B1: Species richness values for the four community-level responses collected from 35 isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Site No.	Total Species Richness	Oak Savanna Associate Richness	Tree Forager Richness	Non-tree Forager Richness
1	8	3	3	5
2	4	2	1	2
3	8	4	3	5
4	14	4	8	6
5	8	6	0	8
6	5	1	2	3
7	9	5	2	7
8	5	2	3	2
9	9	4	5	4
10	13	5	3	10
11	3	1	1	2
12	7	3	3	4
13	4	2	1	3
14	5	3	3	2
15	8	1	3	5
16	6	1	2	4
17	4	1	1	3
18	4	1	1	3
19	4	1	3	1
20	3	3	0	3
21	4	2	1	3
22	8	1	2	6
23	7	2	1	6
24	8	4	2	6
25	7	2	1	6
26	13	5	3	10
27	8	0	2	6
28	4	0	1	3
29	7	4	2	5
30	6	3	1	5
31	12	4	5	7
32	10	5	3	7
33	4	1	0	4
34	8	5	4	4
35	5	2	1	4

Table B2: Four letter species codes for the 47 birds detected using 35 isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Species	Species Name	Species	Species Name
ACWO	Acorn Woodpecker	MODO	Mourning Dove
AMCR	American Crow	NOFL	Northern Flicker
AMGO	American Goldfinch	OCWA	Orange-crowned Warbler
AMKE	American Kestrel	PUFI	Purple Finch
AMRO	American Robin	RBNU	Red-breasted Nuthatch
BCCH	Black-capped Chickadee	RTHA	Red-tailed Hawk
BHCO	Brown-headed Cowbird	RWBL	Red-winged Blackbird
BHGR	Black-headed Grosbeak	SAVS	Savannah Sparrow
BRBL	Brewer's Blackbird	WESJ	Western Scrub Jay
BUOR	Bullock's Oriole	SOSP	Song Sparrow
BUSH	Bush Tit	SPTO	Spotted Towhee
CAQU	California Quail	SWTH	Swainson's Thrush
CEDW	Cedar Waxwing	TRES	Tree Swallow
CHSP	Chipping Sparrow	TUVU	Turkey Vulture
CORA	Common Raven	VGSW	Violet-green Swallow
COYE	Common Yellowthroat	WBNU	White-breasted Nuthatch
DEJU	Dark-eyed Junco	WCSP	White-crowned Sparrow
EUST	European Starling	WEBL	Western Bluebird
HAWO	Hairy Woodpecker	WEKI	Western Kingbird
HOFI	House Finch	WETA	Western Tanager
HOSP	House Sparrow	WEWP	Weston Wood-pewee
HOWR	House Wren	WIWA	Wilson's Warbler
LAZB	Lazuli Bunting	YWAR	Yellow Warbler
LEGO	Lesser Goldfinch		

Table B3: Species detection matrix of birds using isolate white oak legacy trees in nine oak savanna reserve sites in the in the southern Willamette Valley, OR between 15 May and 30 June 2007.

	Site ID								
Species	1	6	7	8	16	19	20	21	22
AMGO	01010	00000	10000	00000	00000	00000	00000	00000	00000
AMRO	00000	00000	00000	00000	00001	10001	00000	00000	10010
BCCH	00001	00000	00000	00000	00000	00001	00000	00000	00001
BUOR	00000	00000	00000	00000	00011	00000	00000	00000	00100
CAQU	00000	00000	00000	00000	00000	00000	00000	00000	00010
CHSP	10000	00000	10000	00000	00000	00000	00000	00000	00000
COYT	00001	00111	01100	00000	00000	00000	00000	00000	01100
EUST	00000	00000	11100	01000	11011	00000	00000	00000	00100
HAWO	00000	00000	00000	00001	00000	00000	00000	00000	00000
HOWR	00001	10111	00000	10101	10101	00000	00000	00000	00000
LAZB	11001	10111	11111	00101	00001	00000	10010	11000	00000
LEGO	00000	00000	00000	00000	00000	00000	00010	00000	00111
RBNU	00001	00000	00000	00000	00000	00000	00000	00000	00000
SCJA	00000	00000	01010	00000	00000	00000	11110	01000	00000
SOSP	00000	00000	00000	00000	00000	00000	00000	00000	01111
SPTO	100000	00100	01001	00000	00000	00000	00000	11011	00000
WCSP	00000	00000	00000	00000	00000	00000	00000	00000	00000
WETA	00000	00000	00000	00000	00000	00000	00000	00000	00000
WEWP	00000	00000	00001	00000	00000	00000	00000	00000	00000
YEWA	00000	10000	10000	00000	00000	00000	00000	01000	00000

Table B4: Species detection matrix of birds using isolate white oak legacy trees in 13 pasture sites in the in the southern Willamette Valley, OR between 15 May and 30 June 2007.

	Site ID												
Species	1	2	3	4	5	9	15	18	23	26	28	29	35
ACWO	00000	10000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
AMCR	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
AMGO	01010	00000	10001	00000	00000	00000	00000	00001	00000	00000	00000	00000	10000
AMKE	00000	00100	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
AMRO	00000	00000	00100	00010	01000	11111	10010	10100	00000	00000	00000	00000	00001
BCCH	00001	00000	00010	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
BHCB	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
BHGR	00000	00000	00000	00000	00000	00000	00011	00100	00000	00000	00000	00000	00000
BRBL	00000	00000	00000	00000	00000	00101	00100	00000	00000	00000	00000	00000	00000
BUOR	00000	00000	00000	00000	00000	10000	00011	00000	00000	00000	00000	00000	00000
BUTI	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
CAQU	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
CEWA	00000	00000	00000	00000	00000	00000	00010	00000	00000	00000	00000	00000	00000
CHSP	10000	00000	00100	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
CORA	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
COYT	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
DEJU	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	01000	00000	00000
EUST	00000	00000	00000	10000	00011	00010	11111	00111	10010	00000	00000	00011	10000
HAWO	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
HOFI	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
HOSP	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
HOWR	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
LAZB	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
LEGO	00000	00000	01011	00000	00000	00000	00000	00000	00000	00000	00000	00010	00000

Continued

Table B4 (continued)

Species	Site ID 1	2	3	4	5	9	15	18	23	26	28	29	35
MODO	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00010	00000
OCWA	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
PUFI	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
RBNU	00001	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
RTHA	00000	00000	00000	00000	10010	00000	00000	00000	00100	01000	00000	00000	00000
RWBL	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
SASP	00000	00000	00000	00000	00000	00000	00011	00000	00000	00000	01001	00000	10001
SCJA	00000	00000	00000	00000	00000	00000	00000	00000	00000	01101	00000	00001	00000
SOSP	00000	00000	00000	00000	00000	00000	00000	00000	00000	01100	00000	00000	00000
SPTO	10000	00000	00000	00000	00000	00000	00000	00000	00000	01110	00000	00000	00000
SWTH	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
TRSW	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
TUVU	00000	00000	00000	00000	00000	00000	00000	00000	01000	00000	00100	00000	00000
VGSW	00000	00000	00000	00000	10011	00000	00000	00000	00000	00000	00000	00000	00000
WBNU	00000	00000	00000	00000	00000	00001	00000	00000	00000	00010	00000	00000	00001
WCSP	00000	00000	00000	00000	00000	00000	10100	00000	00000	00000	00000	00000	00000
WEBL	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
WEKI	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
WETA	00000	00000	00000	00010	00000	00000	00000	00000	00000	00000	00000	00000	00000
WEWP	00000	00000	00011	00111	00000	00010	00000	00000	00000	00000	00000	00000	00000
WIWA	00000	00000	00000	10000	00000	10000	00000	00000	00000	00000	00000	00000	00000
YEWA	00000	00000	00000	00000	00000	00000	00000	00000	00000	10000	00000	00000	00000
YRWA	00000	00000	01000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000

Table B5: Species detection matrix of birds using isolate white oak legacy trees in 13 crop sites in the in the southern Willamette Valley, OR between 15 May and 30 June 2007.

	Site ID												
Species	10	11	12	13	14	17	24	27	30	31	32	33	34
AMCR	00000	00000	00000	00000	00000	00000	00000	00000	00000	10000	01110	00001	00000
AMGO	01100	00000	10110	00000	00000	10000	10000	00000	01101	00000	11100	01000	00000
AMKE	00000	00000	00010	00101	00000	00000	00000	00000	00000	00000	00000	00000	00001
AMRO	01100	00010	00000	00000	00000	00000	01000	10100	11000	10100	00000	00000	00000
BCCH	00000	00000	01000	00000	00000	00000	00000	00000	00000	00011	00000	00000	00000
BHCB	00000	00000	00000	00000	00000	00000	10000	00000	00000	00000	00000	00000	00000
BHGR	01000	00000	00000	10000	00000	00000	00000	00000	00000	00001	00000	00000	00100
BRBL	00100	00000	00000	00000	00000	00000	00101	00000	00000	00000	00000	00000	00001
BUOR	00001	00000	00000	00000	00000	00000	00001	00000	00011	00010	00000	00000	00000
CAQU	00000	00000	00000	00000	00000	00000	00000	01000	00000	00000	00000	00000	00000
CEWA	00111	00000	00000	00000	00000	00100	00000	01100	00000	00000	00000	00000	00000
CHSP	00100	00000	00000	00000	00100	00000	00000	00000	01000	00001	00100	00000	00000
COYT	00000	00000	01100	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
DEJU	10000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
EUST	00000	00000	01000	00000	00000	00000	00010	00000	00100	00101	11011	11101	00000
HAWO	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00100	00000	00000
HOFI	10110	00000	00000	00000	00001	00000	00000	00010	00000	00001	00000	00000	01000
HOSP	00000	00010	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
LAZB	00000	00000	00000	00000	00000	00000	00000	00000	00000	00010	00011	00000	00000
LEGO	00000	00000	00000	00000	00000	00000	00000	00000	11010	00111	00000	00000	00000
MODO	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00100	00100	00000
NOFL	00001	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
RTHA	00000	00000	00000	00000	01000	00000	00000	00000	00000	00000	00000	00000	00010

Continued

Table B5 (continued)

	Site ID												
Species	10	11	12	13	14	17	24	27	30	31	32	33	34
RWBL	00000	00000	00000	01000	00000	00000	00000	11000	00000	00000	00000	00000	00000
SASP	00000	00000	00000	00000	00000	11110	11001	01110	00000	00000	00000	00000	00000
SCJA	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00110	00000
SOSP	00010	00000	00000	00000	00000	00000	00000	01100	00000	00000	00000	00000	00000
SPTO	00001	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
TRSW	00100	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
WBNU	00000	10000	00000	00000	00001	00000	00000	00000	00000	00001	00010	00000	01011
WCSP	10110	00000	00000	00000	00000	11011	00000	11111	00000	00001	11111	00000	00000
WEBL	00000	00000	00000	10000	00000	00000	00000	00000	00000	00000	00000	00000	00000
WETA	00000	00000	00000	00000	01111	00000	00000	00000	00000	00000	10000	00000	00000
WEWP	00000	00000	00001	00000	00000	00000	00011	00000	00000	00000	00000	00000	00100

APPENDIX C: Community level model selection results. We collected data on avian use of 35 isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Table C1: Model selection results for predicting total species richness on isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
FOR(800)	3	-17.13	41.04	0.00	0.25
SIZE + CAVI + FOR(800)	5	-14.83	41.72	0.68	0.18
SIZE + CAVI	4	-16.59	42.50	1.46	0.12
intercept	2	-19.31	43.00	1.96	0.09
DIST.T + FOR(800)	4	-17.06	43.46	2.42	0.08
DIST.T	3	-18.51	43.78	2.74	0.06
SIZE + CAVI + DIST.T + FOR(800)	6	-14.64	44.27	3.23	0.05
SIZE + CAVI + DIST.T	5	-16.55	45.17	4.13	0.03
TYPE	4	-18.04	45.42	4.38	0.03
FOR(800) + TYPE	5	-16.74	45.55	4.51	0.03
SIZE + CAVI + FOR(800) + TYPE	7	-13.72	45.58	4.54	0.03
SIZE + CAVI + TYPE	6	-15.38	45.75	4.71	0.02
DIST.T + TYPE	5	-17.81	47.68	6.64	0.01
FOR(800) + DIST.T + TYPE	6	-16.58	48.17	7.13	0.01
SIZE + CAVI + DIST.T + FOR(800) +TYPE	8	-13.57	48.67	7.63	0.01
SIZE + CAVI + DIST.T + TYPE	7	-15.34	48.82	7.78	0.01
SIZE + CAVI + DIST.T + FOR(800) + TYPE + DENS*TYPE	10	-12.32	53.80	12.76	0.00

Table C2: Model selection results for predicting species richness of oak savanna associates on isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
SIZE + Oak(1400)	4	-15.29	39.91	0.00	0.21
SIZE	3	-16.59	39.95	0.03	0.21
OAK(1400)	3	-16.74	40.24	0.33	0.18
intercept	2	-18.56	41.49	1.57	0.10
SIZE + DIST.T	4	-16.58	42.49	2.58	0.06
SIZE + DIST.T + OAK(1400)	5	-15.25	42.56	2.65	0.06
DIST.T + OAK(1400)	4	-16.69	42.71	2.79	0.05
DIST.T	3	-18.20	43.18	3.27	0.04
SIZE + TYPE	5	-16.03	44.13	4.22	0.03
TYPE	4	-17.84	45.02	5.10	0.02
SIZE + OAK(1400) + TYPE	6	-15.05	45.09	5.18	0.02
OAK(1400) + TYPE	5	-16.73	45.53	5.61	0.01
SIZE + DIST.T + TYPE	6	-16.00	47.01	7.09	0.01
DIST.T + TYPE	5	-17.79	47.65	7.74	0.00
SIZE + DIST.T + OAK(1400) + TYPE	7	-15.01	48.17	8.26	0.00
DIST.T + OAK(1400) + TYPE	6	-16.68	48.36	8.45	0.00

Table C3: Model selection results for predicting tree foraging species richness on isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
SIZE	3	-16.99	40.75	0.00	0.33
SIZE + OAK(150)	4	-16.32	41.97	1.22	0.18
intercept	2	-19.23	42.83	2.08	0.12
SIZE + DIST.T	4	-16.98	43.30	2.55	0.09
SIZE + DIST.T + OAK(150)	5	-16.22	44.51	3.76	0.05
DIST.T	3	-18.98	44.74	3.99	0.05
OAK(150)	3	-19.00	44.76	4.02	0.04
SIZE + TYPE	5	-16.54	45.16	4.41	0.04
SIZE + OAK(150) + TYPE	6	-15.32	45.64	4.89	0.03
DIST.T + OAK(150)	4	-18.34	46.02	5.27	0.02
TYPE	4	-19.11	47.54	6.79	0.01
SIZE + DIST.T + TYPE	6	-16.54	48.08	7.33	0.01
OAK(150) + TYPE	5	-18.09	48.24	7.49	0.01
SIZE + DIST.T + OAK(150) +TYPE	7	-15.29	48.74	7.99	0.01
DIST.T + TYPE	5	-18.95	49.97	9.22	0.00
DIST.T + OAK(150) + TYPE	6	-17.72	50.45	9.70	0.00

Table C4: Model selection results for predicting non-tree foraging species richness on isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
FOR(150)	3	-12.34	31.46	0.00	0.49
CAVI + OAK(150)	4	-12.26	33.86	2.40	0.15
DIST.T + OAK(150)	4	-12.34	34.02	2.56	0.14
intercept	2	-15.88	36.13	4.67	0.05
OAK(150) + TYPE	5	-12.14	36.35	4.89	0.04
CAVI + DIST.T + OAK(150)	5	-12.26	36.59	5.13	0.04
DIST.T	3	-15.29	37.35	5.88	0.03
CAVI	3	-15.46	37.69	6.23	0.02
TYPE	4	-14.70	38.73	7.27	0.01
CAVI + OAK(150) + TYPE	6	-11.93	38.86	7.39	0.01
DIST.T + OAK(150) + TYPE	6	-12.14	39.28	7.81	0.01
CAVI + DIST.T	4	-15.01	39.35	7.89	0.01
CAVI + TYPE	5	-14.51	41.08	9.62	0.00
DIST.T + TYPE	5	-14.58	41.23	9.77	0.00
CAVI + DIST.T + OAK(150) +TYPE	7	-11.92	41.99	10.53	0.00
CAVI + DIST.T + TYPE	6	-14.42	43.84	12.38	0.00

APPENDIX D: Species-specific model selection results.

Table D1: Model selection results for predicting American Goldfinch use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
FOR 1400	5	-20.32	47.41	0.00	0.41
CAVI + FOR 1400	5	-20.13	49.59	2.18	0.14
DIST.T + FOR 1400	4	-20.22	49.78	2.37	0.13
intercept	7	-23.25	50.87	3.45	0.07
DIST.T	6	-22.38	51.53	4.12	0.05
CAVI + DIST.T + FOR 1400	4	-19.96	51.99	4.57	0.04
FOR 1400 + TYPE	5	-20.25	52.57	5.16	0.03
CAVI	6	-22.95	52.67	5.26	0.03
TYPE	6	-21.71	52.76	5.35	0.03
CAVI + DIST.T	5	-21.99	53.32	5.91	0.02
CAVI + TYPE	3	-21.19	54.45	7.04	0.01
DIST.T + FOR 1400 + TYPE	3	-20.07	55.14	7.73	0.01
CAVI + FOR 1400 + TYPE	2	-20.11	55.22	7.81	0.01
DIST.T + TYPE	4	-21.59	55.26	7.85	0.01
CAVI + DIST.T + TYPE	4	-21.00	57.00	9.58	0.00
CAVI + DIST.T + FOR 1400 + TYPE	**3**	-19.89	57.92	10.51	0.00

Table D2: Relative factor importance for predicting American Goldfinch use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.26
Distance	0.26
Density	0.77
Matrix	0.10

Table D3: Model selection results for predicting American Robin use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
DIST.P	**3**	-18.91	44.60	0.00	0.67
FOR700	3	-20.84	48.45	3.85	0.10
SIZE + FOR700	4	-20.82	50.97	6.37	0.03
FOR700 + TYPE	5	-19.81	51.70	7.10	0.02
intercept	2	-22.17	48.72	4.12	0.09
DIST.P + FOR700	4	-21.09	51.50	6.91	0.02
SIZE + DIST.P + FOR700	5	-19.69	51.45	6.86	0.02
SIZE + FOR700 + TYPE	6	-17.99	50.98	6.38	0.03
SIZE	3	-22.68	52.14	7.54	0.02
DIST.P + FOR700 + TYPE	6	-19.83	54.65	10.06	0.00
TYPE	4	-21.25	51.83	7.23	0.02
SIZE + DIST.P	4	-21.73	52.78	8.18	0.01
SIZE + TYPE	5	-21.61	55.29	10.69	0.00
SIZE + DIST.P + FOR700 + TYPE	7	-19.35	56.84	12.24	0.00
DIST.P + TYPE	5	-22.34	56.75	12.15	0.00
SIZE + DIST.P + TYPE	6	-20.72	56.45	11.85	0.00

Table D4: Relative factor importance for predicting American Robin use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.11
Distance	0.74
Density	0.26
Matrix	0.10

Table D5: Model selection results for predicting Black-capped Chickadee use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
DIST.T	3	-12.36	31.49	0.00	0.29
DIST.T + OAK500 + TYPE	6	-8.71	32.42	0.93	0.18
DIST.T + OAK500	4	-11.95	33.23	1.74	0.12
COMP + DIST.T	4	-12.10	33.53	2.04	0.10
OAK500	3	-13.55	33.88	2.39	0.09
COMP + DIST.T + OAK500 +TYPE	7	-8.37	34.88	3.39	0.05
COMP + DIST.T + OAK500	5	-11.56	35.18	3.69	0.05
COMP + OAK500	4	-13.06	35.46	3.97	0.04
DIST.T + TYPE	5	-11.87	35.80	4.31	0.03
OAK500 +TYPE	5	-12.53	37.14	5.65	0.02
intercept	2	-16.51	37.40	5.91	0.01
COMP + DIST.T + TYPE	6	-11.69	38.39	6.90	0.01
COMP + OAK 500 + TYPE	6	-11.92	38.84	7.35	0.01
COMP	3	-16.15	39.07	7.58	0.01
TYPE	4	-15.89	41.12	9.63	0.00
COMP +TYPE	5	-15.52	43.11	11.62	0.00

Table D6: Relative factor importance for predicting Black-capped Chickadee use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.26
Distance	0.83
Density	0.55
Matrix	0.30

Table D7: Model selection results for predicting Black-headed Grosbeak use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
SIZE + FOR100	4	-8.09	25.52	0.00	0.65
SIZE + DIST.T + FOR100	5	-8.05	28.16	2.64	0.17
SIZE + FOR100 + TYPE	6	-7.19	29.37	3.86	0.09
SIZE + DIST.T + FOR100 + TYPE	7	-7.03	32.20	6.69	0.02
FOR100	3	-12.76	32.30	6.78	0.02
DIST.T + FOR100	4	-12.16	33.65	8.13	0.01
DIST.T	3	-14.22	35.22	9.70	0.01
SIZE	3	-14.53	35.84	10.32	0.00
SIZE + DIST.T	4	-13.36	36.06	10.54	0.00
FOR100 + TYPE	5	-12.32	36.71	11.19	0.00
intercept	2	-16.51	37.40	11.89	0.00
TYPE	4	-14.05	37.43	11.91	0.00
SIZE + TYPE	5	-12.74	37.56	12.04	0.00
DIST.T + TYPE	5	-13.04	38.15	12.64	0.00
DIST.T + FOR100 + TYPE	6	-11.86	38.72	13.20	0.00
SIZE + DIST.T + TYPE	6	-12.27	39.55	14.03	0.00

Table D8: Relative factor importance for predicting Black-headed Grosbeak use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.95
Distance	0.22
Density	0.98
Matrix	0.13

Table D9: Model selection results for predicting Brewer's Blackbird use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(L)	AICc	Δ AICc	ω_i
DIST.P	3	-12.64	32.05	0.00	0.32
DIST.P + FOR450	4	-12.05	33.43	1.39	0.16
FOR450	3	-13.72	34.21	2.16	0.11
CAVI + DIST.P	4	-12.45	34.24	2.19	0.11
DIST.P + TYPE	5	-11.35	34.78	2.73	0.08
CAVI + FOR450	4	-13.13	35.59	3.54	0.05
CAVI + DIST.P + FOR450	5	-11.78	35.63	3.58	0.05
intercept	2	-16.51	37.40	5.36	0.02
TYPE	4	-14.05	37.43	5.38	0.02
DIST.P + FOR450 + TYPE	6	-11.30	37.61	5.56	0.02
CAVI + DIST.P + TYPE	6	-11.32	37.63	5.59	0.02
FOR450 + TYPE	5	-13.32	38.71	6.66	0.01
CAVI	3	-16.14	39.04	7.00	0.01
CAVI + TYPE	5	-13.82	39.70	7.66	0.01
CAVI + DIST.P + FOR450 + TYPE	7	-11.22	40.58	8.53	0.00
CAVI + FOR450 + TYPE	6	-12.80	40.61	8.56	0.00

Table D10: Relative factor importance for predicting Brewer's Blackbird use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.26
Distance	0.76
Density	0.41
Matrix	0.17

Table D11: Model selection results for predicting Bullock's Oriole use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
intercept	2	-19.94	44.25	0.00	0.21
FOR150	3	-18.85	44.48	0.23	0.19
DIST.P	3	-19.06	44.90	0.65	0.15
CAVI	3	-19.26	45.30	1.05	0.12
DIST.P + FOR150	4	-18.49	46.31	2.05	0.08
CAVI + DIST.P	4	-18.50	46.33	2.07	0.07
CAVI + FOR150	4	-18.52	46.38	2.12	0.07
CAVI + DIST.P + FOR150	5	-18.15	48.37	4.11	0.03
TYPE	4	-19.82	48.96	4.71	0.02
FOR150 + TYPE	5	-18.69	49.45	5.20	0.02
DIST.P + TYPE	5	-19.04	50.15	5.89	0.01
CAVI + TYPE	5	-19.15	50.37	6.12	0.01
DIST.P + FOR150 + TYPE	6	-18.09	51.18	6.92	0.01
CAVI + FOR150 + TYPE	6	-18.45	51.91	7.65	0.00
CAVI + DIST.P + TYPE	6	-18.49	51.97	7.72	0.00
CAVI + DIST.P + FOR150 + TYPE	7	-17.92	53.99	9.74	0.00

Table D12: Relative factor importance for predicting Bullock's Oriole use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.32
Distance	0.35
Density	0.39
Matrix	0.07

Table D13: Model selection results for predicting Cedar Waxwing use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
FOR750	**3**	-5.04	16.85	0.00	0.66
DIST.P + FOR750	4	-4.93	19.19	2.34	0.21
SIZE + CAVI + FOR750	5	-4.90	21.87	5.02	0.05
FOR750 + TYPE	5	-5.01	22.09	5.23	0.05
SIZE + CAVI + DIST.P + FOR750	6	-4.74	24.49	7.64	0.01
DIST.P + FOR750 + TYPE	6	-4.89	24.78	7.93	0.01
SIZE + CAVI + FOR750 + TYPE	7	-4.87	27.88	11.03	0.00
DIST.P	3	-11.72	30.21	13.36	0.00
SIZE + CAVI + DIST.P + FOR750 + TYPE	8	-4.69	30.92	14.07	0.00
intercept	2	-13.35	31.08	14.23	0.00
SIZE + CAVI	4	-11.49	32.32	15.47	0.00
TYPE	4	-11.60	32.54	15.69	0.00
DIST.P + TYPE	5	-10.85	33.77	16.92	0.00
SIZE + CAVI + DIST.P	5	-11.49	35.05	18.20	0.00
SIZE + CAVI + TYPE	6	-11.06	37.11	20.26	0.00
SIZE + CAVI + DIST.P + TYPE	7	-9.94	38.02	21.17	0.00

Table D14: Relative factor importance for predicting Cedar Waxwing use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.07
Distance	0.23
Density	1.00
Matrix	0.06

Table D15: Model selection results for predicting Chipping Sparrow use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
SIZE + DIST.P + OAK1600	4	-12.57	37.20	0.00	0.52
SIZE + OAK1600	3	-15.39	40.11	2.91	0.12
SIZE	6	-16.73	40.24	3.04	0.11
SIZE + DIST.P	4	-15.81	40.94	3.75	0.08
SIZE + DIST.P + OAK1600 + TYPE	5	-11.83	41.81	4.61	0.05
DIST.P + OAK1600	2	-16.71	42.76	5.56	0.03
OAK1600	5	-18.25	43.27	6.07	0.02
SIZE + OAK1600 + TYPE	4	-14.57	44.14	6.94	0.02
intercept	5	-19.94	44.25	7.05	0.02
SIZE + TYPE	6	-16.73	45.53	8.33	0.01
DIST.P + OAK1600 + TYPE	7	-15.53	46.06	8.86	0.01
SIZE + DIST.P + TYPE	3	-15.56	46.11	8.91	0.01
DIST.P	3	-19.73	46.24	9.04	0.01
OAK1600 + TYPE	6	-17.55	47.17	9.97	0.00
TYPE	4	-19.45	48.24	11.04	0.00
DIST.P + TYPE	5	-18.77	49.61	12.41	0.00

Table D16: Relative factor importance for predicting Chipping Sparrow use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.91
Distance	0.70
Density	0.77
Matrix	0.09

Table D17: Model selection results for predicting Common Yellowthroat use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
COMP + OAK500	4	-10.61	30.56	0.00	0.50
COMP + DIST.P + OAK500	5	-10.51	33.09	2.53	0.14
COMP + TYPE	5	-11.08	34.22	3.66	0.08
OAK500	3	-13.96	34.70	4.14	0.06
COMP	3	-14.10	34.97	4.41	0.06
COMP + OAK500 + TYPE	6	-10.29	35.59	5.03	0.04
COMP + DIST.P	4	-13.63	36.59	6.03	0.02
COMP + DIST.P + TYPE	6	-11.03	37.06	6.50	0.02
DIST.P + OAK500	4	-13.96	37.25	6.69	0.02
intercept	2	-16.51	37.40	6.84	0.02
TYPE	4	-14.29	37.91	7.35	0.01
DIST.P	3	-15.67	38.11	7.55	0.01
COMP + DIST.P + OAK500 + TYPE	7	-10.10	38.35	7.79	0.01
OAK500 + TYPE	5	-13.71	39.49	8.93	0.01
DIST.P + TYPE	5	-14.28	40.62	10.07	0.00
DIST.P + OAK500 + TYPE	6	-13.71	42.41	11.86	0.00

Table D18: Relative factor importance for predicting Common Yellowthroat use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.87
Distance	0.23
Density	0.78
Matrix	0.17

Table D19: Model selection results for predicting European Starling use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
OAK1600	3	-20.50	47.77	0.00	0.26
SIZE + OAK1600	4	-19.94	49.22	1.46	0.12
DIST.P + OAK1600	4	-20.29	49.92	2.16	0.09
OAK1600 + TYPE	5	-18.95	49.98	2.21	0.09
DIST.P	3	-21.64	50.05	2.29	0.08
intercept	2	-22.90	50.18	2.41	0.08
SIZE + DIST.P + OAK1600	5	-19.58	51.23	3.47	0.05
DIST.P + TYPE	5	-19.67	51.40	3.64	0.04
DIST.P + OAK1600 + TYPE	6	-18.23	51.46	3.70	0.04
SIZE + DIST.P	4	-21.11	51.56	3.80	0.04
TYPE	4	-21.18	51.69	3.92	0.04
SIZE	3	-22.71	52.19	4.42	0.03
SIZE + OAK1600 + TYPE	6	-18.86	52.73	4.96	0.02
SIZE + DIST.P + TYPE	6	-19.57	54.14	6.37	0.01
SIZE + TYPE	5	-21.13	54.32	6.56	0.01
SIZE + DIST.P + OAK1600 + TYPE	7	-18.10	54.34	6.58	0.01

Table D20: Relative factor importance for predicting European Starling use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.29
Distance	0.36
Density	0.67
Matrix	0.26

Table D21: Model selection results for predicting House Finch use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
SIZE + OAK400	4	-11.75	32.84	0.00	0.27
OAK400	3	-13.27	33.32	0.47	0.21
SIZE	3	-14.20	35.18	2.33	0.08
DIST.T + OAK400	4	-13.10	35.54	2.70	0.07
SIZE + DIST.T + OAK400	5	-11.75	35.58	2.74	0.07
TYPE	4	-13.24	35.82	2.98	0.06
SIZE + TYPE	5	-12.18	36.43	3.59	0.04
OAK400 + TYPE	5	-12.28	36.63	3.79	0.04
SIZE + DIST.T	4	-13.97	37.28	4.44	0.03
intercept	2	-16.51	37.40	4.56	0.03
SIZE + OAK400 + TYPE	6	-11.28	37.57	4.73	0.03
DIST.T	3	-15.44	37.65	4.81	0.02
DIST.T + TYPE	5	-13.08	38.22	5.38	0.02
SIZE + DIST.T + TYPE	6	-12.18	39.36	6.51	0.01
DIST.T + OAK400 + TYPE	6	-12.18	39.36	6.52	0.01
SIZE + DIST.T + OAK400 + TYPE	7	-11.28	40.72	7.87	0.01

Table D22: Relative factor importance for predicting House Finch use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.54
Distance	0.24
Density	0.70
Matrix	0.22

Table D23: Model selection results for predicting House Wren use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
FOR100	3	-6.40	19.58	0.00	0.52
CAVI + FOR100	4	-6.35	22.03	2.45	0.15
DIST.P + FOR100	4	-6.40	22.14	2.56	0.14
FOR100 + TYPE	5	-5.85	23.78	4.19	0.06
CAVI + DIST.P + FOR100	5	-6.35	24.77	5.18	0.04
CAVI + FOR100 + TYPE	6	-5.75	26.49	6.91	0.02
DIST.P + FOR100 + TYPE	6	-5.85	26.70	7.11	0.01
TYPE	4	-8.71	26.75	7.17	0.01
CAVI + TYPE	5	-7.84	27.76	8.18	0.01
CAVI + DIST.P	4	-9.26	27.85	8.27	0.01
DIST.P	3	-10.61	27.99	8.40	0.01
DIST.P + TYPE	5	-8.66	29.38	9.80	0.00
CAVI + DIST.P + FOR100 + TYPE	7	-5.74	29.64	10.06	0.00
CAVI	3	-11.67	30.12	10.54	0.00
CAVI + DIST.P + TYPE	6	-7.78	30.55	10.97	0.00
intercept	2	-13.35	31.08	11.50	0.00

Table D24: Relative factor importance for predicting House Wren use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.23
Distance	0.22
Density	0.95
Matrix	0.13

Table D25: Model selection results for predicting Lazuli Bunting use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
TYPE	4	-14.93	39.19	0.00	0.23
DIST.T	3	-16.76	40.29	1.10	0.13
OAK50	3	-16.89	40.55	1.35	0.12
DIST.T + TYPE	5	-14.37	40.81	1.62	0.10
DIST.T + OAK50	4	-15.80	40.92	1.73	0.10
OAK50 +TYPE	5	-14.71	41.50	2.30	0.07
SIZE + TYPE	5	-14.82	41.71	2.52	0.07
SIZE + DIST.T	4	-16.75	42.83	3.63	0.04
SITE + OAK50	4	-16.82	42.97	3.78	0.03
DIST.T + OAK50 + TYPE	6	-14.30	43.60	4.41	0.03
SIZE + DIST.T + OAK50	5	-15.80	43.66	4.47	0.02
SIZE + DIST.T + TYPE	6	-14.36	43.72	4.53	0.02
SIZE + OAK50 + TYPE	6	-14.65	44.31	5.11	0.02
intercept	2	-20.79	45.95	6.76	0.01
SIZE + DIST.T + OAK50 + TYPE	7	-14.30	46.74	7.55	0.01
SIZE	3	-20.14	47.06	7.87	0.00

Table D26: Relative factor importance for predicting Lazuli Bunting use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.21
Distance	0.45
Density	0.39
Matrix	0.54

Table D27: Model selection results for predicting Lesser Goldfinch use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
DIST.P + FOR50	4	-12.86	35.04	0.00	0.30
FOR50	3	-14.45	35.68	0.63	0.22
intercept	2	-16.51	37.40	2.36	0.09
COMP + DIST.P + FOR50	5	-12.86	37.78	2.74	0.08
COMP + DIST.P	4	-14.31	37.96	2.91	0.07
DIST.P + TYPE	5	-13.06	38.20	3.15	0.06
DIST.P	3	-16.00	38.78	3.73	0.05
DIST.P + FOR50 + TYPE	6	-12.20	39.40	4.35	0.03
COMP	3	-16.36	39.50	4.46	0.03
COMP + FOR50 + TYPE	6	-13.01	41.02	5.97	0.02
COMP + DIST.P	4	-15.94	41.22	6.17	0.01
TYPE	4	-16.37	42.08	7.03	0.01
COMP + DIST.P + FOR50 + TYPE	7	-12.20	42.55	7.50	0.01
DIST.P + TYPE	5	-15.88	43.83	8.79	0.00
COMP + TYPE	5	-16.25	44.57	9.53	0.00
COMP + DIST.P + TYPE	6	-15.84	46.68	11.63	0.00

Table D28: Relative factor importance for predicting Lesser Goldfinch use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.22
Distance	0.49
Density	0.80
Matrix	0.14

Table D29: Model selection results for predicting Red-tailed Hawk use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
SIZE	3	-10.27	27.32	0.00	0.23
SIZE + TYPE	5	-7.86	27.79	0.47	0.19
SIZE + FOR150	4	-9.44	28.22	0.90	0.15
SIZE + DIST.T	4	-10.09	29.51	2.20	0.08
SIZE + FOR150 + TYPE	6	-7.35	29.69	2.38	0.07
FOR150	3	-11.72	30.21	2.89	0.06
SIZE + DIST.T + TYPE	6	-7.84	30.68	3.36	0.04
SIZE + DIST.T + FOR150	5	-9.42	30.91	3.59	0.04
intercept	2	-13.35	31.08	3.77	0.04
DIST.T	3	-12.20	31.17	3.86	0.03
DIST.T + FOR150	4	-11.31	31.95	4.64	0.02
TYPE	4	-11.60	32.54	5.23	0.02
SIZE + DIST.T + FOR150 + TYPE	7	-7.35	32.84	5.52	0.01
FOR150 + TYPE	5	-10.81	33.69	6.37	0.01
DIST.T + TYPE	5	-11.04	34.15	6.83	0.01
DIST.T + FOR150 + TYPE	6	-10.50	36.00	8.68	0.00

Table D30: Relative factor importance for predicting Red-tailed Hawk use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.81
Distance	0.24
Density	0.36
Matrix	0.35

Table D31: Model selection results for predicting Savannah Sparrow use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
SIZE + DIST.P + FOR150	5	-3.24	18.55	0.00	0.56
SIZE + DIST.P	4	-5.35	20.04	1.48	0.27
SIZE + FOR150	4	-6.34	22.01	3.46	0.10
SIZE + DIST.P + TYPE	6	-4.49	23.97	5.42	0.04
SIZE + DIST.P + FOR150 + TYPE	7	-3.13	24.41	5.85	0.03
SIZE + FOR150 + TYPE	6	-6.16	27.32	8.77	0.01
DIST.P + FOR150	4	-10.55	30.43	11.87	0.00
DIST.P	3	-12.15	31.07	12.51	0.00
FOR150	3	-12.24	31.24	12.69	0.00
SIZE + TYPE	5	-10.71	33.49	14.93	0.00
DIST.P + TYPE	5	-10.87	33.82	15.26	0.00
DIST.P + FOR150 + TYPE	6	-9.51	34.02	15.46	0.00
FOR150 + TYP[E	5	-11.19	34.45	15.90	0.00
SIZE	3	-14.40	35.57	17.02	0.00
intercept	2	-16.51	37.40	18.85	0.00
TYPE	4	-14.05	37.43	18.87	0.00

Table D32: Relative factor importance for predicting Savanna Sparrow use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	1.00
Distance	0.89
Density	0.70
Matrix	0.08

Table D33: Model selection results for predicting Song Sparrow use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
COMP + FOR100	4	-9.51	28.35	0.00	0.25
FOR100	3	-10.79	28.36	0.01	0.25
FOR100 + TYPE	5	-9.22	30.51	2.16	0.09
COMP + FOR100 + TYPE	6	-7.90	30.80	2.45	0.07
DIST.T + FOR100	4	-10.76	30.86	2.52	0.07
COMP + DIST.T + FOR100	5	-9.46	30.99	2.64	0.07
intercept	2	-13.35	31.08	2.74	0.06
COMP	3	-12.53	31.84	3.49	0.04
DIST.T	3	-13.08	32.93	4.58	0.03
DIST.T + FOR100 + TYPE	6	-9.21	33.42	5.07	0.02
COMP + DIST.T	4	-12.21	33.75	5.40	0.02
COMP + DIST.T + FOR100 + TYPE	7	-7.90	33.94	5.60	0.02
TYPE	4	-13.30	35.94	7.59	0.01
COMP + TYPE	5	-12.48	37.03	8.69	0.00
DIST.T + TYPE	5	-13.07	38.21	9.87	0.00
COMP + DIST.T + TYPE	6	-12.21	39.41	11.07	0.00

Table D34: Relative factor importance for predicting Song Sparrow use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.47
Distance	0.22
Density	0.84
Matrix	0.21

Table D35: Model selection results for predicting Spotted Towhee use of white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
DIST.P	3	-12.75	32.27	0.00	0.23
OAK800	3	-12.90	32.58	0.32	0.19
TYPE	4	-12.23	33.80	1.53	0.10
DIST.P + OAK800	4	-12.26	33.84	1.58	0.10
intercept	2	-15.04	34.45	2.18	0.08
COMP + DIST.P	4	-12.74	34.82	2.55	0.06
COMP + OAK800	4	-12.83	34.99	2.72	0.06
DIST + TYPE	5	-11.85	35.77	3.50	0.04
COMP + TYPE	5	-12.09	36.25	3.99	0.03
OAK800 + TYPE	5	-12.19	36.44	4.18	0.03
COMP	3	-14.89	36.55	4.28	0.03
COMP + DIST.P + OAK800	5	-12.25	36.56	4.30	0.03
COMP + DIST.P + TYPE	6	-11.79	38.58	6.32	0.01
DIST.P + OAK800 + TYPE	6	-11.84	38.68	6.42	0.01
COMP + OAK800 + TYPE	6	-12.06	39.13	6.86	0.01
COMP + DIST.P + OAK800 + TYPE	7	-11.79	41.72	9.45	0.00

Table D36: Relative factor importance for predicting Spotted Towhee use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.22
Distance	0.48
Density	0.43
Matrix	0.23

Table D37: Model selection results for predicting Western Scrub Jay use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
CAVI + FOR800	4	-7.20	23.74	0.00	0.57
CAVI + DIST.T + FOR800	5	-7.20	26.47	2.73	0.15
CAVI	3	-10.04	26.85	3.11	0.12
CAVI + DIST.T	4	-9.30	27.93	4.19	0.07
CAVI + FOR800 + TYPE	6	-7.31	29.62	5.88	0.03
CAVI + TYPE	5	-9.06	30.18	6.44	0.02
CAVI + DIST.T + FOR800 + TYPE	7	-6.47	31.08	7.34	0.01
FOR800	3	-12.66	32.10	8.36	0.01
CAVI + DIST.T + TYPE	6	-8.87	32.73	8.99	0.01
intercept	2	-15.04	34.45	10.71	0.00
DIST.T + FOR800	4	-12.66	34.66	10.92	0.00
DIST.T	3	-14.36	35.48	11.75	0.00
FOR800 + TYPE	5	-11.83	35.74	12.00	0.00
TYPE	4	-13.84	37.00	13.26	0.00
DIST.T + TYPE	5	-13.76	39.59	15.85	0.00
DIST.T + FOR800 + TYPE	6	-13.38	41.76	18.02	0.00

Table D38: Relative factor importance for predicting Western Scrub Jay use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.98
Distance	0.24
Density	0.77
Matrix	0.08

Table D39: Model selection results for predicting Western Tanager use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
SIZE	3	-10.81	28.39	0.00	0.34
SIZE + OAK3000	4	-9.73	28.79	0.40	0.28
intercept	2	-13.35	31.08	2.69	0.09
SIZE + DIST.T + OAK3000	5	-9.72	31.51	3.12	0.07
OAK3000	3	-12.87	32.51	4.12	0.04
SIZE + TYPE	5	-10.26	32.59	4.20	0.04
DIST.T	3	-13.15	33.08	4.69	0.03
SIZE + OAK3000 + TYPE	6	-9.22	33.44	5.05	0.03
DIST.T + OAK3000	4	-12.38	34.10	5.71	0.02
SIZE + DIST.T	4	-12.74	34.82	6.43	0.01
SIZE + DIST.T + TYPE	6	-10.23	35.46	7.07	0.01
TYPE	4	-13.30	35.94	7.55	0.01
SIZE + DIST.T + OAK3000 + TYPE	7	-9.14	36.43	8.04	0.01
OAK3000 + TYPE	5	-12.30	36.68	8.29	0.01
DIST.T + TYPE	5	-13.15	38.37	9.97	0.00
DIST.T + OAK3000 + TYPE	6	-12.12	39.25	10.86	0.00

Table 40: Relative factor importance for predicting Western Tanager use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.80
Distance	0.16
Density	0.46
Matrix	0.10

Table D41: Model selection results for predicting Western Wood-pewee use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
CAVI + OAK5000	4	-15.47	40.27	0.00	0.24
OAK5000	3	-16.84	40.45	0.18	0.22
CAVI	3	-17.04	40.85	0.57	0.18
intercept	2	-18.95	42.28	2.00	0.09
CAVI + DIST.P + OAK5000	5	-15.45	42.98	2.70	0.06
CAVI + DIST.P	4	-16.88	43.09	2.82	0.06
OAK5000 + TYPE	5	-16.03	44.12	3.85	0.04
CAVI + OAK5000 + TYPE	6	-14.73	44.47	4.19	0.03
DIST.P	3	-18.91	44.60	4.33	0.03
CAVI + TYPE	5	-16.95	45.97	5.70	0.01
DIST.P + OAK5000	4	-18.49	46.31	6.03	0.01
TYPE	4	-18.77	46.88	6.61	0.01
DIST.P + OAK5000 + TYPE	6	-16.03	47.06	6.78	0.01
CAVI + DIST.P + OAK5000 + TYPE	7	-14.67	47.49	7.21	0.01
CAVI + DIST.P + TYPE	6	-16.63	48.25	7.98	0.00
DIST.P + TYPE	5	-18.57	49.21	8.93	0.00

Table D42: Relative factor importance for predicting Western Wood-pewee use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.60
Distance	0.18
Density	0.61
Matrix	0.11

Table D43: Model selection results for predicting White-breasted Nuthatch use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
SIZE + COMP	4	-14.67	38.68	0.00	0.17
TYPE	4	-14.68	38.70	0.02	0.17
SIZE + COMP + TYPE	6	-12.33	39.66	0.98	0.11
intercept	2	-17.81	40.00	1.32	0.09
SIZE + COMP + FOR1000	5	-14.01	40.09	1.41	0.09
FOR1000 + TYPE	5	-14.32	40.71	2.03	0.06
SIZE + COMP + FOR1000 +TYPE	7	-11.62	41.38	2.70	0.05
SIZE + COMP + DIST.T	5	-14.67	41.42	2.74	0.04
DIST.T + TYPE	5	-14.68	41.43	2.75	0.04
DIST.T + TYPE	3	-17.41	41.59	2.91	0.04
SIZE + COMP + DIST.T + TYPE	7	-11.95	42.05	3.37	0.03
FOR1000	3	-17.76	42.29	3.61	0.03
DIST.T + FOR1000	4	-16.65	42.63	3.95	0.02
SIZE + COMP + DIST.T + FOR1000	6	-13.88	42.76	4.08	0.02
DIST.T + FOR1000 + TYPE	6	-14.32	43.64	4.96	0.01
SIZE + COMP + DIST.T + FOR1000 + TYPE	8	-11.19	43.91	5.23	0.01

Table D44: Relative factor importance for predicting White-breasted Nuthatch use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.52
Distance	0.24
Density	0.30
Matrix	0.49

Table D45: Model selection results for predicting White-crowned Sparrow use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Model	K	ln(*L*)	AICc	Δ AICc	ω_i
FOR150	3	-13.83	34.44	0.00	0.34
SIZE + FOR150	4	-12.68	34.69	0.25	0.30
DIST.P + FOR150	4	-13.76	36.86	2.42	0.10
SIZE + DIST.P + FOR150	5	-12.64	37.35	2.91	0.08
SIZE + FOR150 + TYPE	6	-11.62	38.24	3.79	0.05
FOR150 + TYPE	5	-13.22	38.51	4.07	0.04
intercept	2	-17.81	40.00	5.56	0.02
SIZE + DIST.P + FOR150 + TYPE	7	-11.59	41.33	6.89	0.01
DIST.P + FOR150 + TYPE	6	-13.19	41.38	6.94	0.01
DIST.P	3	-17.42	41.60	7.16	0.01
SIZE	3	-17.51	41.79	7.35	0.01
TYPE	4	-16.38	42.10	7.65	0.01
SIZE + TYPE	5	-15.20	42.47	8.03	0.01
SIZE + DIST.P	4	-16.95	43.23	8.79	0.00
DIST.P + TYPE	5	-16.33	44.73	10.29	0.00
SIZE + DIST.T + TYPE	6	-15.11	45.23	10.78	0.00

Table D46: Relative factor importance for predicting White-crowned Sparrow use of isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Hypothesis	Weight
Tree	0.46
Distance	0.22
Density	0.94
Matrix	0.13

APPENDIX E: Explanatory variable data collected from 35 isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Table E1: Distance (m) of study trees to the nearest tree and patch (≥ 5 contiguous trees). We collected data from 35 isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Site ID	Distance_Tree	Distance_Patch
1	34.16	34.16
2	76.61	76.61
3	39.54	105.12
4	156.81	156.81
5	55.67	119.77
6	43.40	43.4
7	59.15	68.13
8	27.68	79.71
9	75.30	133
10	111.71	175.51
11	55.48	55.48
12	90.75	118.18
13	92.39	92.39
14	87.58	162.71
15	148.43	555
16	33.24	33.24
17	71.02	287.91
18	107.34	107.34
19	21.25	21.25
20	94.74	94.74
21	32.08	32.08
22	68.16	82.86
23	128.37	207.59
24	85.24	504.75
25	155.64	274.66
26	104.54	104.54
27	113.01	113.01
28	133.16	133.16
29	47.82	47.82
30	251.50	251.5
31	53.53	53.53
32	118.00	189.25
33	85.30	404.79
34	278.88	278.88
35	96.01	141.84

Table E2: Tree characteristics data collected from 35 isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Site ID	Height (m)	Basal Area (m^2)	Canopy Volume (m^3)	Size Index	Deadlimbs	Mistletoe	Lichen	Complexity Index	Cavities
1	15.29	0.72	4516.35	497.68	8	9	2	6	0
2	19.97	0.99	2323.97	461.32	11	10	1	5	16
3	19.71	0.85	4271.10	715.13	1	14	2	5	1
4	21.14	1.85	5357.06	2099.74	13	0	2	5	0
5	17.79	1.35	3159.04	757.47	12	1	2	5	4
6	13.32	0.60	4238.85	339.51	5	7	2	5	5
7	21.24	1.47	4902.91	1535.11	15	0	1	4	5
8	19.68	0.92	5261.82	948.63	15	10	2	6	4
9	22.58	0.61	3472.38	476.88	3	14	1	4	0
10	21.97	1.43	5654.02	1778.05	13	31	2	8	2
11	16.44	0.77	3264.00	413.06	5	2	1	3	2
12	18.4	1.00	4354.05	803.45	4	0	1	3	0
13	22.95	1.41	4922.88	1593.31	5	22	2	7	2
14	25.78	1.79	9780.74	4515.42	15	15	2	6	4
15	20.44	0.69	5426.69	761.60	3	6	2	5	3
16	18.21	1.10	685.57	137.69	6	10	2	6	1
17	16.43	0.64	1593.34	168.40	8	13	1	5	5
18	19.27	0.94	4150.27	754.27	2	21	2	7	0
19	21.86	0.68	3920.90	580.00	9	2	2	5	1
20	13.92	1.14	3154.94	500.62	11	1	2	5	0
21	14.4	0.31	1270.27	57.02	4	2	1	3	0
22	17.79	1.55	4147.71	1144.00	9	2	2	5	0
23	15.09	0.96	3833.86	554.80	12	21	1	7	0
24	20.05	0.79	4610.05	733.23	12	0	2	5	0
25	19.29	1.26	4250.12	1030.40	1	5	1	3	0
26	17.94	1.01	5431.30	985.84	3	1	1	3	0

Continued

Table E2 (continued)

Site ID	Height (m)	Basal Area (m^2)	Canopy Volume (m^3)	Size Index	Deadlimbs	Mistletoe	Lichen	Complexity Index	Cavities
27	14.6	0.70	2829.31	289.73	5	0	1	3	0
28	18.66	0.45	3193.34	266.77	7	17	1	6	0
29	16.7	0.77	1738.24	223.45	10	0	1	4	3
30	20.59	1.34	4159.49	1145.53	14	2	2	5	0
31	17.81	1.12	5264.38	1048.60	9	0	2	5	0
32	21	1.31	3879.42	1064.77	18	4	2	6	4
33	16.79	1.12	6779.90	1276.73	21	18	2	9	4
34	20.76	1.72	8184.32	2922.96	10	2	2	5	1
35	16.64	0.44	2792.96	205.32	12	0	2	5	0

Table E3: Forest density (%) in buffer sizes from 50 m to 800 m centered on 35 isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Site ID	Buffer Size (m)															
	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800
1	0.40	0.54	0.65	0.69	0.71	0.71	0.69	0.66	0.64	0.61	0.57	0.52	0.48	0.44	0.41	0.39
2	0.00	0.06	0.10	0.13	0.13	0.11	0.08	0.07	0.07	0.08	0.08	0.08	0.07	0.07	0.06	0.06
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.05
6	0.93	0.86	0.65	0.49	0.35	0.27	0.22	0.21	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.23
7	0.00	0.00	0.06	0.11	0.12	0.14	0.18	0.22	0.25	0.28	0.32	0.36	0.37	0.37	0.36	0.35
8	1.00	1.00	0.99	0.92	0.74	0.60	0.51	0.45	0.42	0.41	0.44	0.48	0.50	0.51	0.50	0.48
9	0.42	0.31	0.28	0.24	0.19	0.13	0.10	0.10	0.11	0.12	0.13	0.14	0.17	0.19	0.20	0.20
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
11	0.00	0.03	0.03	0.02	0.02	0.03	0.05	0.07	0.08	0.07	0.07	0.06	0.06	0.06	0.05	0.05
12	0.00	0.00	0.00	0.02	0.04	0.06	0.06	0.04	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01
13	0.00	0.00	0.00	0.01	0.08	0.14	0.17	0.19	0.19	0.17	0.15	0.14	0.13	0.13	0.14	0.14
14	0.07	0.02	0.01	0.05	0.06	0.08	0.09	0.09	0.10	0.11	0.12	0.12	0.13	0.14	0.13	0.13
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	1.00	1.00	0.01	0.84	0.72	0.61	0.53	0.46	0.40	0.34	0.30	0.27	0.26	0.27	0.29	0.30
17	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.03	0.04	0.03	0.03	0.03	0.02	0.02
18	0.00	0.00	0.06	0.12	0.10	0.08	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.06
19	0.58	0.76	0.84	0.87	0.82	0.73	0.70	0.69	0.67	0.63	0.59	0.55	0.52	0.49	0.47	0.46
20	0.00	0.00	0.11	0.13	0.15	0.16	0.20	0.23	0.29	0.33	0.37	0.42	0.43	0.45	0.46	0.47
21	0.57	0.47	0.48	0.44	0.42	0.39	0.37	0.36	0.37	0.42	0.46	0.50	0.52	0.54	0.56	0.57
22	0.00	0.00	0.00	0.00	0.03	0.13	0.23	0.33	0.41	0.48	0.51	0.52	0.51	0.49	0.48	0.47
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.03
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
25	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.07	0.10	0.14	0.15	0.14	0.13	0.12	0.12	0.01

Continued

Table E3 (continued)

Site ID	Buffer Size (m)															
	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800
26	0.00	0.00	0.01	0.10	0.16	0.18	0.16	0.15	0.14	0.13	0.13	0.12	0.12	0.12	0.11	0.11
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
28	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.08	0.12	0.15	0.16	0.18	0.20	0.21	0.23	0.24
29	0.00	0.01	0.07	0.12	0.14	0.15	0.16	0.18	0.19	0.20	0.19	0.18	0.18	0.18	0.19	0.19
30	0.00	0.00	0.00	0.00	0.01	0.05	0.06	0.05	0.04	0.03	0.03	0.02	0.02	0.03	0.04	0.04
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
32	0.00	0.00	0.00	0.02	0.04	0.07	0.10	0.13	0.15	0.17	0.17	0.17	0.17	0.16	0.15	0.15
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.07	0.09	0.10	0.11	0.12	0.12
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.06	0.09	0.10	0.09	0.08	0.07	0.06
35	0.00	0.00	0.00	0.04	0.08	0.10	0.10	0.09	0.07	0.07	0.06	0.06	0.05	0.04	0.04	0.03

Table E4: Forest density (%) in buffer sizes from 850 m to 5000 m centered on 35 isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Site ID	Buffer Size (m)														
	850	900	950	1000	1200	1400	1600	1800	2000	2500	3000	3500	4000	4500	5000
1	0.36	0.33	0.31	0.31	0.26	0.25	0.25	0.25	0.25	0.23	0.20	0.17	0.17	0.17	0.17
2	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.04	0.05	0.05
3	0.02	0.03	0.04	0.05	0.04	0.03	0.02	0.02	0.04	0.08	0.08	0.08	0.08	0.08	0.08
4	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04
5	0.05	0.05	0.05	0.05	0.04	0.03	0.02	0.04	0.06	0.08	0.08	0.09	0.09	0.08	0.08
6	0.23	0.24	0.25	0.26	0.26	0.23	0.18	0.14	0.12	0.09	0.07	0.07	0.06	0.06	0.05
7	0.34	0.33	0.31	0.29	0.26	0.22	0.17	0.14	0.12	0.09	0.07	0.06	0.06	0.05	0.05
8	0.46	0.44	0.41	0.38	0.29	0.22	0.17	0.14	0.12	0.09	0.08	0.07	0.06	0.05	0.05
9	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.19	0.18	0.17	0.17	0.15	0.12	0.11	0.09
10	0.02	0.03	0.04	0.04	0.08	0.09	0.11	0.12	0.12	0.10	0.09	0.08	0.08	0.09	0.09
11	0.05	0.05	0.04	0.05	0.05	0.05	0.07	0.08	0.09	0.07	0.05	0.05	0.06	0.07	0.08
12	0.01	0.01	0.01	0.02	0.03	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.05	0.05	0.04
13	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.12	0.11	0.12	0.12	0.12	0.12	0.11
14	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.12	0.11	0.11	0.11	0.10	0.09	0.08
15	0.00	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.02	0.02	0.03	0.04	0.04	0.05	0.05
16	0.32	0.34	0.36	0.37	0.42	0.42	0.38	0.37	0.36	0.32	0.29	0.25	0.21	0.19	0.18
17	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.03	0.04	0.03	0.04	0.06	0.07	0.07	0.07
18	0.06	0.05	0.05	0.04	0.04	0.05	0.06	0.07	0.08	0.16	0.19	0.19	0.19	0.21	0.23
19	0.44	0.43	0.42	0.41	0.38	0.39	0.39	0.39	0.39	0.39	0.37	0.31	0.27	0.25	0.23
20	0.47	0.47	0.46	0.45	0.42	0.39	0.37	0.35	0.33	0.33	0.31	0.30	0.26	0.24	0.23
21	0.58	0.58	0.58	0.57	0.55	0.53	0.51	0.50	0.49	0.45	0.39	0.32	0.27	0.23	0.22
22	0.46	0.44	0.43	0.41	0.37	0.35	0.33	0.32	0.30	0.30	0.30	0.30	0.29	0.25	0.23
23	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.05	0.07
24	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.02	0.02	0.03	0.05	0.04	0.04	0.04	0.04
25	0.10	0.09	0.08	0.08	0.10	0.08	0.07	0.06	0.06	0.11	0.14	0.13	0.11	0.11	0.10

Continued

TableE4 (continued)

Site ID	Buffer Size (m)														
	850	900	950	1000	1200	1400	1600	1800	2000	2500	3000	3500	4000	4500	5000
26	0.10	0.09	0.09	0.08	0.07	0.07	0.07	0.07	0.07	0.11	0.15	0.15	0.14	0.13	0.13
27	0.02	0.03	0.04	0.06	0.12	0.16	0.18	0.17	0.16	0.11	0.08	0.06	0.05	0.05	0.06
28	0.26	0.28	0.29	0.31	0.34	0.35	0.34	0.33	0.31	0.26	0.21	0.16	0.14	0.13	0.13
29	0.19	0.19	0.19	0.18	0.15	0.12	0.10	0.12	0.13	0.13	0.12	0.11	0.11	0.10	0.09
30	0.05	0.04	0.05	0.05	0.06	0.05	0.04	0.03	0.03	0.03	0.05	0.11	0.15	0.15	0.13
31	0.02	0.02	0.02	0.02	0.03	0.04	0.04	0.05	0.06	0.06	0.11	0.14	0.13	0.14	0.14
32	0.14	0.14	0.13	0.13	0.14	0.14	0.15	0.16	0.15	0.15	0.13	0.11	0.11	0.10	0.09
33	0.11	0.11	0.10	0.09	0.07	0.06	0.04	0.04	0.03	0.03	0.03	0.04	0.06	0.06	0.07
34	0.06	0.06	0.06	0.06	0.07	0.09	0.09	0.09	0.09	0.08	0.08	0.09	0.09	0.08	0.08
35	0.03	0.03	0.03	0.04	0.06	0.06	0.09	0.05	0.04	0.05	0.05	0.06	0.07	0.06	0.05

Table E5: Oak density (%) in buffer sizes from 50 m to 800 m centered on 35 isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Site ID	Buffer Size (m)															
	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800
1	0.40	0.54	0.65	0.69	0.71	0.71	0.69	0.66	0.64	0.61	0.57	0.52	0.48	0.44	0.41	0.37
2	0.00	0.06	0.10	0.13	0.13	0.11	0.08	0.07	0.07	0.07	0.08	0.07	0.07	0.07	0.06	0.05
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.05
6	0.93	0.86	0.65	0.49	0.35	0.27	0.22	0.21	0.22	0.22	0.22	0.22	0.22	0.21	0.20	0.23
7	0.00	0.00	0.06	0.11	0.12	0.14	0.18	0.22	0.22	0.22	0.22	0.23	0.23	0.22	0.21	0.19
8	1.00	1.00	0.98	0.85	0.64	0.48	0.37	0.28	0.23	0.21	0.21	0.23	0.24	0.23	0.22	0.21
9	0.42	0.31	0.28	0.24	0.19	0.13	0.10	0.10	0.11	0.12	0.13	0.14	0.17	0.19	0.20	0.20
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
11	0.00	0.03	0.03	0.02	0.02	0.03	0.05	0.07	0.08	0.07	0.07	0.06	0.06	0.06	0.05	0.05
12	0.00	0.00	0.00	0.02	0.04	0.06	0.06	0.04	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01
13	0.00	0.00	0.00	0.01	0.08	0.14	0.17	0.19	0.19	0.17	0.15	0.14	0.13	0.13	0.13	0.14
14	0.07	0.02	0.01	0.01	0.01	0.03	0.04	0.05	0.06	0.08	0.09	0.10	0.11	0.12	0.12	0.12
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	1.00	1.00	0.01	0.84	0.72	0.61	0.53	0.46	0.40	0.34	0.30	0.27	0.23	0.21	0.19	0.17
17	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.03	0.04	0.03	0.03	0.03	0.02	0.02
18	0.00	0.00	0.06	0.12	0.10	0.08	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.06
19	0.58	0.76	0.84	0.87	0.82	0.72	0.66	0.63	0.60	0.57	0.53	0.51	0.48	0.46	0.44	0.43
20	0.00	0.00	0.11	0.13	0.00	0.01	0.04	0.07	0.09	0.10	0.12	0.14	0.16	0.18	0.18	0.18
21	0.57	0.47	0.48	0.44	0.42	0.39	0.36	0.34	0.34	0.30	0.40	0.43	0.44	0.45	0.45	0.45
22	0.00	0.00	0.00	0.00	0.03	0.13	0.23	0.33	0.41	0.48	0.51	0.51	0.48	0.46	0.44	0.42
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.03
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
25	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.07	0.10	0.14	0.15	0.14	0.13	0.12	0.12	0.01

Continued

Table E5 (continued)

Site ID	Buffer Size (m)															
	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800
26	0.00	0.00	0.01	0.10	0.16	0.18	0.16	0.15	0.14	0.13	0.13	0.12	0.12	0.12	0.11	0.11
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.05	0.07	0.09	0.10	0.11	0.12	0.13
29	0.00	0.01	0.07	0.12	0.14	0.15	0.16	0.18	0.19	0.20	0.19	0.18	0.18	0.18	0.19	0.19
30	0.00	0.00	0.00	0.00	0.01	0.05	0.06	0.05	0.04	0.03	0.03	0.02	0.02	0.03	0.04	0.04
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
32	0.00	0.00	0.00	0.02	0.04	0.07	0.10	0.13	0.15	0.17	0.17	0.17	0.17	0.16	0.15	0.15
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.07	0.09	0.10	0.11	0.12	0.12
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.06	0.09	0.10	0.09	0.08	0.07	0.06
35	0.00	0.00	0.00	0.04	0.08	0.10	0.10	0.09	0.07	0.07	0.06	0.06	0.05	0.04	0.04	0.03

Table E6: Oak density (%) in buffer sizes from 850 m to 5000 m centered on 35 isolated white oak legacy trees in the southern Willamette Valley, OR between 15 May and 30 June 2007.

Site ID	Buffer Size (m) 850	900	950	1000	1200	1400	1600	1800	2000	2500	3000	3500	4000	4500	5000
1	0.33	0.30	0.28	0.26	0.19	0.15	0.13	0.12	0.13	0.15	0.14	0.13	0.13	0.13	0.14
2	0.05	0.05	0.05	0.05	0.05	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.64
3	0.02	0.03	0.04	0.05	0.04	0.03	0.02	0.02	0.02	0.04	0.04	0.05	0.06	0.06	0.06
4	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
5	0.05	0.05	0.05	0.05	0.04	0.03	0.02	0.03	0.04	0.04	0.05	0.06	0.07	0.07	0.06
6	0.18	0.17	0.16	0.15	0.13	0.10	0.08	0.07	0.06	0.05	0.04	0.04	0.03	0.04	0.04
7	0.18	0.17	0.15	0.14	0.11	0.10	0.08	0.07	0.06	0.05	0.04	0.04	0.03	0.03	0.03
8	0.20	0.19	0.17	0.16	0.12	0.10	0.08	0.07	0.06	0.05	0.04	0.04	0.03	0.03	0.03
9	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.19	0.17	0.15	0.13	0.11	0.10	0.09	0.07
10	0.02	0.03	0.04	0.04	0.06	0.07	0.09	0.10	0.09	0.07	0.07	0.07	0.07	0.08	0.08
11	0.05	0.05	0.04	0.05	0.05	0.05	0.07	0.08	0.08	0.06	0.05	0.04	0.06	0.06	0.06
12	0.01	0.01	0.01	0.02	0.03	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.05	0.05	0.04
13	0.13	0.13	0.12	0.12	0.11	0.11	0.10	0.09	0.09	0.08	0.10	0.11	0.10	0.11	0.10
14	0.11	0.11	0.11	0.10	0.09	0.08	0.10	0.10	0.09	0.09	0.10	0.10	0.09	0.08	0.08
15	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.03	0.04	0.04
16	0.14	0.15	0.15	0.15	0.15	0.13	0.13	0.15	0.17	0.19	0.17	0.16	0.14	0.13	0.13
17	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.03	0.04	0.03	0.03	0.05	0.06	0.07	0.07
18	0.06	0.05	0.05	0.04	0.04	0.05	0.06	0.07	0.08	0.16	0.17	0.16	0.15	0.14	0.15
19	0.42	0.41	0.40	0.39	0.34	0.30	0.27	0.24	0.20	0.19	0.21	0.18	0.17	0.16	0.17
20	0.18	0.18	0.17	0.16	0.14	0.13	0.12	0.11	0.11	0.14	0.16	0.16	0.15	0.15	0.15
21	0.44	0.42	0.41	0.39	0.33	0.29	0.29	0.29	0.29	0.26	0.22	0.19	0.16	0.15	0.15
22	0.39	0.37	0.35	0.33	0.27	0.25	0.23	0.22	0.20	0.17	0.15	0.17	0.19	0.17	0.16
23	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.05	0.07
24	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.02	0.02	0.03	0.05	0.04	0.04	0.04	0.04
25	0.10	0.09	0.08	0.08	0.10	0.08	0.07	0.06	0.06	0.11	0.14	0.12	0.10	0.09	0.08

Continued

Table E6 (continued)

Site ID	Buffer Size (m)														
	850	900	950	1000	1200	1400	1600	1800	2000	2500	3000	3500	4000	4500	5000
26	0.10	0.09	0.09	0.08	0.07	0.07	0.07	0.07	0.07	0.11	0.14	0.13	0.11	0.09	0.09
27	0.02	0.03	0.04	0.06	0.12	0.16	0.18	0.17	0.16	0.11	0.08	0.06	0.05	0.05	0.06
28	0.14	0.15	0.16	0.18	0.21	0.20	0.18	0.15	0.14	0.12	0.10	0.08	0.07	0.07	0.08
29	0.19	0.19	0.19	0.18	0.15	0.12	0.10	0.11	0.12	0.11	0.11	0.11	0.10	0.09	0.09
30	0.05	0.04	0.05	0.05	0.06	0.05	0.04	0.03	0.03	0.03	0.03	0.05	0.08	0.08	0.08
31	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.03	0.03	0.06	0.06	0.06	0.07	0.08
32	0.14	0.14	0.13	0.13	0.08	0.06	0.05	0.06	0.07	0.08	0.08	0.08	0.08	0.08	0.07
33	0.11	0.11	0.10	0.09	0.07	0.06	0.04	0.04	0.03	0.03	0.03	0.02	0.04	0.04	0.05
34	0.06	0.06	0.06	0.05	0.06	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.08
35	0.03	0.03	0.03	0.04	0.06	0.06	0.05	0.05	0.04	0.04	0.04	0.05	0.06	0.05	0.04

Appendix F: Lepidopteran use of isolate white oak legacy trees in the southern Willamette Valley.

Introduction

I also evaluated caterpillar (Lepidopteran spp.) use of isolated white oak legacy trees. Using an approach similar to the avian part of the study, my objective was to assess the relative importance of four factors thought to influence Lepidopteran use of white oak trees. Specifically, I tested whether Lepidopteran use of isolated white oak legacy trees is best explained by: (i) the characteristics of the tree itself; (ii) the distance of the tree to the nearest tree or patch; (iii) the density of forest or oak-specific vegetation in the surrounding landscape; and (iv) the matrix in which the tree is embedded. I investigated the response of species richness and species-specific responses.

The response of Lepidoptera is expected to differ from that of birds due to differences in relative mobility and food resource requirements. For assessing how characteristics of the tree itself might affect Lepidopteran response, the plant-architecture hypothesis has been suggested for explaining species richness patterns on host plants (Lawton 1983). In essence, the plant-architecture hypothesis predicts that larger, more structurally diverse plants will harbor higher herbivorous insect species richness than smaller plants. Further, a larger, more structurally diverse tree will likely harbor higher invertebrate herbivore abundances than a smaller tree (Campos et al 2006). Studies testing this hypothesis have produced results both supporting

(Araujo et al 2006, Campos et al 2006) and rejecting (Marques et al 2000) its central prediction.

Lepidopteran response to the relative isolation of a white oak tree will likely be affected by the relative permeability of the intervening matrix and species-specific dispersal capabilities (Kupfer et al 2006). For host-specific species in particular, the effect of increasing tree isolation may be most pronounced when the intervening matrix is significantly different from its historical native condition (Steffan-Dewenter 2003). In the context of this study, Lepidopteran white oak specialists are thus likely to be most affected by isolation, particularly when an individual tree is embedded in a homogenous cropland site and situated beyond the estimated historical spacing of savanna-form white oak trees in the Willamette Valley (20 – 80 m spacing – Bart Johnson, personal communication).

When considering Lepidopteran response to the density of forest or oak-specific vegetation in the surrounding landscape, the resource concentration hypothesis (Root 1973) has been used to explain herbivore densities on habitat fragments. Compared to fragments that have high plant diversity, fragments that are low in plant diversity but high in density of a particular plant will have lower invertebrate herbivore species richness but higher abundances of invertebrate species specialized to the dominant plant. In the context of this study, then, the resource concentration hypothesis predicts that Lepidopteran species richness will decrease on an individual oak tree but abundances of a few specialist herbivore species will increase with decreasing forest or oak-specific density in the surrounding landscape.

Methods

Site Selection

I sampled a subset of the study sites used for the avian part of the study (see Chapter 2 Methods). The main criterion for a study tree to be selected for Lepidopteran sampling was the height of the tree canopy from the ground. I sampled only those study trees that had a canopy that I could reasonably reach with a 2-m ladder. Consequently, I sampled 24 of the 35 study trees for Lepidopteran use as 11 trees had inaccessible canopies that had been trimmed high by landowners to minimize the tree's impact on agricultural production. Nine trees were situated in oak savanna reserves, ten in pastures and five in croplands.

Lepidopteran Sampling

I conducted Lepidopteran surveys between 4 June and 29 June 2007. Within this time frame, I visited each tree twice with each visit separated by at least 10 days. During each survey, I randomly selected six branches that could reasonably be reached with a 2-m ladder from the lower tree canopy and employed a beat sampling method to sample for caterpillars. I beat each branch thoroughly with a 75-cm long by 4-cm diameter piece of oak doweling to dislodge caterpillars into a 1-m^2 canvas beating tray. After each beat sample, I thoroughly inspected the canvas tray for caterpillars. I identified caterpillars to species where possible and recorded the number of individuals of each species. For caterpillars that could not be identified in the field, I collected one individual for later identification assistance from Jeff Miller, Ph.D., an

Oregon State University entomologist. Due to their unclear taxonomy, micromoth caterpillars were identified only to family.

To quantify sampling effort, I counted the number of leaves sampled during each beating effort. For community-level responses, I divided the number of caterpillar species detected by the number of leaves sampled to calculate the number of species per leaf at each site. For species-specific responses, I divided the number of individuals of each species encountered by the number of leaves sampled to calculate the number of individuals per leaf at each site. In both instances, I multiplied the number per leaf value by 100 for convenience in later data analysis.

Site and Landscape Variables

At the site level, I collected data on tree size and leaf nitrogen content to determine how characteristics of the tree itself affected caterpillar use. For tree size, I used the same tree size index values as calculated during the avian part of the study (see Chapter 2: Methods). Because variability in leaf phenology between individual oak trees may affect Lepidopteran herbivory patterns (Suzuki 1998, Murakami et al 2005), I collected 50-100 leaves from each study tree and had these leaf samples later analyzed for leaf nitrogen content by the Oregon State University Central Analytical Laboratory.

To determine how the spatial context of the study tree affected Lepidopteran use, I used the distance and vegetation variables as measured during the avian part of the study (see Chapter 2: Methods). I used program Focus (Holland et al 2004) to determine the characteristic scale of Lepidopteran response to vegetation density.

Data Analysis

Using methods developed in the avian part of the study, I used a two stage model selection approach to assess how the explanatory variables influenced Lepidopteran use of these individual trees (Burnham & Anderson 2002). I developed the following *a priori* models describing the tree characteristics, distance and vegetation density factors using Poisson log-linear regression to assess species-specific responses and the response of species richness:

i. Tree characteristics

Number of caterpillars / leaf = tree size index + leaf nitrogen content

ii. Distance

Number of caterpillars / leaf = distance to nearest tree

and

Number of caterpillars / leaf = distance to nearest patch

iii. Vegetation density

Number of caterpillars / leaf = forest vegetation density at characteristic scale of response

and

Number of caterpillars / leaf = oak vegetation density at characteristic scale of response

Using Akaike's Information Criterion with a small sample size correction factor (AIC_c), I evaluated all models within each explanatory factor and, for tree characteristics, all subsets of the full two-variable model. In the first stage of model selection, I selected the model with the lowest AIC_c value as the most parsimonious model for each factor. In the second stage of model selection, I combined the top model for each factor along with an indicator variable for the site (or matrix) type and fit this model to the data:

Number of caterpillars / leaf = top tree characteristics model + top distance model + top vegetation density model + matrix indicator variable

For this model, the matrix indicator variable was categorical with the reference variable being oak savanna reserve. I ran all subsets of this model to arrive at an overall best model for the response of species richness and species-specific responses where possible. To evaluate the strength of evidence for a given model, I assessed model weights (see Chapter 2: Methods) and 90% confidence intervals of parameter estimates within each model.

Results

I recorded 214 individual caterpillars, representing 13 Lepidopteran species and 1 micromoth family, using the selected individual trees from surveys conducted between 4 June and 29 June 2007 (Tables F1-2). Micromoth species of the family Tortricidae were the most frequently encountered caterpillar (n = 86). Among macromoth species, *Besma quercivoraria* were the most frequently detected caterpillars.

Unexpected low abundances of caterpillars sampled using the selected trees impacted the analysis of Lepidopteran response to the explanatory variables. The top model for explaining Lepidopteran use was the intercept model (Table F3). All of the other species richness models had AIC_C values that were within 2 AIC_C units of each other. Moreover, the values of the single-variable models representing the tree characteristics, distance, and density factors all had had AIC_C values that were within 0.11 of each other, making discrimination between competing models difficult. Assessing parameters within the model set, all parameter estimates had relatively large standard errors with 90% confidence intervals that were closely centered on zero (Table F3). These results indicate that the response data collected was insufficient to discriminate how the explanatory variables affected Lepidopteran use of individual oak trees. The results of species-specific responses followed a similar pattern as no one species was sufficiently abundant to allow strong inferences to be made about how the explanatory variables affected species-specific use.

Table F1: Lepidopteran caterpillars detected using isolated white oak legacy trees in the Willamette Valley, Oregon during surveys conducted between 4 June and 29 June, 2007. Caterpillars are presented from most to least frequently encountered.

Species	Number of Sites Detected	Total Number of Individuals Detected
Tortridae spp.	17	86
Besma quercivoraria	6	7
Orthosia pacifica	5	7
Cosmia calami	5	9
Hydriomena rununciata	5	8
Lambdina fiscellaria	3	3
Lithophane contenta	3	3
Cissusa indiscreta	3	3
Clemensia albata	3	6
Lithophane georgii	2	2
Orthosia hibisci	2	2
Erynnis propertius	1	1
Egira crucialis	1	1
Nemoria darwiniata	1	1

Table F2: Site-specific species richness of Lepidopteran caterpillars using isolated white oak legacy trees in the Willamette Valley, Oregon during surveys conducted between 4 June and 29 June, 2007.

Site ID	Number of Species	Lepidopteran Species [a]	Number of Leaves Sampled	Caterpillars Per Leaf [b]
1	2	Cle alb, Ery pro	4635	0.04
3	3	Tortri, Cle alb, Ort pac	3425	0.09
4	3	Tortri, Cos cal, unk 1	3446	0.09
6	0		4646	0.00
7	0		5227	0.00
8	2	Bes que, Lam fis	5758	0.03
9	5	Tortri, Cle alb, Cos cal, Lam fis, unk 1	4422	0.11
12	1	Lit con	2496	0.04
15	0		5917	0.00
16	3	Bes que, Lit geo, Tortri	4727	0.06
18	3	Ort pac, Tortri, Cos cal	3696	0.08
19	4	Hyd run, Tortri, Ort pac, Egi cru	6747	0.06
20	3	Tortri, Ort pac, Hyd run	4330	0.07
21	6	Cis ind, Cos cal, Bes que, Hyd run, Lit con, Tortri	6354	0.09
22	4	Cis ind, Hyd run, Ort hib, Tortri	5364	0.07
25	2	Eup bes, Lit con	2631	0.08
26	4	Bes que, Cis ind, Lit geo, Tortri	4906	0.08
27	1	Tortri	2896	0.03
28	4	Bes que, Hyd run, Nem dar, Tortri	6577	0.06
29	1	Tortri	3221	0.03
31	1	Tortri	7615	0.01
32	1	Tortri	3573	0.03
33	2	Cos cal, Tortri	3881	0.05
35	4	Lam fis, Ort hib, Ort pac, Tortri	5542	0.07

[a] Species codes: Bes que = *Besma quercivoraria*, Cis ind = *Cissusa indiscreta*, Cle alb = *Clemensia albata*, Cos cal = *Cosmia calami*, Egi cru = *Egira crucialis*, Ery pro = *Erynnis properties*, Hyd run = *Hydriomena renunciata*, Lam fis = *Lambdina fiscellaria*, Lit con = *Lithophane contenta*, Lit geo = *Lithophane georgii*, Nem dar = *Nemoria darwiniata*, Ort hib = *Orthosia hibisci*, Ort pac = *Orthosia pacifica*, Tortri = Tortridae spp., unk 1 = unknown caterpillar 1.

[b] Caterpillar per leaf values have been multiplied by 100 for convenience in data analysis

Table F3: Model selection results and parameter estimates (SE) for predicting Lepidopteran use of isolated white legacy trees in the Willamette Valley, Oregon during surveys conducted between 4 June and 29 June, 2007.

Explanatory Factor	Model	Parameter Estimates β_1	β_2	AIC_C
Tree Architecture	Tree size + Leaf N_2	-0.0046 (0.19)	0.20 (3.19)	7.78
	Tree size	-0.0054 (0.19)		5.79
	Leaf N_2	0.21 (3.18)		5.78
Distance	Nearest tree	0.0018 (0.021)		5.78
	Nearest patch	-0.0007 (0.0080)		5.78
Density	Forest (3000)	2.01 (7.70)		5.72
	Oak (1600)	2.07 (10.53)		5.75
Site Type [a]	Pasture + Crop	0.39 (1.96)	-0.38 (2.93)	7.69
intercept				3.18

[a] Site type is a single two-variable model containing pasture and crop variables.

Savanna reserve is the reference variable.

Discussion

The Lepidopteran part of the study was marred by unexpectedly low abundances of caterpillars using the selected trees. The simplest explanation for my results is the random sample hypothesis (Connor & McCoy 1979, Andren 1994), represented by the intercept model. The random sample hypothesis states that the numbers of species found on habitat fragments are simply random sub-samples from larger source areas. However, I believe that this simple explanation does not necessarily explain Lepidopteran response to isolated white oak trees because the results of my study may have been more affected by factors related to study design.

First, temporal variation in Lepidopteran abundances could account for the low numbers of caterpillars I detected using the study's trees. Many Lepidopteran species are known to experience substantial variation in abundances year-to-year (Summerville et al 2007). My study likely coincided with a year in which abundances were low for many Lepidopteran species occurring in the Willamette Valley. To account for likely annual variation in Lepidopteran abundances, future studies should be designed for multiple sampling seasons.

Temporal variation in caterpillar emergence could also have affected my results. In the Willamette Valley, peak caterpillar emergence for most Lepidopteran species using Oregon white oak is thought to occur during the month of June (Jeff Miller, personal communication). However, caterpillar emergence can be variable, depending on host leaf emergence, which in turn can be influenced by climate effects (Dell et al 2005). In the Willamette Valley, the spring of 2007 was generally warmer and drier than average (OCS 2008) which could have caused earlier-than-normal date of emergence for some caterpillar species. Anecdotal evidence from one land manager suggested that I had missed peak caterpillar abundance at his site by about 2 weeks. Thus, for future studies examining Lepidopteran use of Oregon white oak trees, I would recommend increasing the seasonal length of the sampling period by beginning to sample for caterpillars shortly after leaf emergence (~ mid May). A further consideration would be to also extend the sampling period into the middle of summer to potentially capture a wider range of Lepidopteran species using Oregon white oak trees.

Another factor that could have affected my results is the degree of my sampling effort. A sample size of 24 trees was likely too small, particularly for an observational ecological study, and thus lacked statistical power to discern effects of the explanatory variables on Lepidopteran use. Per tree sampling effort also could have impacted my results. Due to time and equipment constraints, I was only able to sample the lower portion of the tree canopy. This type of sampling effort assumes that caterpillars are evenly distributed throughout a typical Oregon white oak tree, which in fact may be a false assumption. Further, the number of leaves sampled per tree (mean = 4668) may have been an insufficient sample size for a large oak tree. Increasing sampling effort in future studies, however, will necessarily have to be balanced with economic considerations as equipment costs and time requirements will be substantially increased.

When considering the above recommendations, it becomes apparent that assessing Lepidopteran response to Oregon white oak trees is a study in and of itself. Recommendations for future studies investigating Lepidopteran response to isolated Oregon white oak trees are summarized below:

1. Studies should be multi-season, preferably 3 or more, to account for the natural temporal variation in Lepidopteran abundances.
2. Within-season sampling effort should be increased to account for temporal variation in caterpillar emergence and to ensure sampling of a wide range of Lepidopteran species.
3. Increase the number of study sites. It is difficult to estimate an absolute cutoff for the number required, but considering that satisfactory results were achieved with the avian part of the study, a minimum of 35 sites is suggested.
4. Per tree sampling effort should be increased and a systematic sampling design should be employed to sufficiently sample the entire tree canopy.

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