Relationship Between Avian and Vegetation Diversities in an Ecotonal Habitat

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Abstract

This study investigated bird community diversity as it relates to vegetation height and species diversity in an ecotonal habitat in Northern California. We performed a vegetation survey to evaluate perch and vegetation type diversity, as well as several bird censuses along transects in the Big Chico Creek Ecological Reserve. Avian communities in ecotonal forest demonstrated greater diversity than communities found in other study sites comprised of riparian, grassland or oak woodland. Even though bird species diversity was high, a small number of bird species dominated the habitat. When compared with class data, foliage species and height diversities in our ecotone site had the highest diversity indicies. Our results may indicate that higher vegetation diversity provides suitable resources to a broad variety of avian species. Perhaps edge effect in ecotone communities produces a greater density of organisms of one species and greater overall number of species than found in bordering communities (Encyclopedia Britannica 2011). We found that birds distributed themselves disproportionately in regard to foliage types and heights. This indicates that birds preferentially select microhabitats that benefit their survival the most.

Introduction

The purpose of this study is to investigate diversity relationships within an ecotonal habitat and determine if birds are selectively using vegetation. A classic ecological study by MacArthur inspired many biologists to consider how plant foliage heights and diversities influence the distribution of bird species within a community (MacArthur and MacArthur 1961).

Diversity indices are important to ecologists as they often determine health and stability of an ecosystem. It is expected that a higher diversity of birds are recorded in this econtonal habitat compared

to the other study sites comprised of grassland, oak woodland, and riparian communities. A study site that falls between two habitat types is expected to demonstrate edge effects, having properties of the two communities that meet and possibly show an increase in total species diversity. An amplification in plant species and foliage heights likely lead to a broad variety of resources suitable to an expanded number of bird species. We expect that our field site will show high diversity values in comparison to the other habitat types surveyed by other member of our class. As different plant types and heights offer different potential resources, we would assume that birds will use selectively to their own benefit. We expect to show that birds distribute themselves among vegetation selectively, not just proportionally to foliage type and height availability. Our null hypothesis is that bird species would be evenly distributed proportional to plant type and heights present in the environment.

This study investigated height and species of vegetation utilized by birds and relates this to diversities. We conducted several bird censuses within our ecotone study site and recorded vegetation species and height in which birds were found perching, preening and foraging. Our site data is presented as Shannon's diversity and our foliage utilization data is tested with a Chi-squared test.

Study Area (see Figure 1 in Appendicies)

Our census site was located at Big Chico Creek Ecological Reserve off of highway 32 between Chico and Forest Ranch and east of Big Chico Creek canyon. The study area consisted of an ecotonal environment bordered by chaparral and oak woodland/mixed conifer forest. Foliage dominating the area included grass, forb, Poison Oak *(Toxicodendron diversilobum)*, California Black Oak *(Quercus kelloggii)*, Ponderosa Pine *(Pinus ponderosa)*, and Big Leaf Maple *(Acer macrophyllum).* Canopy cover was varied throughout the site with an intermediate to open understory. Slope of the study area is approximately 18 degrees with a northwest aspect and an elevational range between 1280 feet to 1560 feet.

It is significant to note the abundant precipitation throughout the winter; snowpack is recorded to be in excess of 150% of normal.

Materials and Methods

The study site covered approximately 10,000 square meters or one hectacre. Transects were laid along parallel lines ten meters apart determined by a meter unit measuring tape. A total of 100 avian

survey/vegetative identification points were set at ten meter intervals along transects. Census points were recorded using a standard Global Positioning Systems unit. Surveys began March 31, 2011 and were concluded on April 26, 2011. Six censuses were conducted beginning at dawn and lasting for a duration of two and a half hours; survey dates were separated by at least three days. Transects were slowly walked stopping at each census point for a duration of one minute to identify and record birds seen utilizing vegetation. Vegetation species and height estimations at which birds were seen were recorded. Birds noted while walking between survey points were also recorded and observers were careful to avoid duplicate recordings of the same individual. Birds flying by were not counted. Unknown birds were described and recorded for possible future identification.

The Shannon Diversity Index for avian and vegetation diversities was calculated and compared to the habitats surveyed by other class members. Random or selective utilization of plant species by birds was determined by calculating the Chi-Square and Critical Values of Chi-Square for all birds that were counted more than five times. The Alpha Value for these values was set at 0.05.

Results

- The most common plants composing our study area were grasses, forbs, California black oak, Ponderosa pine, Bigleaf maple, and coffeeberry (see Table 1). The foliage height profile is depicted in Figure 3.
- We counted a total of 618 birds, composed of 31 species. The most frequently counted birds were Yellow-rumped warblers, Mourning doves, and Acorn Woodpeckers (see Table 3 in Appendices).
- Most birds used habitat (foliage height and type) selectively, distributing themselves disproportionately to foliage availability (see Figures 4.1-4.21 and Figures 5.1-5.21 in Appendices). The top three most commonly counted birds have their foliage height and type graphs shown below.
- Our ecotonal study site had the highest diversity values when compared to the class (see Table 4)

Table 1: Foliage composition of the study area.

Species Common Name	Species Scientific Name	% of Observations
Grasses	*n/a*	33.8
Forbs	*n/a*	20.7
Buckbrush	*Ceanothus cuneatus*	1.5
Poisonoak	*Toxicodendrum diversilobum*	0.5
Black oak	*Quercus kelloggii*	22.2
Pondorosa	*Pinus ponderosa*	7.1
Grey Pine	*Pinus sabiana*	1
Bigleaf Maple	*Acer macrophyllum*	6.6
Coffeeberry	*Rhamnus rubra*	5.6
Interior Live Oak	*Quercus wislizenii*	0.5
Canyon Live Oak	*Quercus chrysolepis*	0.5

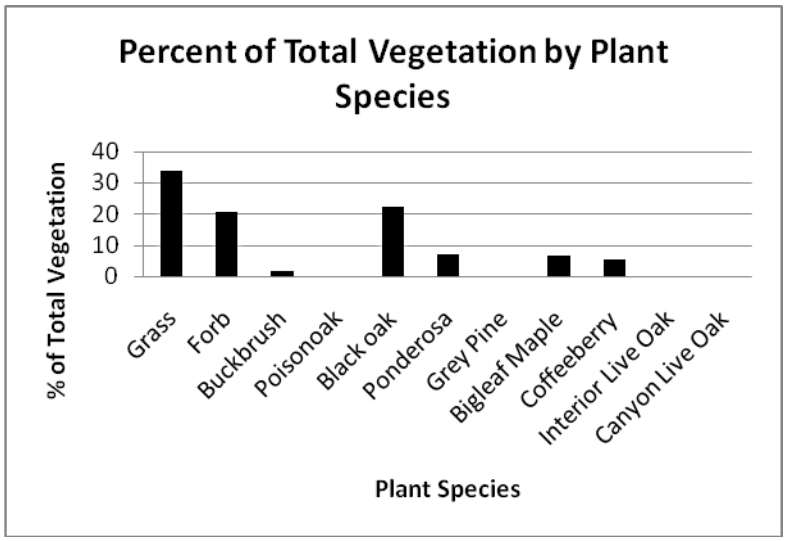

Figure 2: Foliage composition of study area

Table 2: Foliage height profile of study area.

Foliage Heights	Percent
0-1m	33.09
1-2m	10.66
2-3m	9.19
3-5m	11.4
5-10m	19.85
>10m	15.81

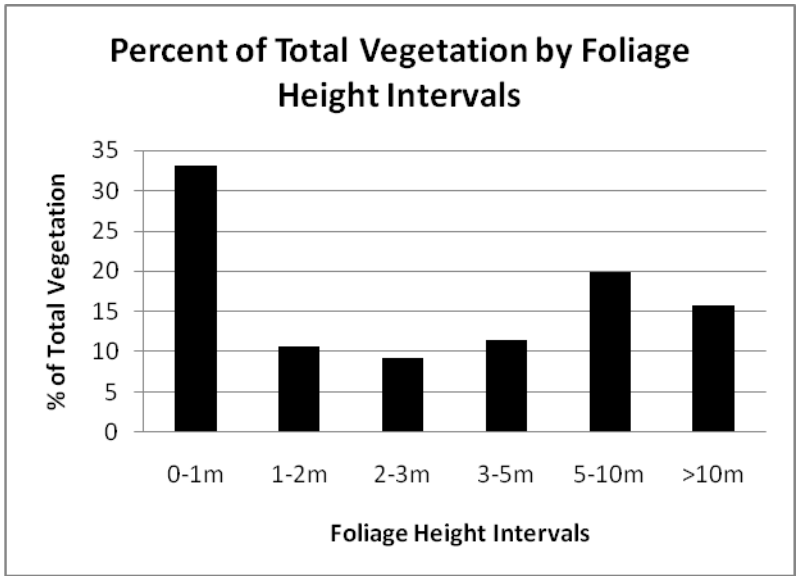

Figure 3: Foliage height profile of study area depicted graphically.

Table 4: Shannon's diversity values for foliage type, foliage height, and bird species found at different study sites surveyed by the Ornithology Spring 2011 class.

Habitat (Site)	**Plant Species Diversity**	**Foliage Height Diversity**	**Bird Species Diversity**
Blue Oak	0.39	0.17	1.03
Sacramento River Riparian	0.675	0.721	1.18
Ecotone	**0.75**	**0.73**	**2.49**
Grassland	0.073	0	0.198

Discussion

From our data, we can determine that there was a high level of diversity in our habitat. However, there were some bird species that were more dominant than others. Of the species we surveyed, most bird species seemed to be using California black oaks (*Quercus kellogii*) and positioning themselvs high up in the trees. Yellow-rumped warblers (*Dendroica coronate)*, Mourning Doves *(Zenaida macroura)* and Acorn woodpeckers (*Melanerpes formicivorus)* were the most dominant species of birds. According to research done by Hutto, a habitat is defined as an area that has a more or less homogenous vegetation type that is distinct from other areas of vegetation (Hutto 1985). Yellow-rumped warblers also used Big Leaf Maple (*Acer macrophyllum*) for their habitat. A majority of the observations of these birds were seen very high in the trees, where foliage was very dense. Birds that utilize different levels of a tree within a habitat are said to be living in a microhabitat within the overall habitat (Hutto 1985). If the birds were selecting these specific tree types and heights, what were the characteristics that made these habitats suitable to the birds?

We believe that the birds would choose this habitat because it might have the food resources they need and also provide a level of protection from predators that would not be able to see them through thick foliage. According to Hutto, birds do not actually choose their habitat but simply select or avoid the habitat that will be most or least beneficial to them and the factors that affect their choice are more likely based on the geographical area, the habitat type, previous experience in a habitat, and random exploration of new habitat rather than a conscious choice (Hutto 1985). When we started the surveys, the foliage on the trees was minimal at best. After a few weeks, the weather had warmed and the trees began to blossom, creating new layers of foliage. Plant species can directly or indirectly affect the abundance and type of resources available to birds (Deppe 2008). As the foliage increased, the level of insects, a food resource for many birds, would theoretically increase as well. Most of the bird species found in the tops of oak and maple trees are generalist insectivores; this leads us to believe that the insects are in high abundance at the tops of these trees. Most birds likely positioned themselves high up in trees because they feel most protected from predators here (which is why these birds weren't found searching for insects on the ground) and because the insect resources are located high up. It should be mentioned that resources are abundant in the spring and summer in this region, which is why many birds migrate to and through here to utilize this plethora of resources. If we were to survey non-migratory birds and assess their microhabitat preferences in December, we would likely see drastic changes in microhabitat use in this time of resource scarcity.

The makeup of the vegetation can be an important factor in shaping the associations that a bird has with its environment and can provide information about the availability of roost sites, shelter from predators and environmental factors, and availability of food resources (Deppe 2008). A bird that is able to make use of a large, dense tree will be more likely to survive than one using an open unobstructed habitat for foraging. One habitat may be more attractive to bird species because it has more internal variation within its boundaries and also because if it has more height variation; it will be able to support all types of birds, from ground dwellers to canopy dwellers (MacArthur 1962). We could categorize out study area as an ecotone because it is transitional between a coniferous forest and oak woodland. Because of this, there is a higher degree of diversity of vegetation that birds have to choose from.

The ecotonal study site produced a higher bird diversity value than the grassland, oak woodland and riparian zones. Plant species and height values were also proportionally diverse. Ecotones are commonly characterized by greater diversities than bordering communities (Milne et al. 1996). The riparian ecosystem had the next greatest bird diversity values most likely resulting from the diverse plant species and structures commonly found along a riparian corridor.

Local diversity appears to reflect the structural complexities of the habitat. The vertical distribution of plants produces an index to the variety of foraging opportunities and the variety of species that can occupy a habitat; different plant species provide a wide source of foraging opportunities for different bird species. Plant species and structural heights have been found to contribute to habitat complexity and influence the local diversity of birds (Gill 1995).

Statistical analysis of our data demonstrates that birds observed within our study site were selectively using vegetation. Birds likely are selecting vegetation types and heights that increase their chances of survival and reproduction. Different species of birds have different nutritional needs and needs for cover; they have been adapted for a specific habitat. For example, Acorn woodpeckers used California black oak more frequently than expected by proportional availability (see Figure 4.3). This makes sense because the woodpeckers use oak acorns as a food source in the winter and also frequently eats insects that would be pollinating the blooming oak buds. The bird likely uses the tops of the trees because this is where most of the new growth is occurring (see Figure 5.3). If we look at the California quail (see Figures 4.7 and 5.7 in Appendices), we will see that the birds choose to spend most of their time low to the ground, in grasses or shrubs. This species is an understory specialist, it eats mostly vegetation, but also will eat seeds and insects, and it nests on the ground. It is also interesting to mention that the California Quail does not migrate, as do many of the other birds, so it has adapted to

use resources throughout the whole year. Many of the birds counted in the tops of oak trees are here seasonally to use the abundant resources and then leave. Armed with life history information and functional morphology education, it should not be surprising to any birder that different bird species distribute choose to position themselves in microhabitats that give them resource advantages.

Our study found that birds species choose to position themselves in microhabitats disproportionally to the available microhabitats, this is likely because they are best adapted for and benefitted by certain microhabitats. We found that the majority of birds preferred to use the tops of California black oak trees; during the spring there are many resources in this microhabitat that can be exploited by a variety of species. If we were to build on these results, it would be interesting to see how weather events (like harsh winters or droughts) influence bird microhabitat choice or to see how resident bird species distribute themselves in the winter in the same habitat. We found that our site had high plant type and height diversity; we attribute this to the mix of habitats that compose this transitional ecotonal habitat. Through learning about bird life history and the available foliage resources to them, we learned a lot about how these animals function in their environment.

Appendices:

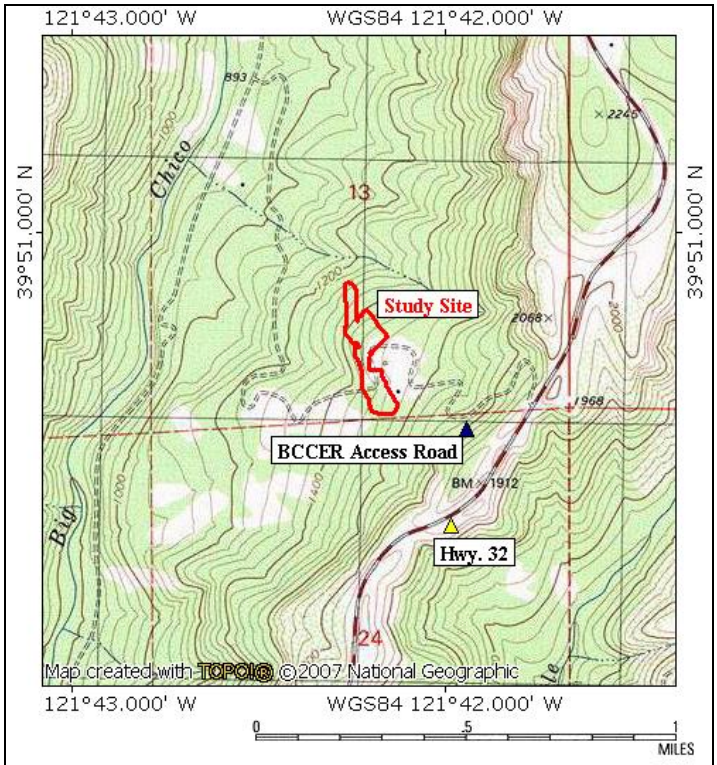

Figure 1:Map of study location.

Table 1: Foliage composition of the study area.

Species Common Name	Species Scientific Name	% of Observations
Grasses	*n/a*	33.8
Forbs	*n/a*	20.7
Buckbrush	*Ceanothus cuneatus*	1.5
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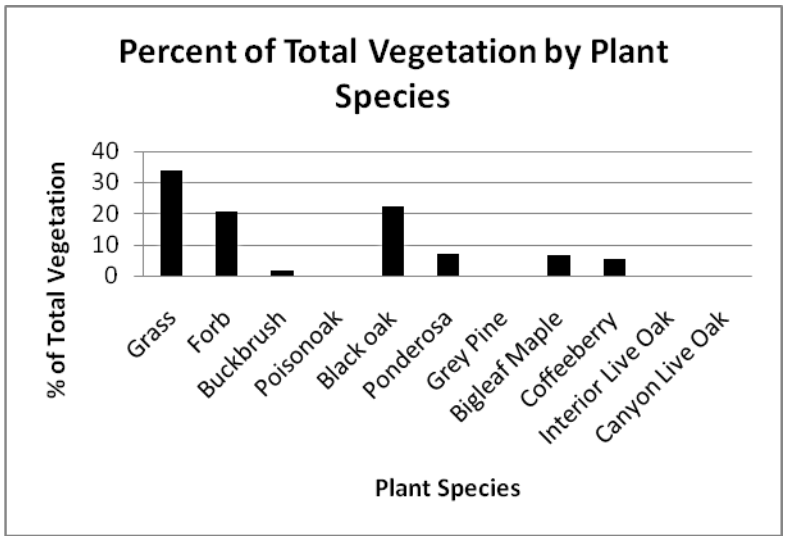

Figure 2: Foliage composition of study area.

Table 2: Foliage height profile of study area.

Foliage Heights	Percent
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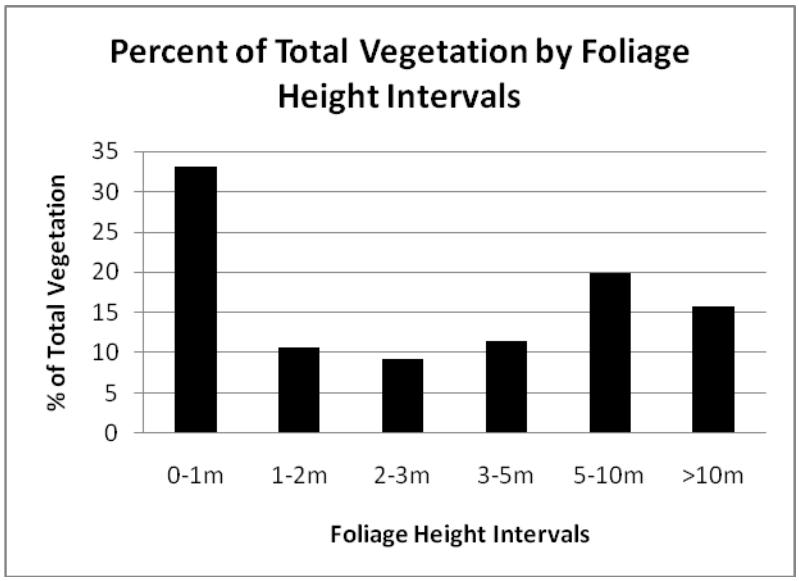


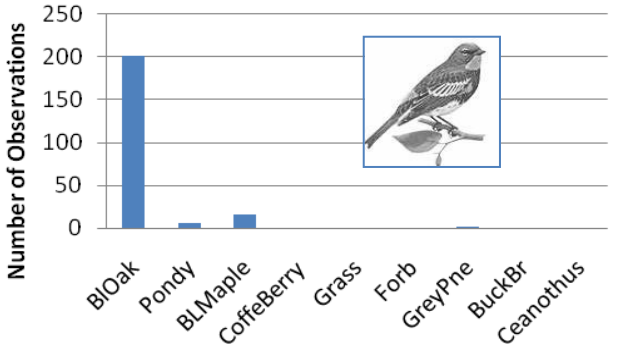
Figure 3: Foliage height profile of study area depicted graphically.

Table 3: Bird species observation frequecies.

Common Species Name	**Scientific Name**	**Total Observations**
Yellow-rumped Warbler	*Dendroica coronata*	223
Mourning Dove	*Zenaida macroura*	72
Acorn Woodpecker	*Melanerpes formicivorus*	65
Unknown	*n/a*	60
European Starling	*Sturnus vulgaris*	27
Brewer's Blackbird	*Euphagus cyanocephalis*	23
California Quail	*Callipepla californica*	17
Band-tailed Pigeon	*Columba fasciata*	16
American Robin	*Tundrus migratorius*	12
Scrub Jay	*Aphelocoma californica*	11
CaliforniaTowee	*Pipilo crissalis*	9
Ruby-crowned Kinglet	*Regulus calendula*	8
Steller's Jay	*Cyanocitta stelleri*	7
House Finch	*Passer domesticus*	6
Purple Finch	*Carpodactus purpureus*	6
White-breasted Nuthatch	*Sitta carolinensis*	6
Yellow-throated Warbler	*Dendroica dominica*	6
Unknown Warbler	*n/a*	6
Lesser Gold Finch	*Carduelis psaltria*	5
Northern Flicker	*Colaptesauratus*	5
Spotted Towee	*Pipilo maculatus*	5
Orange Crowned Warbler*	*Vermivora celata*	4
Finch Unknown*	*n/a*	3
Song Sparrow*	*Melospiza melodia*	2
Turkey Vulture*	*Cathartes aura*	2
WrenTit*	*Chamaea fasciata*	2
Sparrow Unknown*	*n/a*	2
Black-throated Sparrow*	*Amphispiza bilineata*	1
Mountain Chickadee*	*Poecile gambeli*	1
American Crow*	*Corvus brachyrhynchos*	1
Brown-headed Cowbird*	*Molothrus ater*	1
Dark Eyed Junco*	*Junco hyemalis*	1
Hairy Woodpecker*	*Picoides villosus*	1
Red-tailed Hawk*	*Buteo jamaicensis*	1
WesternTanager*	*Piranga ludoviciana*	1
*Birds not analyzed by Chi-squared test, less than 5 obs.	*Total Observations=*	618

Fig. 4.1 – 4.21: Vegetation use by bird species. (95% confidence level, df=10)

Fig 5.1-5.21: Foliage height utilization by bird species (95% confidence level, df=5).



4.1: Foliage utilizartion by Yellow-rumped warblers. Birds use folaige disproportionately (X sq. 638.4 > 18.4 Xcrit).

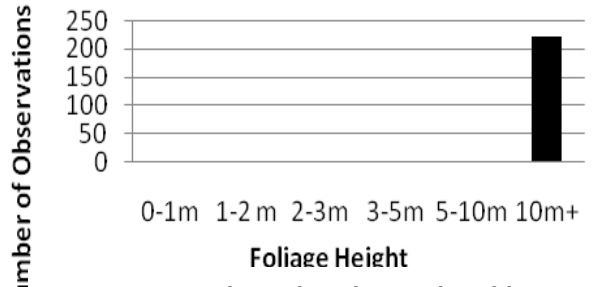


Figure 5.1: Foliage heights utilized by Yellow-rumped warblers. Birds disproportionately use foliage height (Xsq. 1185.6>11.1 Xcrit.).

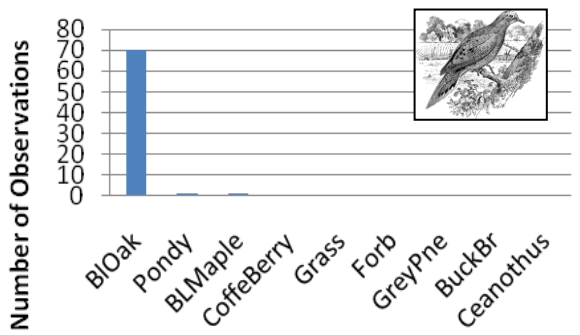


Figure 4.2: Vegetation utilization by Mourning doves. Birds use vegetation disproportionately (Xsq. 241.5 > 18.4 Xcrit).

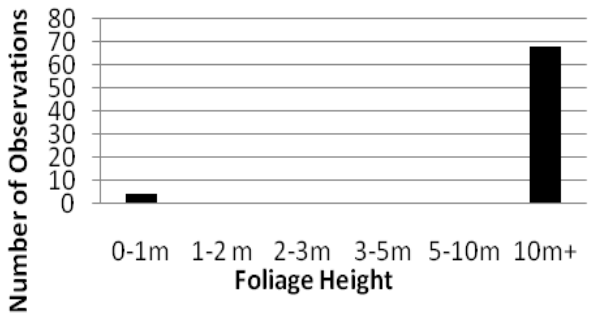


Figure 5.2: Foliage height utilization by Mourning doves. Birds use is disproportionate (Xsq.334.9>11.1Xcrit.).

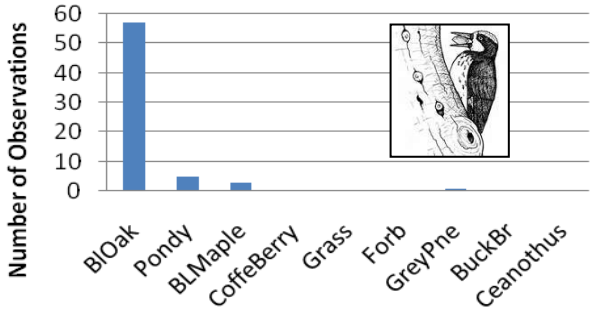


Figure 4.3: Acorn wood peckers use vegetation types disproportionately to avalibility (X sq.165.9 > Xcrit 19.7)

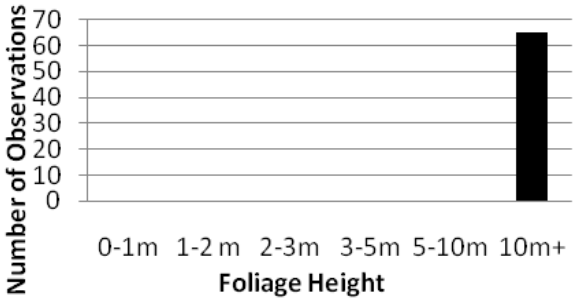


Figure 5.3: Foliage height use by Acorn woodpeckers. Birds use is disproportionate.

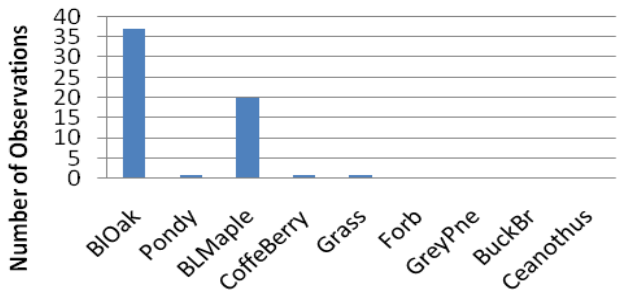


Figure 4.4: Use of vegetation by unknown birds. Birds use foliage disproportionately (Xsq. 149.8 > 18.4 Xcrit)

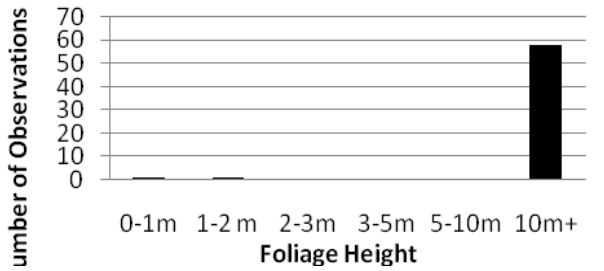


Figure 5.4: Foliage height use by unknown birds. Use is disproportionate (Xsq.294.9>11.1 Xcrit.).

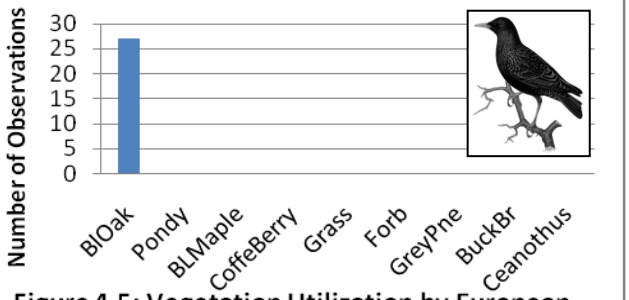


Figure 4.5: Vegetation Utilization by European starlings. Birds use vegetation disproportionately (Xsq. 97.1 > 18.4 Xcrit).

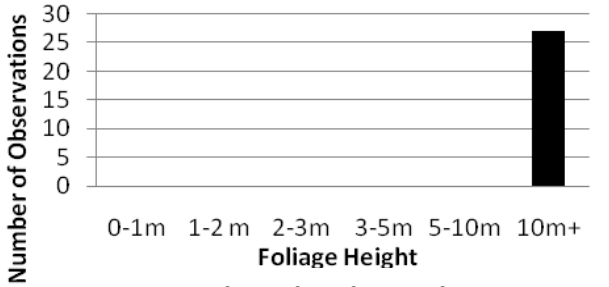


Figure 5.5: Foliage height use by European starlings. Use is disproportionate (Xsq.143.8>11.1 Xcrit.).

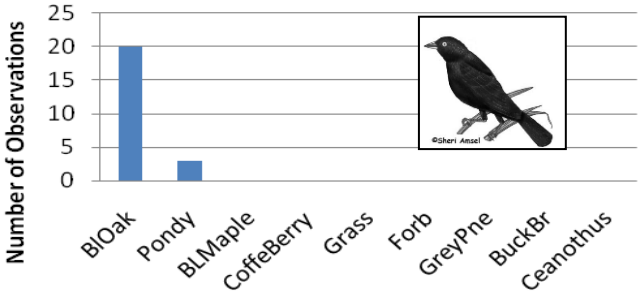


Figure 4.6: Vegetation Species Utilization by Brewer's blackbird. Birds use vegetation disproportionately (Xsq. 62.9 > 18.4 Xcrit).

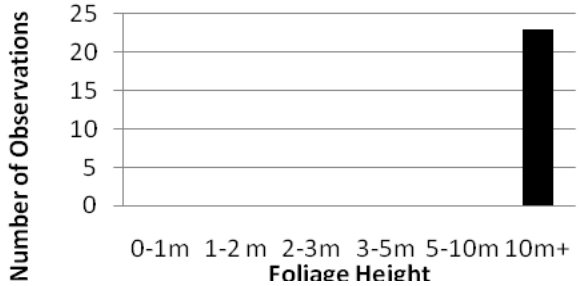


Figure 5.6: Foliage height use by Brewer's blackbird. Use is disproportionate (Xsq.122.5>11.1 Xcrit.).

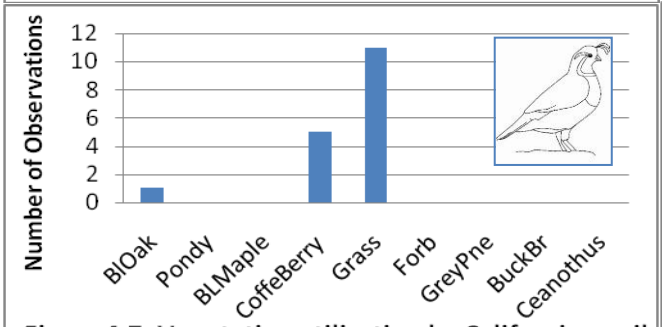


Figure 4.7: Vegetation utilization by California quail. Birds are disprportionately using foliage (Xsq. 32.2 > 18.4 Xcrit)..

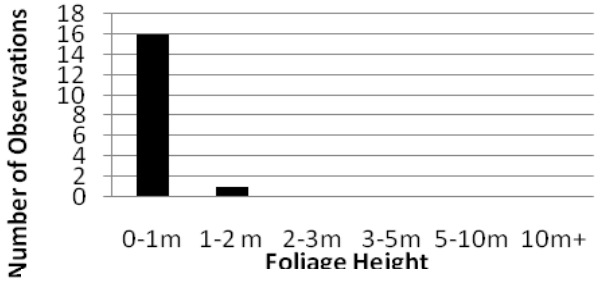


Figure 5.7: Foliage height use by California quail. Use is disproportionate (Xsq.31.7>11.1Xcrit.).

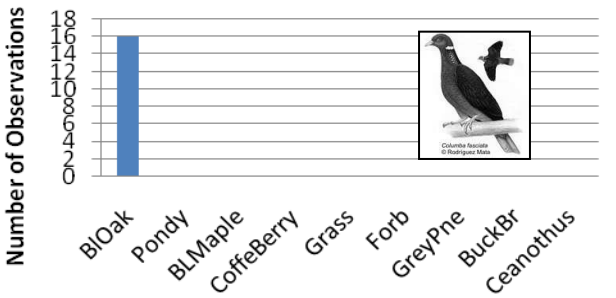


Figure 4.8: Vegetation Utilization by Band-tailed pigeons. Birds use foliage disproportionately (Xsq. 57.2 > 18.4 Xcrit)

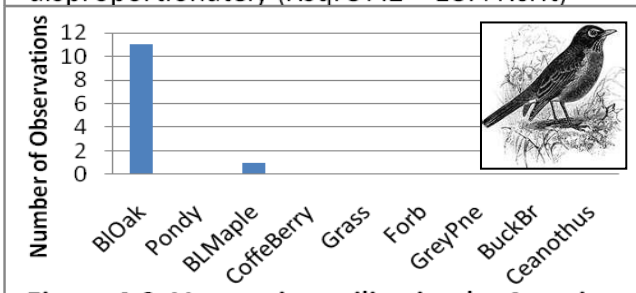


Figure 4.9: Vegetation utilization by American robins. Birds use foliage disproportionately (Xsq. 34.6 > 18.4 Xcrit).

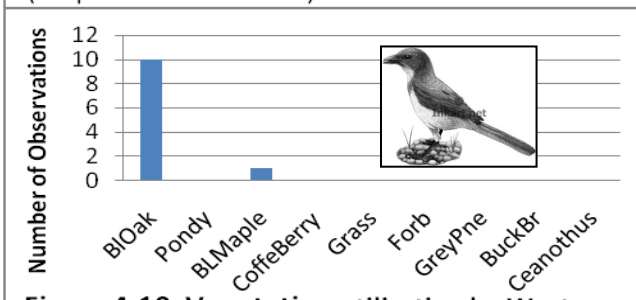


Figure 4.10: Vegetation utilization by Western scrub jays. Birds use foliage disproportionately (Xsq. 32.3 > 18.4 Xcrit).

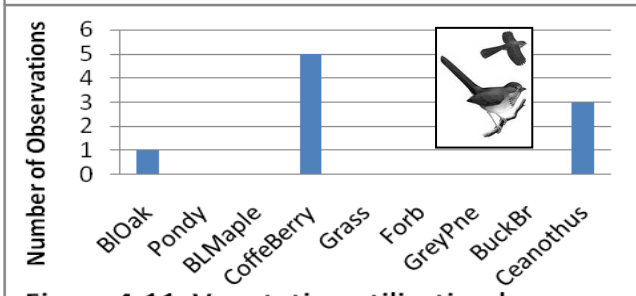
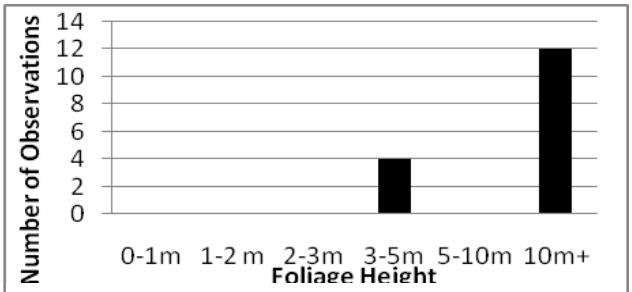


Figure 4.11: Vegetation utilization by California towhees. Birds use vegetation disproportionately (Xsq. 47.9> 18.4 Xcrit).



5.8: Foliage height use by Band-tailed pigeons. Birds use is disproportionate (Xsq. 49.7>11.1 Xcrit.).

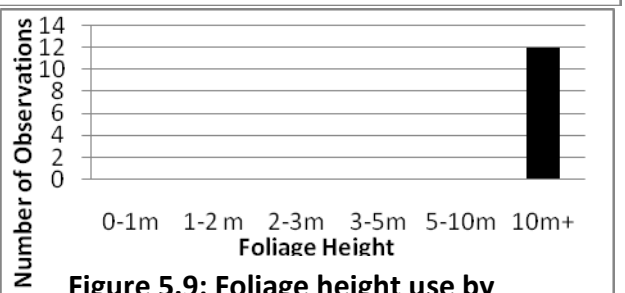


Figure 5.9: Foliage height use by American robins. Birds use is disproportionate (Xsq.69.3>11.1 Xcrit.).

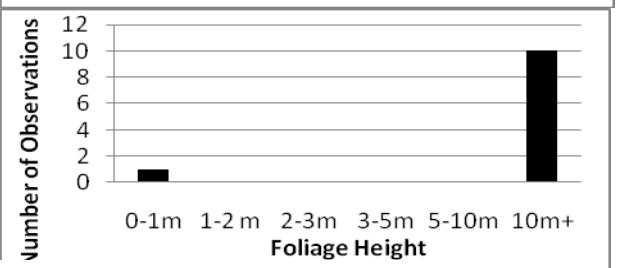


Figure 5.10: Foliage height use by Western scrub jays. Use is disproportionate (Xsq. 58.6>11.1Xcrit.).

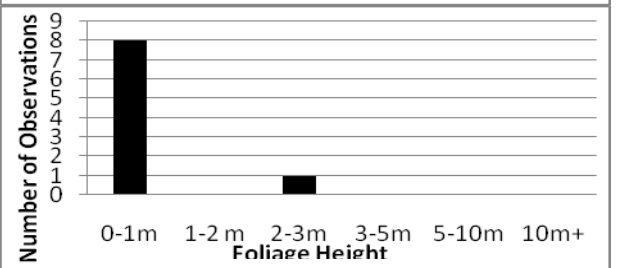


Figure 5.11: Foliage height use by California towees. Use is disproportionate (Xsq. 29.3>11.1 Xcrit.).

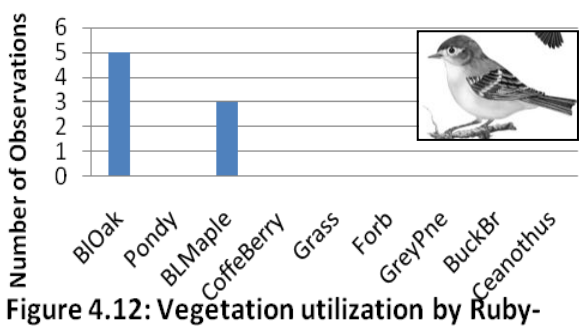


Figure 4.12: Vegetation utilization by Ruby-crowned kinglets. Birds are using foliage disproportionately (Xsq. 23.9 > 18.4).

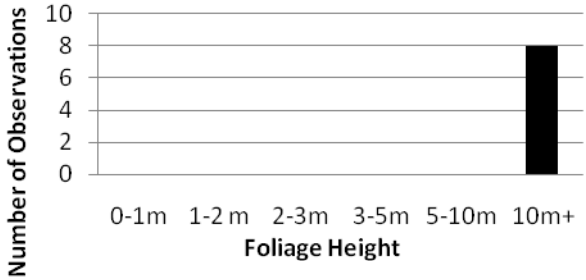


Figure 5.12: Foliage height use by Ruby-crowned kinglets. Use is disproportionate (Xsq. 42.6>11.1 Xcrit.).

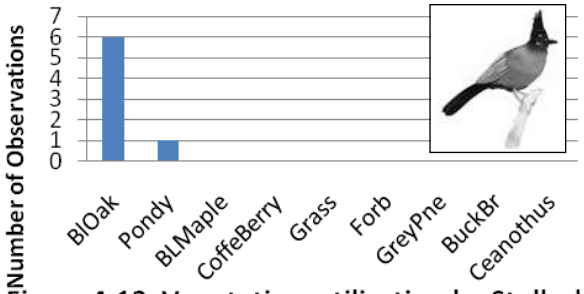


Figure 4.13: Vegetation utilization by Steller's jays. Birds use vegetation disproportionally (Xsq. 18.8 > 18.4 Xcrit.).

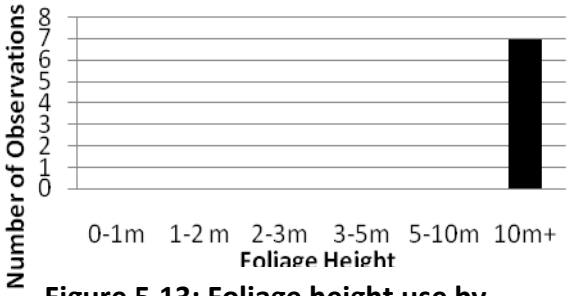


Figure 5.13: Foliage height use by Steller's jays. Use is disproportionate (Xsq.37.3>11.1 Xcrit.).

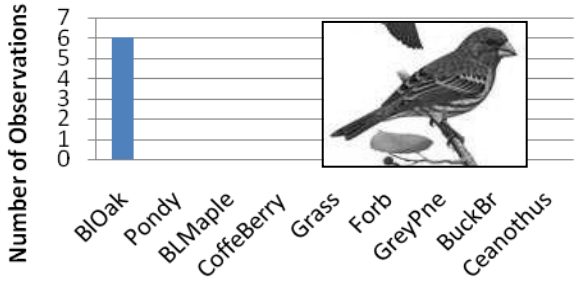


Figure 4.14: Vegetation utilization by House finches. Birds use foliage disproportionately (Xsq. 21.6 > 18.4 Xcrit.).

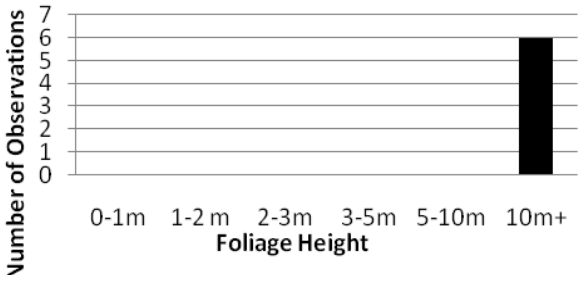
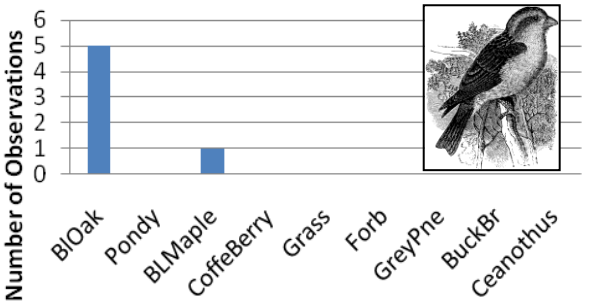


Figure 5.14: Foliage height use by house finches. Use is disproportionate (Xsq.31.9>11.1 Xcrit.).



4.15: Vegetation utilization by Purple finches. Birds use foliage proportionally to vegetation composition (Xsq. 15.9 <18.4 Xcrit.).

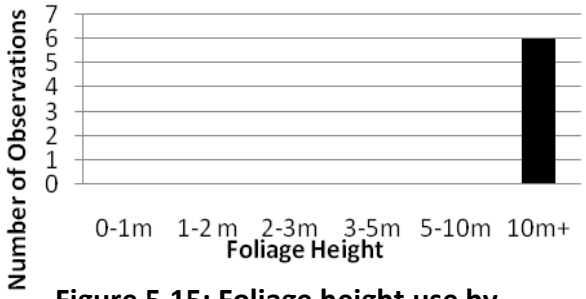


Figure 5.15: Foliage height use by Purple finches. Use is disproportionate (Xsq. 31.9>11.1 Xcrit.).

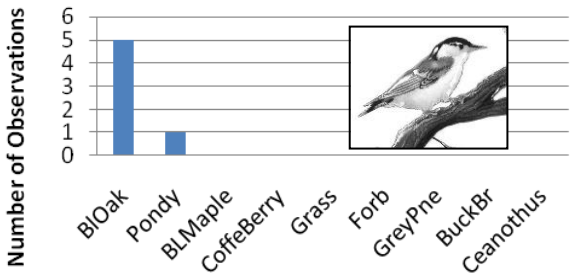


Figure 4.16: Vegatation use by White-breasted nuthatches. We cannot conclude that birds disporoportionally use foiliage (Xsq. 15.6 < 18.4 Xcrit).

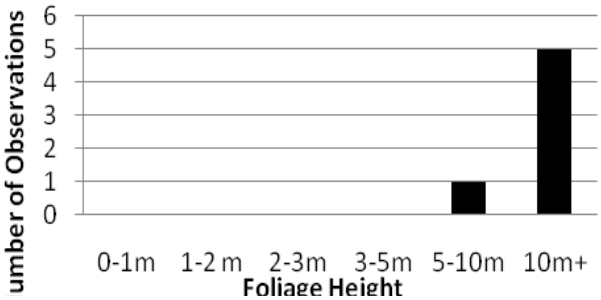


Figure 5.16: Foliage height use by White-breasted nuthatches. Use is disproportional (Xsq. 20.8>11.1 Xcrit.).

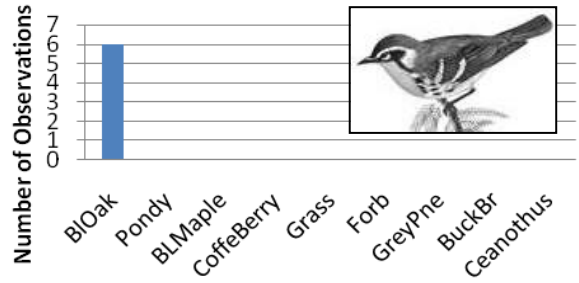
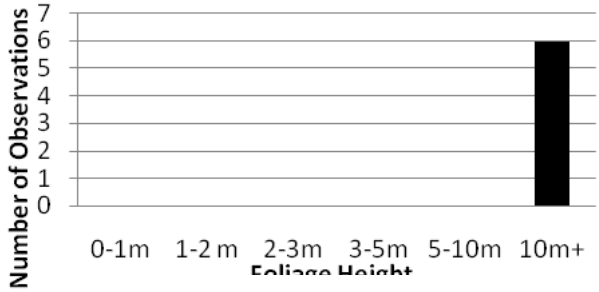


Figure 4.17: Vegetation utilization by Yellow-throated warblers. Birds are using foliage disproportionately (Xsq. 21.7 > 18.4 Xcrit.).



5.17: Foliage height use by Yellow throated warblers. Use is disproportionate (Xsq.31.9>11.1 Xcrit.).

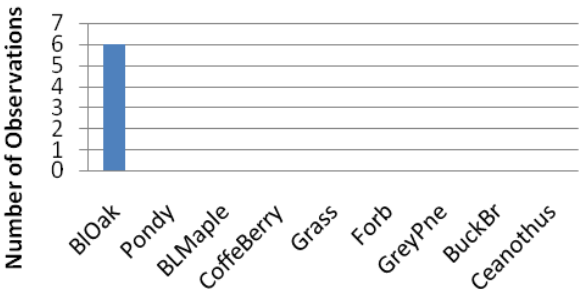


Figure 4.18 Vegetation utilized by unknown warblers. Birds use foliage disproportionally (Xsq. 21.6 > 18.4 Xcrit.).

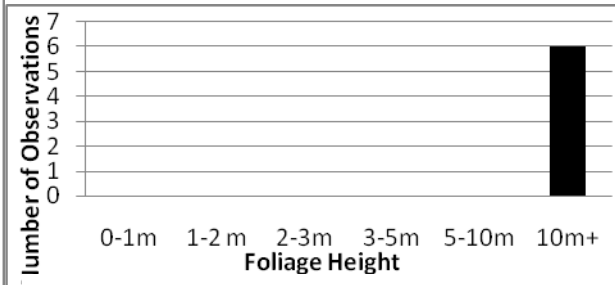


Figure 5.18: Foliage height use by unknown warblers. Use is disproportionate (Xsq. 31.9>11.1 Xcrit.).

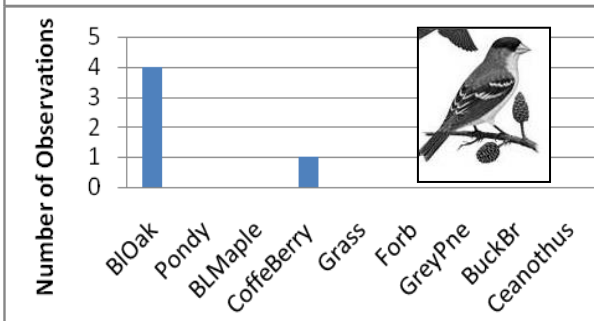


Figure 4.19: Vegetation utilization by Lesser goldfinches. We cannot conclue that birds use foliage disprop[ortionately (Xsq.14.4<18.4 Xcrit.).

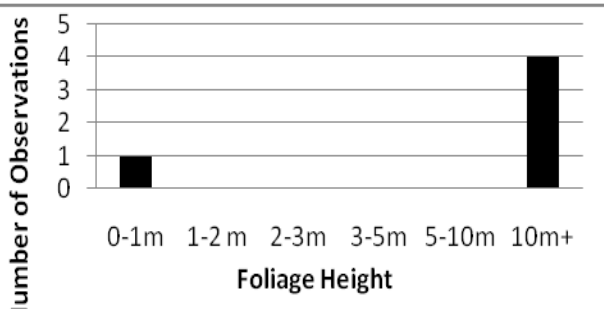


Figure 5.19: Foliage height use by Lesser goldfinches. Use is disproportionate (Xsq. 15.8 >11.1 Xcrit.)

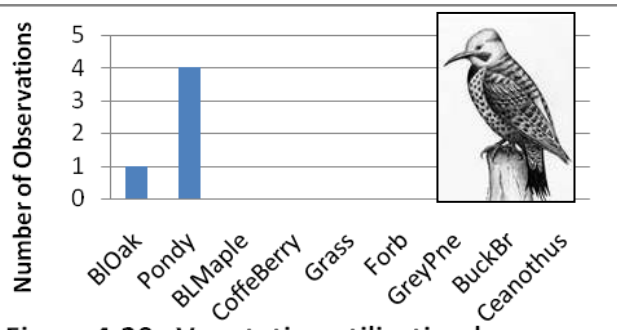


Figure 4.20: Vegetation utilization by Northern flickers. Birds are using foliage disproportionally (Xsq.41.4 > 18.4 Xcrit.).

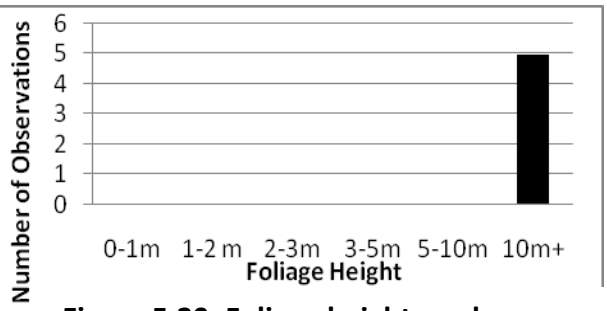


Figure 5.20: Foliage height use by Northern flickers. Use is disproportionate (Xsq.26.6<11.1 Xcrit.).

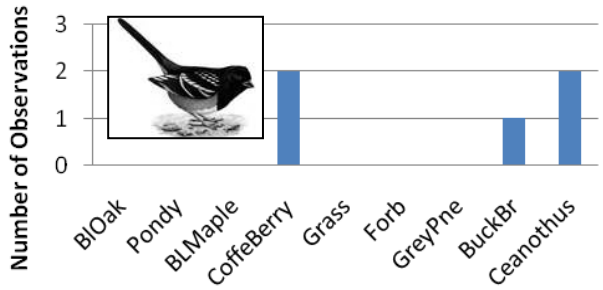


Figure 4.21: Vegetation utilization by Spotted towhees. Birds not analysed by Chi-squared test as "ceanothus" cannot be analysed (it was not present in our initial vegetation surveys).

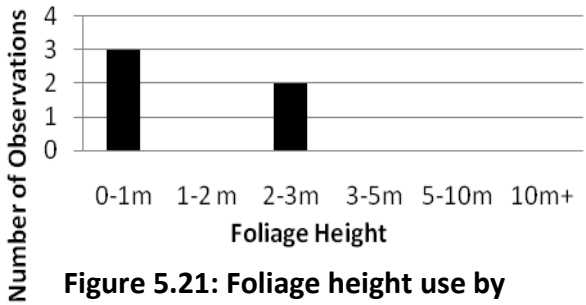


Figure 5.21: Foliage height use by Spotted towees. Use is proportionate (Xsq. 9.1<11.1 Xcrit.).

Literature Cited

Brower J.E, and J.H. Zar. 1984. Field and laboratory methods for general ecology, 2nd edition. Wm. C. Brown Publishers, Dubuque, Iowa. 226pp.

Deppe, Jill L., and John T. Rotenberry. "Scale-Dependent Habitat Use by Fall Migratory Birds: Vegetation Structure, Floristics, and Geography." *Ecological Monographs* 78.3 (2008): 461-87.

Dunn, J.L., and J. Alderfer. 2006. Field guide to the birds of North America, 5th edition. National Geographic Society, Washington D.C.

Encyclopedia Britannica Online. 2011. Edge effects. http://www.britannica.com/EBchecked/topic/179088/edge.effect. Accessed 8 May, 2011.

Gill, F.B. 1995. Ornithology, 2nd edition.W.H. Freeman and Company, New York. 554-555.

Hutto, Richard L. "Ch 16: Habitat Selection by Nonbreeding, Migratory Land Birds." *Habitat Selection in Birds*. Academic Press, Inc., 1985. Web. 10 May 2011. <http://dbs.umt.edu/research_labs/huttolab/PDF/publications/1985-Hutto-book-habitat.pdf>.

Laws, J.M. 1997. The Laws field guide to the Sierra Nevada. John Muir Laws, Berkeley, California.

MacArthur, R.H., and J.W. MacArthur. 1961. On bird species diversity. Ecology 42: 594-598.

MacArthur, Robert H., John W. MacArthur, and James Preer. "On Bird Species Diversity: Prediction of Bird Census from Habitat Measurements." *The American Naturalist* 96.888 (1962): 167-74. Print.

Milne, B.T., A.R. Johnson, T.H. Keitt, C.A. Hatfield, J. David, and P.T. Hraber. 1996. Detection of critical densities associated with pinon-juniper woodland ecotones. Ecology. 77:805-21.