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Does tree size affect northern spotted owl prey species richness?

Introduction

The northern spotted owl (NSO) is federally listed as a threatened species and has been continually monitored for over twenty years. The HJ Andrews demography study has closely monitored their survival, fecundity, and population, however, little is known regarding the distribution of the owl's prey base. In the west Cascades the NSO is an old-growth obligate species that hunts primarily on arboreal prey, creatures that spend their life in trees. Owls regurgitate the less-digestible parts of consumed prey such as bones, feathers, fur, and insect parts in a neat package known as a pellet. When owl surveyors encounter pellets they are collected and UTMs are recorded. Each pellet is linked to a site location and a list of prey items contained within that pellet. Pellet information is combined in a relational database to represent owl pair per site as determined by the spotted owl demography protocol (Franklin *et al.* 1996). The prey composition will be represented as species richness, which is a total count of different prey items found in that site. I expect that as the number of prey species decreases, the amount of old-growth forest also decreases within northern spotted owl nest patch and core.

The presence of down wood and larger old-growth patch sizes have been strongly related to spotted owl site selection (Meyer *et al.* 1998). Pellet locations are often around nest trees. For this study two sizes are considered for spatial analysis: the nest patch (300 m radius) and core (800m radius). These values were derived from telemetry studies and landscape occupancy models (Olson et al. 2005, Dugger et al. 2005, Zabel et al. 2003, Swindle et al. 1999, Meyer et al. 1998, Glenn et al. 2004, and Carey et al. 1992).

Methods

The analysis time line will include 2000-2005 pellet and demography data for two reasons. First, the gradient nearest neighbor (GNN) vegetation data is for the year 2000 (Ohmann and Gregory 2002). There was little disturbance to the landscape in the study region after 2000 except for the Clark Creek and B&B fires both of which occurred in 2003. Second, I feel that barred owls would not have such a confounding effect on detectability of spotted owls before 2004.

In order to build a GIS in ArcGIS 9.3 the following datasets are required.

- GNN map of existing vegetation, 2000 data from the LEMMA IMAP homepage http://www.fsl.orst.edu/lemma/gnnpac/
- pellet data and occupancy locations for six years obtained from Oregon Cooperative Fish and Wildlife Research Unit (OCFWRU)
- HJ Andrews Study area boundary

The GNN vegetation layer is obtained through the Lemma (Landscape Ecology, Modeling, Mapping, & Analysis) portal. This portal provides spatially explicit raster data for the all physiographic provinces involved in the Northwest Forest Plan with a 30 x 30m pixel size. For the purposes of this study I used West Cascades physiographic province. It provides regional gradients of tree species composition and forest structure. The HJ Andrews demography study is located along the western slope of the Cascade Range in Oregon in the Willamette National Forest. The forest is dominated by Douglas-fir. I chose size class as the stand level summary because it is as accurate as Landsat TM (Ohmann and Gregory 2002) and the tree species is homogenous across the range of the study area. Another consideration was the possible exclusion of foraging habitat such as lava fields and high elevation meadows, which would be excluded using a dominant species cover class. Land cover type will be divided into six tree size classes based on the criteria of Johnson and O'Neil (2001) and considered as percent of the buffered location (nest patch and core). The GNN layer (Mr6_sppsz, Flowchart 1) was *reclassified* in the following way:

1. Non forest: This includes roads, water bodies, and grass lands.
2. Shrubs/seedlings: Quadratic mean diameter area of dominant canopy (QMDA_DOM) less than 2.5 cm, or canopy cover less than 10%
3. Saplings/small stands: QMDA_DOM greater than 2.5 cm and less than 37.5 cm
4. Medium stands: QMDA_DOM greater than 37.5 cm and less than 50 cm
5. Large stands: QMDA_DOM greater than 50 cm and less than 75 cm
6. Giant stands: QMDA_DOM greater than 75 cm

After the GNN layer was reclassified it was *clipped* to the size of the HJ Andrews study area boundary. With a manageable sized raster, I was able to use *raster to features* to change the layer into a vector (Figure 1).

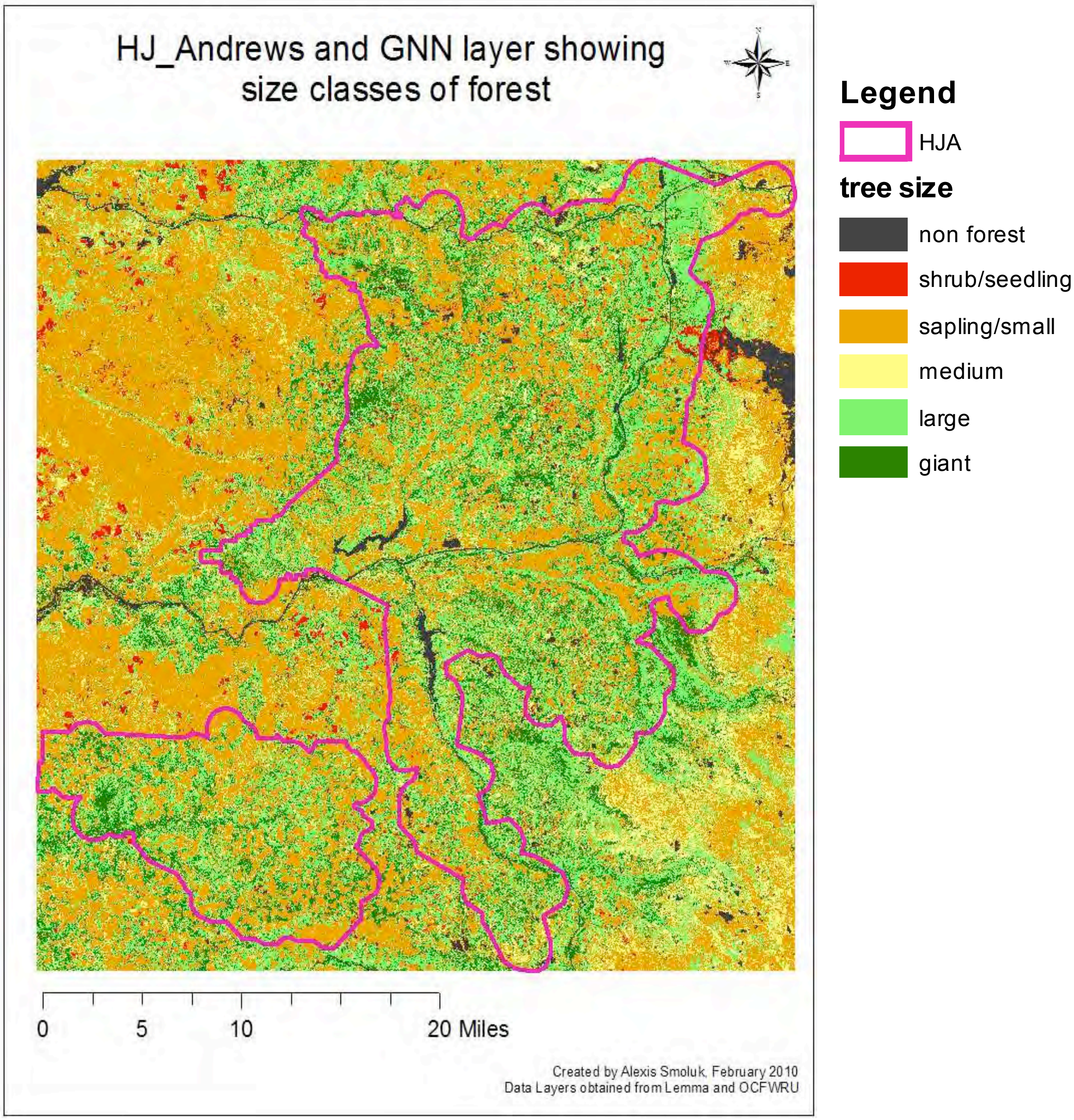


Figure 1: HJ Andrews study area and the gradient nearest neighbor vegetation layer after it was reclassified based on tree size classes.

Spotted owls are "central place" foragers with the core area being the focal area (Rosenburg and McKelvey 1999). Best annual owl locations were buffered using the *buffer* tool at 300m radius to create a nest patch and an 800 m radius to create the core. Buffers were dissolved at the site name. A relational database was created in Access 2003 to link the pellet data and demography data using the site name as the key. The core was overlaid onto the converted GNN layer and "cookie" cuts (Figure 2) were obtained using the *intersect* tool. This process was repeated for the nest patch. Flowchart 1 outlines this process.

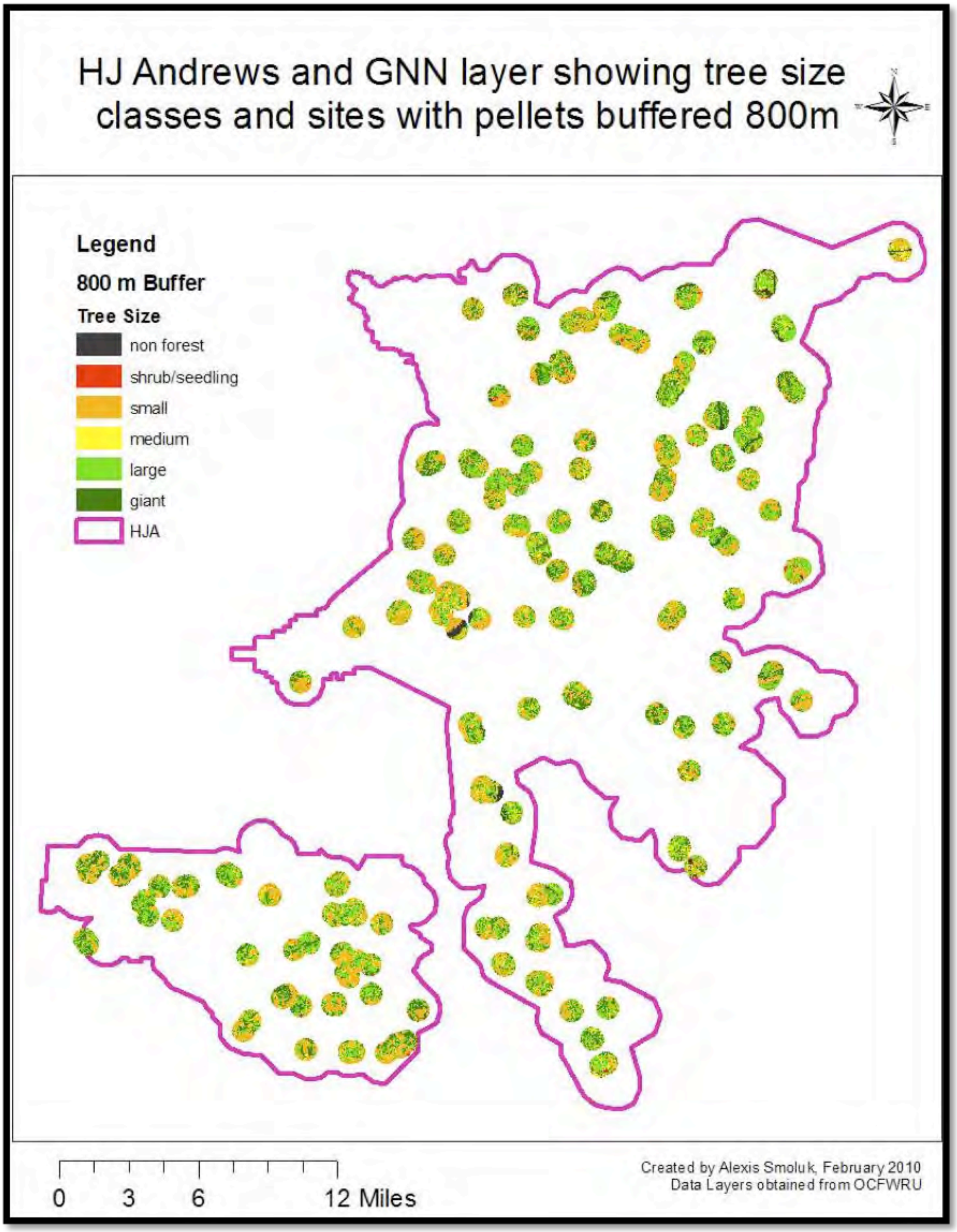
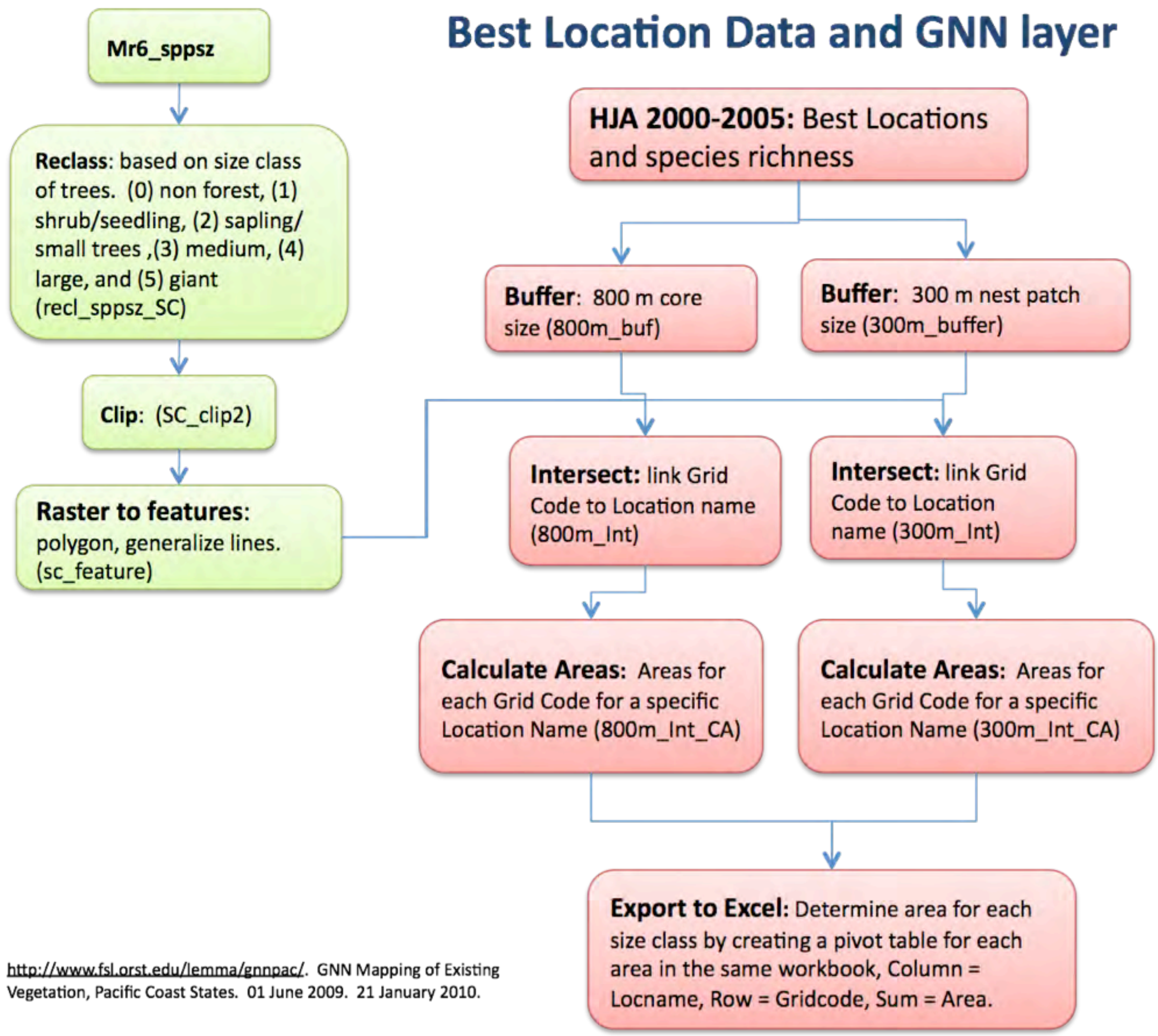


Figure 2: Cookie cuts using 800 m buffered owl locations in converted GNN vegetation layer.

In order to calculate areas the spatial analyst tool, *calculate areas*, was used on both sets of cookies (nest patch and core). The resulting tables were exported into Excel. Pivot tables were produced to calculate the percentage of tree size class in each owl site.



Flowchart 1: Spatial analysis flowchart. Green bubbles are GNN vegetation layer and the red bubbles are the spotted owl prey species data.

The experimental unit is the owl site (n=113). There are 49 different prey species or groups in the HJ Andrews study area and 1,782 total prey items for the years 2000-2005.

Considering all prey items, the pellet data was brought into Excel. The resulting sheet tallied the number of individual prey species for each site. The tallied numbers were changed into a binary form showing presence (1) and absence (0) of a prey item for every site. Presence/absence is the response variable to the different tree sizes. This is called "count" and represents the total number of different species present in a site or species richness.

Results

A one-way ANOVA was performed on all tree size classes with count being the response variable. Table 1 presents the minimum, maximum, mean, standard deviation, and the one-way ANOVA p-value for size classes at each radius. Looking at the standard deviation, there is more variability between percentages of tree size classes at the nest patch scale than at the core scale. There is no statistical evidence that species richness increases with tree size, p-values are all greater than 0.1. The contribution from the shrub size class is negligible except for two sites: Bear Pass and East Beaver Marsh. Both sites contain high elevation meadows. The average

Table 1: Tree classes at different radii (300m and 800m) with their respective minimum, maximum, mean, standard deviation, and one-way ANOVA p-values.

300m	min	max	mean	St dev	ANOVA p-value
giant	3.32	57.17	23.95	12.1	0.28
large	4.29	71.66	37.02	14.1	0.58
medium	0	35.8	8.86	6.18	0.7
small	2.85	79.35	28.22	17.13	0.75
shrub	0	8.05	0.265	0.98	
800m					
giant	6.93	46.98	21.6	8.78	0.26
large	10.69	59.52	33.74	8.33	0.19
medium	0.45	24.84	9.41	3.89	0.12
small	5.78	56.04	32.84	11.9	0.11
shrub	0	4.01	0.42	0.79	

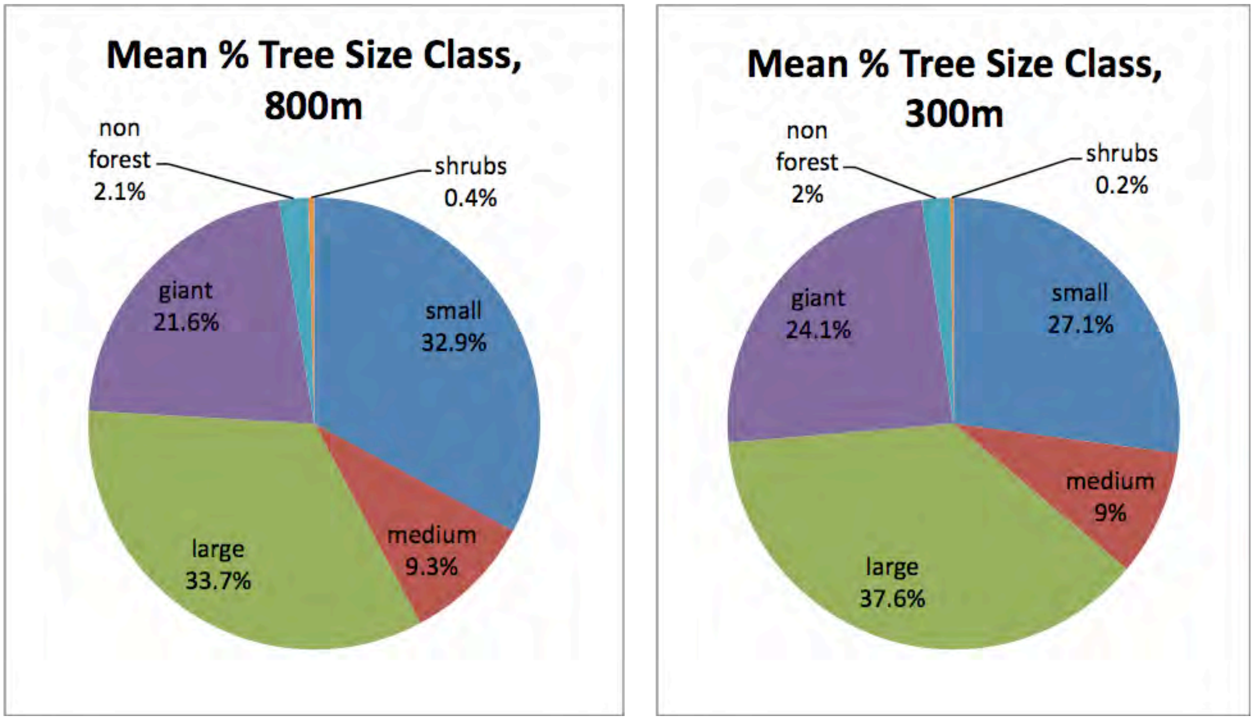


Figure 3: Mean percent contribution of tree size classes at the core (800m) and nest patch (300m).

percent contribution to tree size classes is displayed in Figure 3. As the radius increases, percent contribution from large and giant trees decreases.

Considering the extreme cases, average count and all the accompanying data linked to each site, the sites were ranked by count and tree sizes. Further statistical analysis is beyond my skill level at this time. The top ten sites showing the greatest percentages from each of the categories (5 tree classes and mean of 113 sites) were averaged (Table 2 and 3). Species richness appears lowest when shrubs, small, and medium trees have the greatest percentage. Species richness is higher when medium trees remain below 10%. Species richness increases as giant trees increase (Figure 4).

Table 2: For each tree size at 300m the overall average of all the sites and the top 10 averages from count, shrub, small, medium, large, and giant size classes are listed. This data is used for Figure 1 and 3.

Class 300m	average count	Non forest	shrub	small	medium	large	Giant
Overall average	5.57	1.68	0.27	28.22	8.86	37.02	23.95
count	11.5	3.64	0.24	24.61	6.35	33.16	31.99
shrub	5.1	0.54	2.59	36.69	6.26	33.47	20.46
small	4.7	0.59	1.12	62.47	5.36	16.17	14.29
medium	5	1.85	0.04	24.79	22.57	37.53	13.21
large	4.9	0.18	0.54	13.10	7.74	62.52	15.92
giant	6.9	0.77	0.03	14.36	4.45	32.15	48.25

Table 3: For each tree size at 800m the overall average of all the sites and the top 10 averages from count, shrub, small, medium, large, and giant size classes are listed. This data is used for Figure 2 and3.

Class 800	average count	non forest	shrub	small	Medium	large	giant
Overall average	5.57	1.98	0.42	32.84	9.41	33.74	21.60
count	11.5	2.29	0.64	25.73	7.81	34.44	29.09
shrub	4.1	3.02	2.58	31.06	9.67	37.29	16.39
small	5.3	0.32	0.21	52.88	8.77	23.72	14.09
medium	4.4	2.04	0.48	32.58	16.60	30.85	17.45
large	6.2	3.01	0.36	18.61	7.83	48.61	21.58
giant	6.6	0.59	0.20	22.42	6.93	30.77	39.09

The top ten sites with the highest count were also averaged (Table 2 and 3). It is important to note, that nine out of ten sites with the highest species richness are sites that have the most pellets. For this reason count may not be reliable for comparison with other tree size classes. Except for a site called Lookout Hagan, which had 18 prey items containing 10 different species (Table 4). This site is an outlier. It contains very little large and giant forest. What is interesting about this site is that it is occupied by a pair that has trouble reproducing successfully.

Table 4: Top ten sites with highest species richness (count) and total prey from three key prey species. ARLO (red tree vole), GLSA (northern flying squirrel) and THMA (pocket gopher). The large % of non-forest associated with Lower Browder is Smith Reservoir; with Tamolitch Falls is highway 126. Only % with 300m buffer is shown.

Location Name	count	Prey items	ARLO	GLSA	THMA	non 300	shrub 300	small 300	med 300	large300	giant 300
MACK CREEK	14	69	9	36	1	0.00	0.00	8.35	4.05	49.51	38.09
TAMOLITCH FALLS	14	56	0	29	5	12.75	0.00	13.61	3.25	52.37	18.03
ELBOW CANYON	13	69	5	21	1	0.54	0.00	19.16	8.95	27.49	43.87
LITTLE FALL CREEK	13	57	22	17	0	0.00	0.08	20.82	6.13	27.95	45.02
EAST WILDCAT	11	57	0	30	1	0.50	2.16	15.13	10.28	33.36	38.57
LOWER BROWDER CREEK	10	33	0	13	5	21.92	0.00	6.74	4.85	37.90	28.58
BUDWORM CREEK	10	47	2	27	4	0.00	0.19	20.33	3.75	29.25	46.49
AUGUSTA CREEK	10	41	2	14	5	0.00	0.00	27.46	9.46	30.79	32.30
LOWER MCRAE CREEK	10	35	2	18	1	0.66	0.00	35.18	5.15	38.73	20.27
LOOKOUT HAGAN	10	18	0	4	0	0.00	0.00	79.35	7.67	4.29	8.68

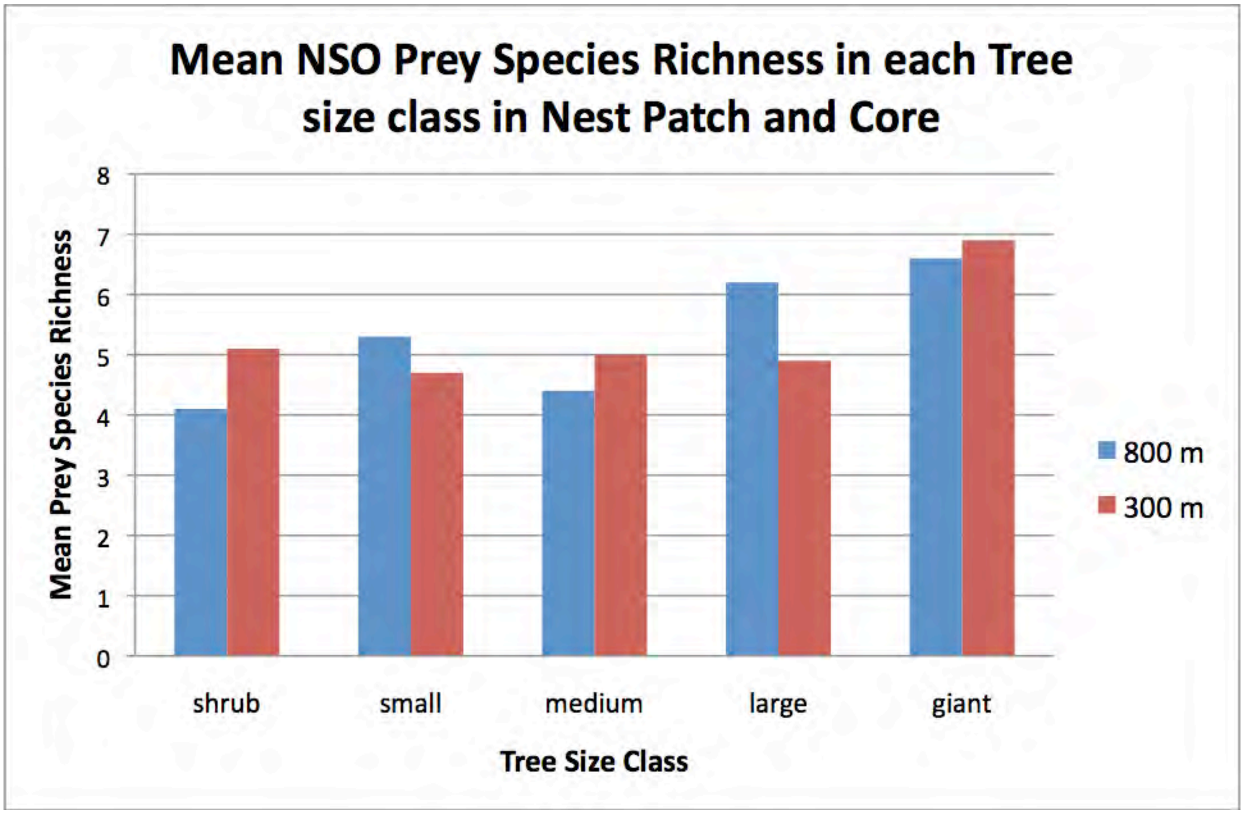


Figure 4: Mean northern spotted owl prey species richness in each tree size class for both the nest patch (300m) and core (800m). Species richness increases as tree size class increases.

Discussion

Looking at Figure 3, it appears that as tree size increases, species richness also increases. Although a difference is observed, the relationship between tree size and species richness is not statistically significant (Table 1). Pellets are found where owls are found. Species richness is not the best way to evaluate this data for many reasons. The data is not randomly collected; pellet collection is left to the whim of the owl surveyor. Because the data is not random, inferences about abundance of prey species cannot be considered. If we had owl pellets from other large owl species that occupy different habitat types such as the great grey owl and the great horned owl, then we may be able to make associations between prey item location and tree size classes. A sample size of 1782 prey items is not large enough to evaluate presence/absence of prey species. This could be amended by extending the time frame to include 1980-1999. Extending the time frame would require the addition of time-step disturbance maps.

Since owls are central place foragers (Rosenburg and McKelvey 1999) they are likely to egest pellets at their roost. In the HJ Andrews owls have a large core (800m radius) and home range (1900 m radius) (Olson *et al*. 2005, Dugger *et al*. 2005, Zabel *et al*. 2003, Swindle *et al.* 1999, Meyer *et al.* 1998, Glenn *et al.* 2004, and Carey *et al.* 1992). When they choose to nest, the chance of finding owl pellets increases. The pellet location says little about the habitat preference of the prey item. Dugger et al (2005) showed that when owl cores reach 50-60% older forest habitat, spotted owl fitness (survival and reproduction) was higher than in core areas with lesser amounts. The owls in the HJ Andrews study area are historically found in forest with large and giant trees (Figure 3) (Forsman *et al.* 1984, Seamans *et al.* 2007). Therefore all prey species will appear associated with large and giant forests regardless of habitat needs for that species.

Prey species composition is another important consideration. Each prey species does not evenly contribute to the northern spotted owl diet (Table 5, Figure 5). Over 44% of the diet came from one prey item, the northern flying squirrel (*Glaucomys sabrinus*). The presence of this prey item may be important to northern spotted owl site selection in the Willamette National Forest.

Table 5: 5 prey species and the percent of total prey items (1782), the actual prey count, and the number of sites that the prey item occurred.

Prey species	percentage	# prey occurrence	# site occurrence
Red tree vole	9.09%	162	50
Flying squirrel	44.2%	788	105
Pocket gopher	4.32%	89	41
Red-backed vole	11.27%	201	66
Bushy-tailed woodrat	4.99%	77	42

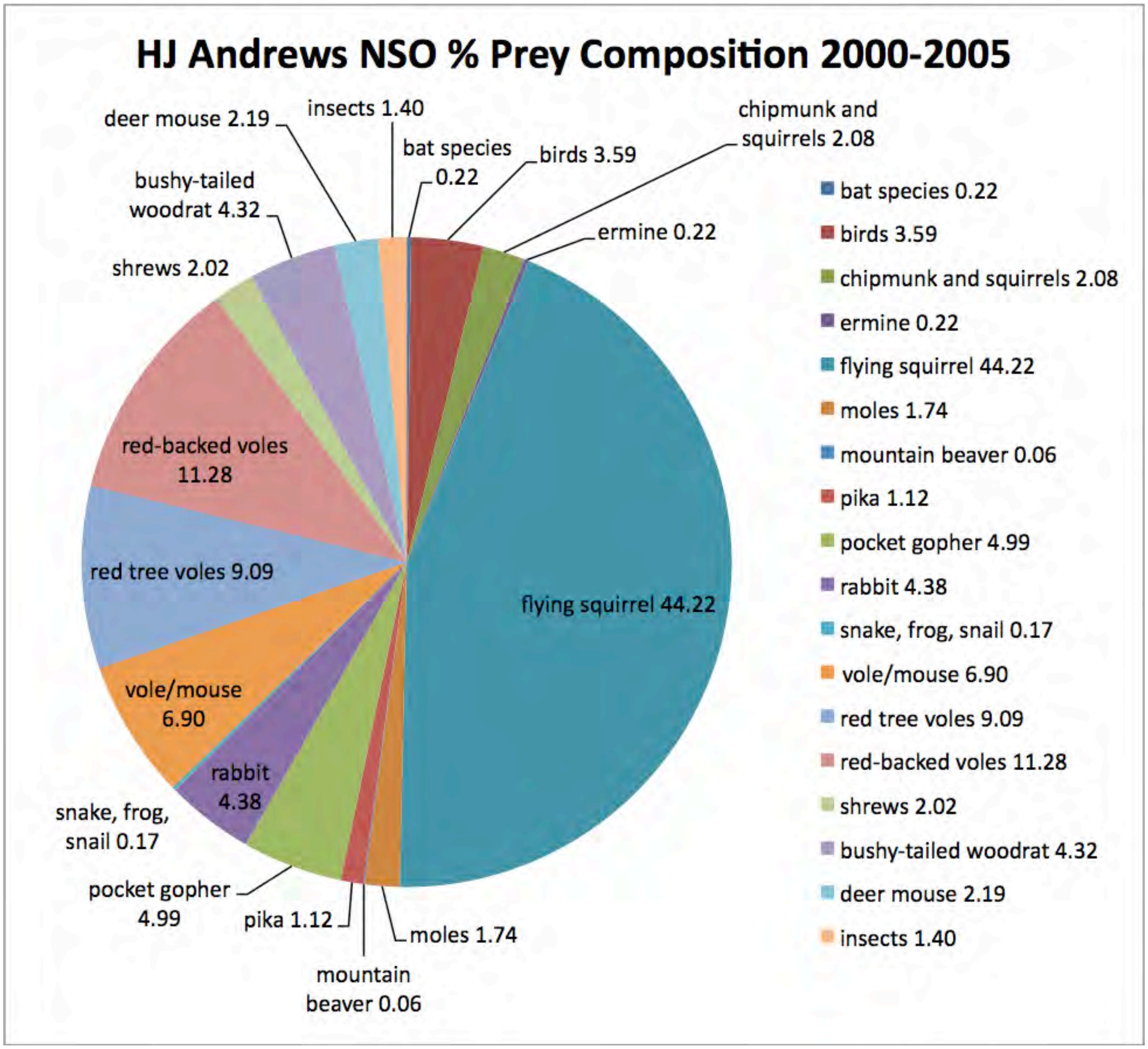


Figure 5: HJ Andrews spotted owl prey composition for the years 2000-2005. Note, some groups like diurnal squirrels and chipmunks were lumped in this figure, but kept separate for analysis. The purpose of this image is to display the uneven distribution of prey items.

This raised the question: how important is species richness to this dataset? Twenty-six prey items occur less than 5 times. Five prey items occur most often. After considering all the information, I feel species richness is not an informative way of analyzing this data. Table 5 presents the 5 key prey species, percent of total prey items (1782), the actual prey count, and the number of sites that the prey item occurred. Key prey species were identified as northern flying squirrel (*Glaucomys sabrinus*), red tree vole (*Arborimus longicaudus*), red-backed vole (*Clethrionomys californicus*), pocket gopher (*Thomomys mazama*), and bushy-tailed woodrat (*Neotoma cinerea*). These species represent 72% of the total prey items. Key species distribution and their ties to the landscape is a more relevant investigation. Another consideration would be comparing tree size to the absence of key prey species.

The presence of flying squirrels is perhaps vital to sustaining spotted owl populations in the Willamette National Forest. Flying squirrels were found everywhere, except in 8 sites. This appears to be a result of under-sampling, because sites without flying squirrels are dispersed among sites containing flying squirrels. Just like the spotted owl, flying squirrels prefer coniferous and mixed forests with large decadent snags (Burt and Grossenheider 1980).

The red-backed vole and bushy-tailed woodrats appear to show no pattern across the landscape; although I expected woodrats to occur more often (Table 5). Perhaps extending the time frame can show a greater distribution.

The red tree vole is an arboreal vole that subsists on Douglas-fir needles. This vole utilizes the inedible resin ducts to create nest structures on wide platforms in giant trees. Home ranges are limited to one or more trees (Carey 1999). The red tree vole appears to be absent from the Northwest and occurs infrequently in high elevation sites. Figure 6 displays the HJ Andrews study area boundary overlaid onto Digital Elevation Model (DEM) with maximum contrasting color. The black dots are pellet locations and the red dots are pellet locations containing red tree voles.

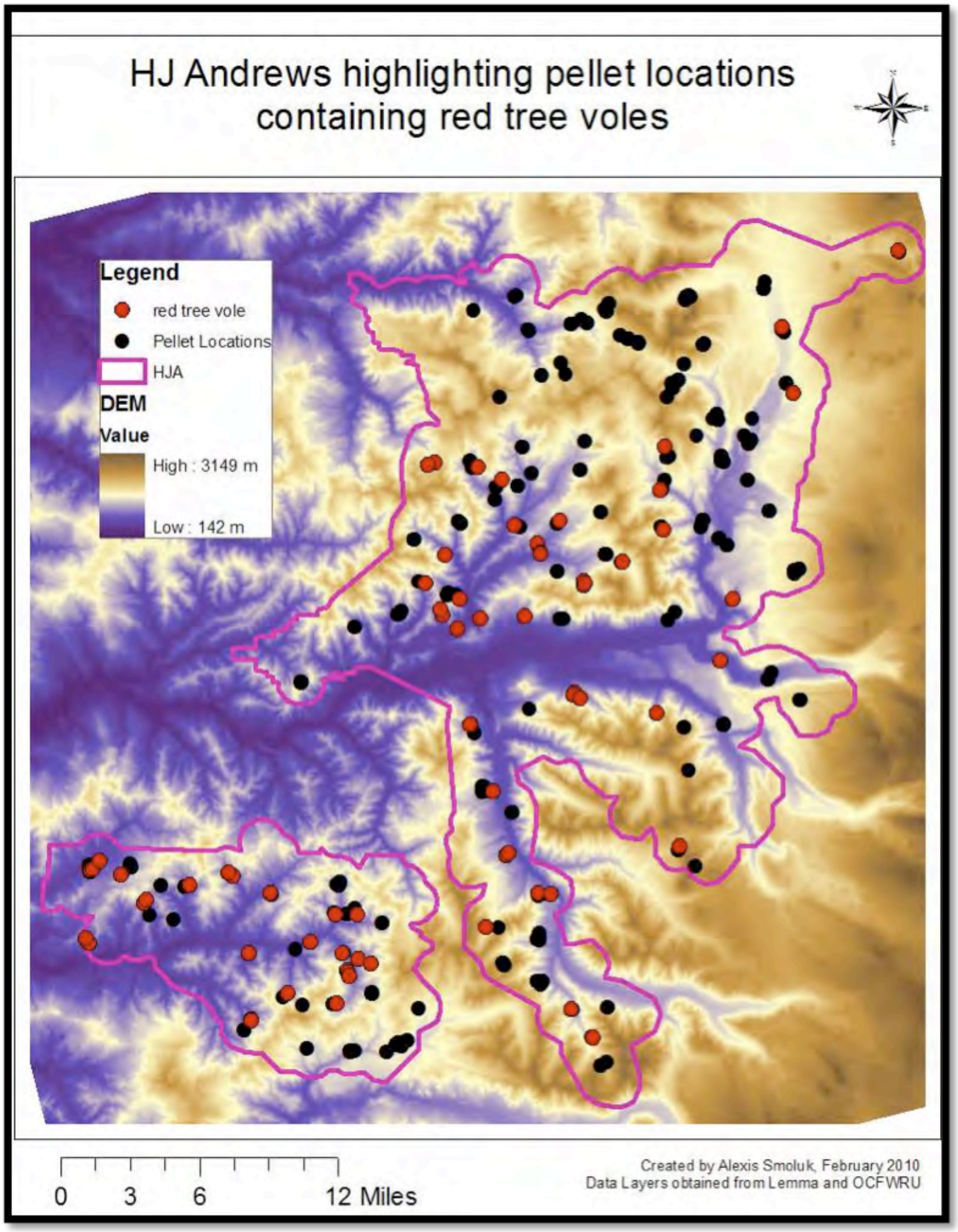


Figure 6: Pellet locations containing red tree voles on the HJ Andrews northern spotted owl demography study during the years 2000-2005.

In contrast pocket gophers do not appear in low elevation sites, and are absent from Southwest portion of the study. Figure 7 displays the HJ Andrews study area boundary overlaid onto a DEM. The black dots are pellet locations and the red dots are pellet locations containing pocket gophers. Pocket gophers are fossorial mammals; they spend the majority of their lives underground. Presence of prey species is most easily explained by the presence of preferred habitat and the range of the species.

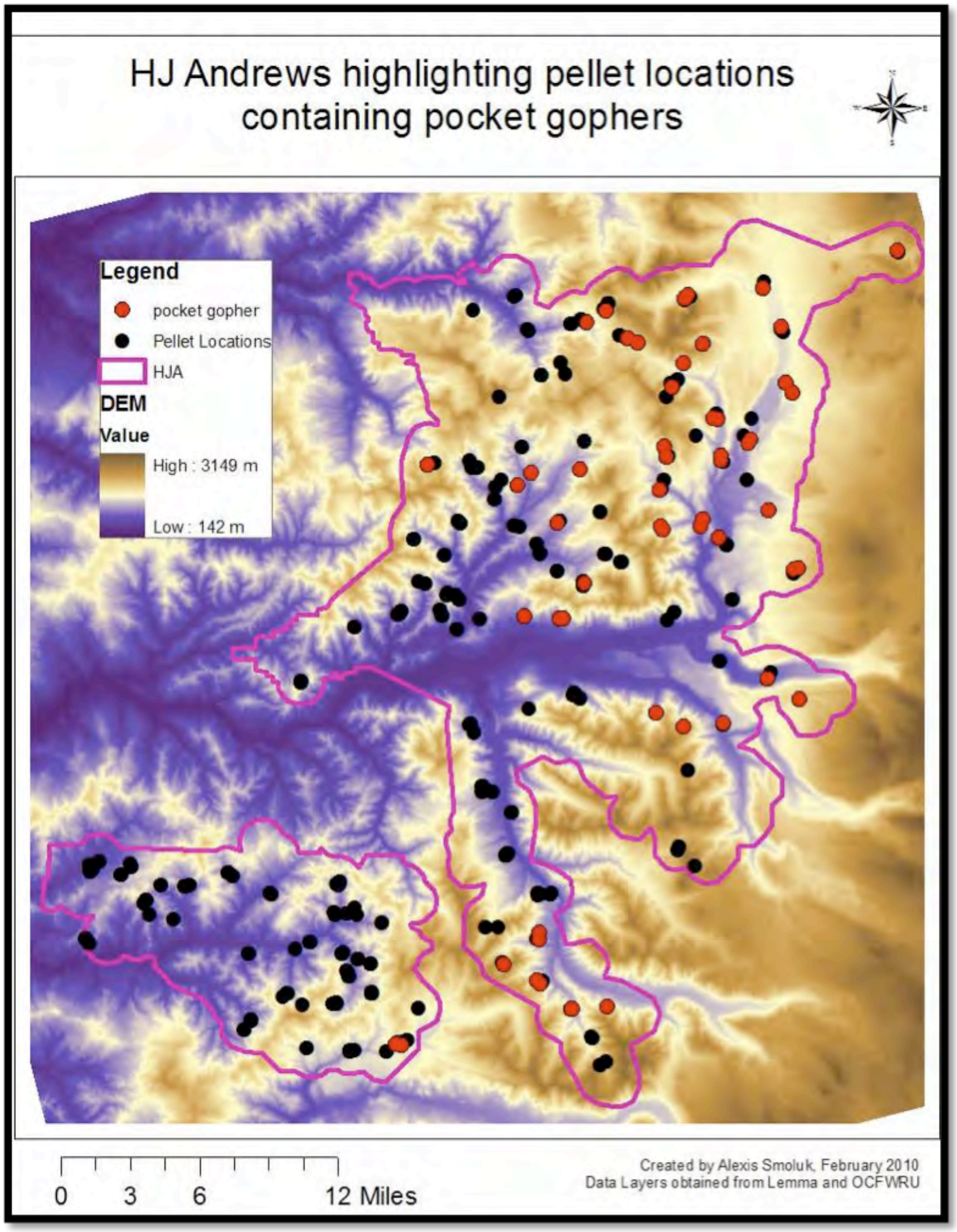


Figure 7: Pellet locations containing red tree voles on the HJ Andrews northern spotted owl demography study during the years 2000-2005.

This data set has many possibilities, especially with the inclusion of demography data. Looking at the demography data, we can tease out nest attempts and non-nesting pellet samples to see if the absence of key prey items is related to nest success. The data can be examined spatially by listing the various prey species consumed by the owl and evaluating the relationship between owl's prey and the landscape. Stratified sampling for prey abundance can begin with the locations gathered from prey data. By including a longer time frame we may get a clearer picture of the distribution of prey items across the landscape. Even though inferences regarding abundance cannot be made, the changes in percent contribution of prey items may be relevant since the arrival of the spotted owl's congeneric competitor, the barred owl (*Strix varia*). Barred owl pellets are difficult to obtain. We may be poised to ask questions about prey base disruption with the inclusion of the barred owl into the community. The next step with this data is a community analysis. But that will have to wait until winter 2011.

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