Monitoring Songbird Populations at the Pioneer Butte Meadow Restoration Project, Siuslaw National Forest

Survey Methods & 2011-2013
Pre-Treatment Results

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Contents

INTRODUCTION

The Siuslaw National Forest (SNF) is planning to conduct habitat restoration activities in 2014 at a site known as Pioneer Butte, Benton County, Oregon (Fig. 1). The SNF is planning to remove most conifers on the site and enlarge the existing openings to benefit wildlife that use early successional habitat. Such habitat has become rare on the SNF since the adoption of the Northwest Forest Plan. Conifer removal will result in an expanded opening of approximately 9 ac (3.6 ha) on the site (Cindy McCain, Siuslaw National Forest, pers. comm).

The SNF restoration site at Pioneer Butte averages approximately 1280 ft (390 m) elevation on the northeast slope of Marys Peak in the Oregon Coast Range. The site lies on a generally southern aspect and drains to an intermittent tributary to Rock Creek, a major supply of water to the City of Corvallis. Forest vegetation on Pioneer Butte is presently dominated by large Douglas-firs (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), big-leaf maple (*Acer macrophyllum*), chinquapin (*Castanopsis chrysophylla*), with other scattered hardwoods in the sub-canopy layer. During the late-1800's, Pioneer Butte lay at the transition between Douglas-fir forest, mixed Douglas-fir/oak (*Quercus garryanna*) woodland, and oak savanna habitat types (Figure 2, Tobalski 2002). The SNF site includes an abandoned homestead with small scattered openings that probably are remnants of what were once more extensive livestock pastures.

At least 91 passerine and woodpecker species are known to inhabit Douglas-fir forests of the Oregon Coast range (Carey et al. 1991). The diversity of avian communities in the region, their well-studied species-habitat relationships, and the relatively low cost of breeding bird surveys (as compared to herpetofauna or mammal surveys), make songbirds excellent subjects of wildlife management monitoring studies.

To characterize pre-treatment conditions at Pioneer Butte, I conducted avian surveys during the 2011-2013 breeding seasons and collected vegetation data during the summer of 2013. I also selected three bird species that that are likely to exhibit different responses to the restoration activities. These three avian "indicator species" are the dark-eyed junco, hermit warbler, and Pacific wren. All three species are widely distributed in the Oregon Coast Range; establish territories that are typically much smaller than the Pioneer Butte restoration area, and whose habitat relationships have been relatively well studied (Appendix I). Given their habitat preferences, dark-eyed junco populations could be expected to expand as the meadow area at Pioneer Butte increases, hermit warblers would be excluded as canopy cover decreases, but may respond to edge effects, and Pacific wrens are likely to be particularly sensitive to coarse woody debris retention and soil disturbance on the site (Table 1). I did not select birds that are closely associated with Willamette Valley grassland or savanna habitats as indicator species because the small size of the meadow (even after restoration) and the conifer forest landscape in which is embedded make it unlikely that such birds will ever occupy the site.

I also surveyed birds at a site owned by the City of Corvallis where an overstory thinning and 3.0 ac (1.2 ha) meadow restoration project had been completed in 2010. The City-owned property is located less than ½ mile from the SNF Pioneer Butte site. This presented an opportunity to collect and examine data on short-term, post-treatment effects for the same species of birds on a meadow site that is similar to planned conditions for the SNF site.

Figure 1. *Overview of the landscape surrounding the Siuslaw National Forest's Pioneer Butte meadow restoration site (SNF Plot) and the City of Corvallis 2010 restoration site (City Plot). Imagery is from 2009.*

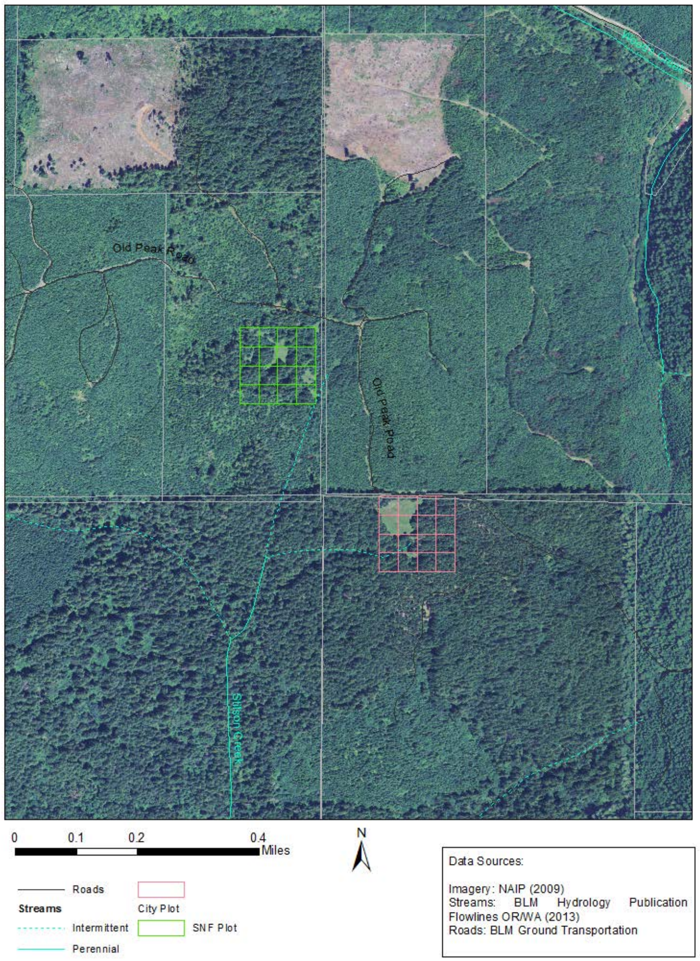


Figure 2. *Late nineteenth century vegetation patterns in the vicinity of Pioneer Butte. Mapping methods are described by Christy and Alverson (2011).*

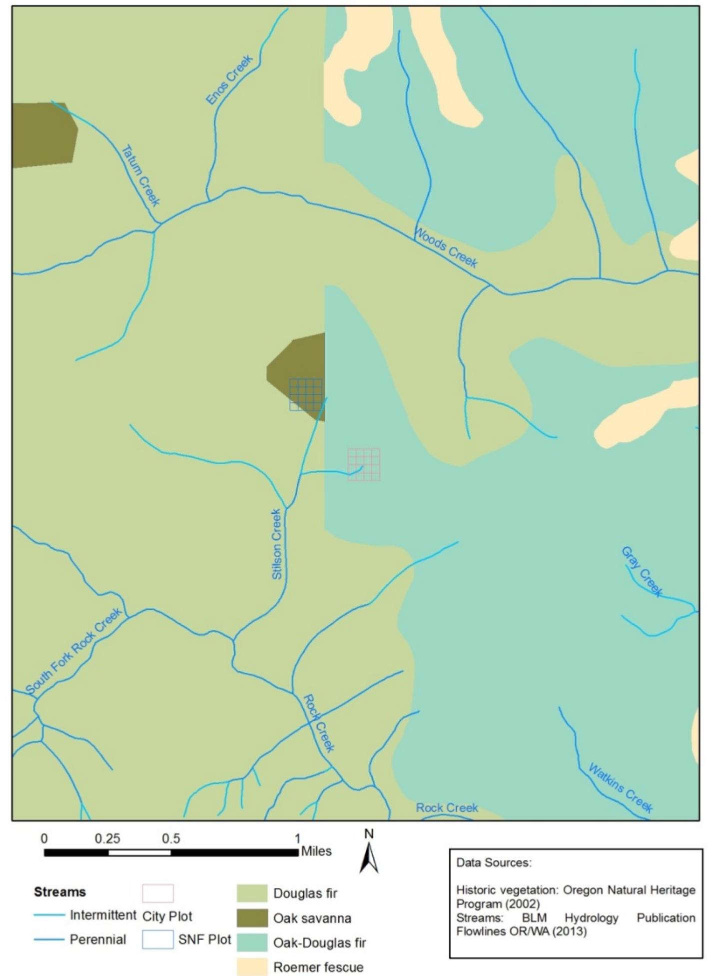


Table 1. *Synopsis of habitat relationships for the Pacific wren, hermit warbler, and dark-eyed junco. Seral stand associations, edge response, and CWD response based on Bunnell, et al. 1997, Appendix II. Seasonal movements, forest strata used, and territory size are based on Weikel 2003 (Pacific wren), Janes 2003 (hermit warbler), Nehls 2003 and Brown 1985 (dark-eyed junco).*

	Pacific Wren	Hermit Warbler	Dark-eyed Junco
Seasonal movement	Winter resident	Neo-tropical migrant	Short-distance migrant
Seral stage associations	(+) association w/advancing stages	Generally associated w/ stand age >40 years	(-) association w/ advancing stages
Forest strata used	Ground; grass/forb layer	Mid-canopy	Ground; grass/forb layer
Response to edges	(-)	?	(+)
Response to woody debris	(+)	---	---
Territory size	range 0.37-2.38 ha	mean 0.65 ha	range 0.8-1.2 ha

METHODS

SITE LAYOUT

I conducted bird surveys on the same 200 X 200 m sampling plots (total area = 4 ha) during all three years of the pre-treatment bird surveys. The plot at the SNF Pioneer Butte site ("SNF plot") was placed over the location of the future meadow restoration according to a map and guidance provided by Cindy McCain, SNF ecologist. The plot at the City of Corvallis site ("City plot") was positioned so that the meadow created in 2010 and edge of the adjacent forest were included. The stand lying along the E and S portions of the City plot were commercially thinned during the same operation that expanded the meadow. Each plot was divided into sixteen 50 X 50 m subplots to aid in navigation during surveys and to facilitate mapping.

I created maps of both plots in a geographic information system (GIS) using 2009 color imagery, Benton county tax lot boundaries, and a U. S. Forest Service roads layers. Using the GIS, I created a vector-format sampling grid for each plot and uploaded the UTM coordinates of the subplot corners into a geographic positioning system (GPS). The GPS was then used to locate subplot corners at each site. Where the forest canopy or topography prevented reception of the GPS signal, I used a compass and laser range finder to locate corners from measurements to known positions. All of the corners should be within 4 m of their true UTM coordinates based on precision estimates recorded by the GPS. Each corner was marked with a wood stake and pink/black flagging ribbon.

BIRD SURVEYS

Table 2 summarizes the bird survey effort and timing during three years of pre-treatment data collection. During each year, the order of surveys on the SNF and City plots were alternated between visits and the pattern of surveyor movement across the plot was varied to minimize the effect of time of day on observations.

Table 2. *Pre-treatment bird survey effort and timing, 2011-2013.*

Survey Year	Number of Visits		Survey Period
	SNF	City	
2011	6	5	June 2-June 23
2012	8	7	June 6-July 5
2013	3	3	May 20-June 8

Bird observations were made as I walked through each of the subplots at a slow pace while listening for bird songs, calls, and drumming by woodpeckers. Visual observations were made with 8 X 30 power binoculars. Surveys were not performed in heavy rain or strong wind because of the effects these conditions have on bird behavior and their detectability. I remained in each of the subplots long enough to be reasonably certain that all of the birds that were detectable that morning had been observed. Subplots with dense vegetation and/or a relatively high number of birds could take as long as 15 minutes while subplots that were mostly open might only take 2 minutes. Counter-singing between males provided the best means to determine the approximate location of territory boundaries and movements of individual birds provided additional information about the area and shape of territories.

During the 2011 survey, UTM coordinates were recorded for each observed location of an indicator species ("registrations", Bibby et al. 1992) using a GPS. However, the dense canopy cover and terrain often prevented reception of the GPS satellite signal across portions of both plots. In these cases, registration coordinates were estimated using a laser rangefinder to measure distance and a compass to determine the azimuth from a control point with known UTM coordinates. The method entailed intensive fieldwork, causing me to revise the protocol for subsequent surveys.

During the 2012 and 2013 surveys, I marked registrations on a paper map of the plots I carried during surveys. I sighted subplot corner markers to estimate my position (and those of birds) within the whole plot. Behavioral observations and position changes were recorded according to methods described by Bibby et al. (1992). I mapped bird positions as far as 100 m beyond the edge of the plot so I could delineate clusters of registrations as fully as practical.

SPECIES INVENTORY AND ACCUMULATION CURVES

I recorded a list of all avian species detected on each plot during each visit. From these lists, an avian species inventory was compiled and detection frequencies (i.e., total number of visits to plot/number of visits species was observed) were calculated for each plot and summarized by year. Other avian species detected outside the plot boundaries were recorded separately.

Using raw, tabulated counts of species detected per visit is invariably an biased, underestimate of total species richness because not all species are detected. Using simple ratios of species per unit of sampling effort does not address the underlying problem and should be avoided (Chazdon et al. 1998). Instead, estimates of species richness should be based on an explicit statistical sampling model (Colwell et al 2012).

In 2012, I used the program *EstimateS* (Colwell 2009) to compute expected species accumulation curves (ACs) based on 2011 and 2012 inventory data from for the SNF and City plots. The procedure allowed me to estimate how many visits I likely would need in order to achieve a full species inventory of the plots. The ACs also permitted comparisons of species density between the SNF and City plots. The ACs represent the predicted numbers of species present on the plot by number of survey visits. Program *EstimateS* uses a sample-based rarefaction function, called *Mao Tau* (Colwell 2009), to compute the ACs based on the frequencies of occurrence for each species among the pooled samples. *Mao Tau* predicts the number of species detected for a sub-sample of the pooled species actually discovered on the plot (without accounting for undetected species), therefore the ACs represent species density (i.e., number of species per unit of area) and are not strictly estimates of total species richness (Colwell 2009).

Territory Mapping

Avian territory mapping (also called "spot mapping") is a survey technique that utilizes behavioral observations and recorded positions of birds collected over repeated visits to construct maps of habitats occupied and defended by breeding males. Territory mapping is generally regarded as one of the least biased methods for estimating population density of songbirds and is often the standard by which other density estimates are measured (Christman 1984, Verner and Ritter 1988, Toms et al. 2006). The method also permits greater specificity in habitat use analyses because data are recorded at the position of the subject rather than the position of the surveyor, who can be more than 100 m away from the bird.

Registrations of indicator species mapped in the field were transferred to ESRI shapefiles by the following procedure. Using a GIS, I displayed recent satellite imagery and subplot corners could while creating a point representing each bird location in the shapefile. These location points were spatially referenced to the survey plot by manually editing their positions relative to the subplot corners represented in the GIS. Since I conducted both the bird survey and cartography, I could use my knowledge of natural landmarks (e.g., canopy gaps, dominant trees) on each plot to further refine bird positions by referring to the satellite imagery viewed in the GIS. The shapefile also has an attribute table containing the date, species, sex (if known) and a behavior code for each record.

Delineating territory boundaries was performed by methods described in Bibby et al. (1992). Several of the most important assumptions and rules are as follows:

- The territory mapping method assumes that the species under investigation lives in discrete, non-overlapping ranges during the breeding season, and territory boundaries fall between clusters of registrations.
- Territories must include at least two registrations at least 10 days apart to avoid classifying stop-over migrants as individuals breeding on the plot.
- Carefully mapped positions of counter-singing males are crucial to separate clusters of registrations into territories held by different birds.

Territory maps for each of the three indicator species was created in the GIS by manually drawing boundaries using the mapping rules described above and further guidance by Bibby et al. (1992). In cases where field observations suggested that territory boundaries extended farther than 100 m beyond the plot, I truncated the outside territory boundary with a straight line. I have presented both 2012 and 2013 territory maps in the results and discussion; however, the unequal survey effort (Table 2) does not permit comparison of the number of territories or bird densities between years. The 2013 results are shown primarily to permit a visual examination of maps for evidence of repeated use in particular areas of the plots across breeding seasons.

Habitat Sampling

During 2013, I performed a vegetation survey to characterize pre-treatment habitat conditions on the SNF and City plots and to explore differences between used versus unused areas of plots by each of the three indicator species. Locations for vegetation sampling points were selected by using the following procedure. First, an ArcGIS tool was used to generate 50 randomly spaced points on the SNF and City plots and the points were saved as an ESRI shapefile. Secondly, another ArcGIS tool was used to generate a kernel density estimation surface (search radius = 50 m) for each indicator species based on their 2011 and 2012 registrations of singing males. The surfaces were saved as an ESRI raster. Finally, the random points were overlaid on the three kernel-density surfaces and then classified as "used" if the point lay above the contour where density of males = 3.0 individuals inside the 50 m search radius and "unused" if the point lay below the same density contour. I selected the 3.0 density contour as the best criterion for distinguishing used and unused points after visually inspecting a range of other contours that appeared too lax (i.e., the entire plot was classified as used) or too stringent (i.e., kernel surfaces were constrained to within just a few meters of the locations of observed males). The procedure resulted in a total of 9 habitat sampling points in the SNF plot and 12 points in the City plot and where there were at least 3 used and 3 unused points on each plot for each indicator species (Appendix II). The UTM coordinates of the selected sampling points were uploaded into a GPS for navigating to each point during fieldwork.

At each habitat sampling point, the line-intercept method was used along a 50 ft. transect to estimate eight types of cover: tall shrub (height >2 m), low shrub (height ≤2 m), grass, forbs, fern, moss, dead wood, and bare ground. Canopy cover (%) was estimated using a spherical densiometer and the basal area of conifers and hardwood trees was estimated using a 20 basal area factor (BAF) prism. Descriptive statistics for each of the habitat metrics are presented in Appendix III.

Habitat Factors Analysis

To identify potential relationships between each of the indicator species and habitat factors, I performed a means comparison between sampling points that were classified as used and unused by the species. I selected only the subset of the 11 habitat metrics that were associated with the vegetation layer(s) used by the species for feeding and breeding to reduce the risk of confusing statistically significant differences with those that are most likely to be ecologically meaningful. The analyses were performed with SAS JMP Version 10 (SAS 2012) statistical software. For each habitat metric, I tested the hypothesis that $used_{mean} = unused_{mean}$ with Student's *t* as the test criterion and a significance level of $P \leq 0.05$.

RESULTS & DISCUSSION

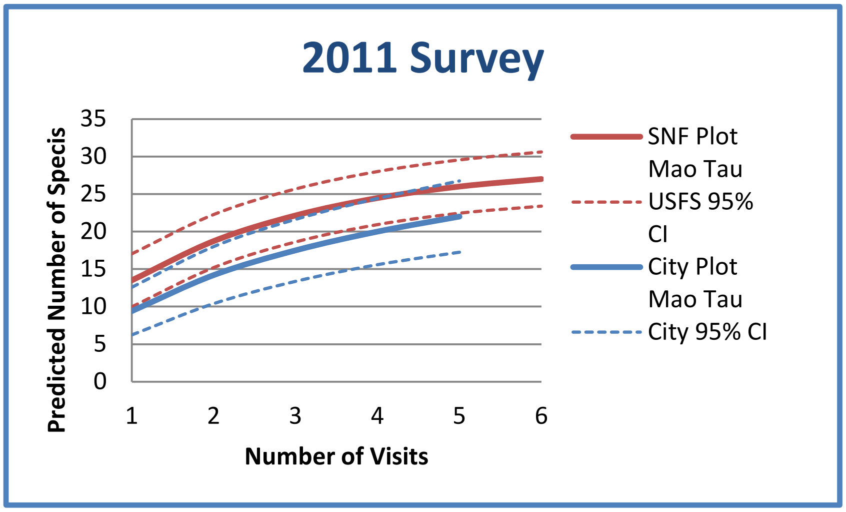
AVIAN INVENTORY

The ACs serve two purposes in this study. The first is to determine whether there were a sufficient number of survey visits to detect all species using the plot. A visual examination of ACs should demonstrate a clear asymptotic curve when an increasing number of visits no longer result in additional species detected (Colwell et al. 2012). The ACs for the 2011 and 2012 surveys indicate that new species still continued to accumulate during the last visits to both plots (Figure 3). These results suggest that increasing the survey effort could lead to slightly higher estimates of species density. Budget constraints during the 2013 allowed for only 3 visits to each of the plots that year. A visual examination of the 2011-2012 ACs suggests that I probably failed to detect 6-7 species that may have been counted if I had made eight visits during the year. Given that the ACs appear to be approaching their asymptotic level at approximately 9-10 visits (Figure 3), Table 3 probably represents a reasonably complete inventory of diurnal birds during the breeding season.

The second purpose of the ACs is to permit comparisons of species density between plots and time periods. The 2013 inventory data was excluded from this comparison because the survey effort was so much less than the previous two years. A cursory examination of the 2012 ACs shows a greater species density at the SNF plot than the City plot across all levels of survey effort (Figure 3). However, the overlapping confidence intervals indicate the difference is not statistically significant. There was markedly stronger contrast between the two plots during the 2011 breeding season. Explaining the difference in 2011 species density between plots is challenging. The most obvious factor is that the 1.2 ha meadow in the City plot seems to be avoided by the entire avian community during the breeding season. Given the reduced habitat area for forest birds on the City plot, it would not be surprising to find less species density. However, the meadow remained relatively unchanged in structure or size during the 2011-2012 survey period. The difference should have also been more apparent during this year's survey if the meadow was causing the effect. It seems more probable that the difference observed one year and not the next is due to the natural, annual variation within the bird community.

The total number of species actually observed during the three years of surveys was 32 on the SNF plot (visits = 17) and 34 (visits = 15) on the City plot. The six most common species observed at both plots were the golden-crowned kinglet, dark-eyed junco, chestnut-backed chickadee, Pacific-slope flycatcher, hermit warbler, and Swainson's thrush.

Figure 3. *2011 and 2012 species accumulation curves (ACs) and their 95% confidence intervals for the USFS and City avian monitoring plots based on sample-based rarefaction. Mao Tau is number of species predicted in the accumulated samples based on the empirical data.*



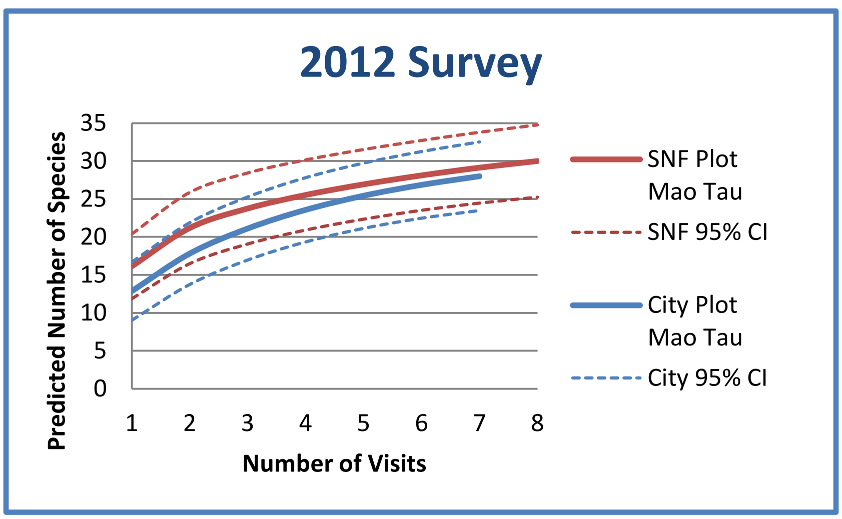


Table 3. *Avian species detection frequencies (total number visits/visits spp. detected) for the SNF and City plots. Data are sorted on the SNF mean frequency. Indicator species indicated in bold.*

		SNF				City			
Common Name	***Scientific Name***	**2011**	**2012**	**2013**	**Mean**	**2011**	**2012**	**2013**	**Mean**
Golden-crowned kinglet	*Regulus satrapa*	1.00	1.00	1.00	1.00	0.60	1.00	1.00	0.94
Dark-eyed junco	***Junco hyemalis***	**1.00**	**0.88**	**1.00**	**0.96**	**0.80**	**0.86**	**0.67**	**0.88**
Chestnut-backed chickadee	*Poecile rufescens*	1.00	0.88	1.00	0.96	0.20	0.71	1.00	0.82
Pacific-slope flycatcher	*Empidonax difficilis*	1.00	0.75	1.00	0.92	1.00	1.00	1.00	0.95
Hermit warbler	***Dendroica occidentalis***	**0.83**	**0.88**	**1.00**	**0.90**	**0.80**	**0.43**	**1.00**	**0.83**
Swainson's thrush	*Catharus ustulatus*	0.50	1.00	1.00	0.83	0.40	0.86	0.67	0.75
Wilson's warbler	*Wilsonia pusilla*	0.67	0.88	0.67	0.74	1.00	0.29	0.67	0.70
Black-headed grosbeak	*Pheucticus*	0.33	0.88	1.00	0.74	0.20	1.00	0.67	0.69
Red-breasted nuthatch	*Sitta canadensis*	0.00	1.00	1.00	0.67	0.40	0.29	1.00	0.62
Pacific wren	***Troglodytes pacificus***	**0.33**	**0.63**	**1.00**	**0.65**	**0.60**	**1.00**	**1.00**	**0.74**
Band-tailed pigeon	*Columba fasciata*	0.17	0.63	1.00	0.60	0.20	0.43	0.00	0.43
Western tanager	*Piranga ludoviciana*	0.33	0.75	0.67	0.58	0.60	0.29	1.00	0.60
Hutton's vireo	*Vireo huttoni*	0.50	0.25	1.00	0.58	0.00	0.43	0.67	0.49
Orange-crowned warbler	*Vermivora celata*	0.17	0.50	1.00	0.56	0.20	0.29	0.33	0.44
Western wood-pewee	*Contopus sordidulus*	1.00	0.50	0.00	0.50	0.20	0.57	0.00	0.40
Hermit thrush	*Catharus guttatus*	0.83	0.63	0.00	0.49	0.20	0.29	1.00	0.49
Steller's jay	*Cyanocitta stelleri*	0.50	0.25	0.67	0.47	0.20	0.14	0.33	0.37
Black-throated gray warbler	*Dendroica nigrescens*	0.50	0.88	0.00	0.46	0.20	0.86	0.33	0.46
Brown creeper	*Certhia americana*	0.33	0.50	0.33	0.39	0.40	0.14	0.67	0.39
Gray jay	*Perisoreus canadensis*	0.33	0.75	0.00	0.36	0.20	0.29	0.00	0.28
Common raven	*Corvus corax*	0.17	0.13	0.33	0.21	0.00	0.00	0.00	0.12
American robin	*Turdus migratorius*	0.50	0.13	0.00	0.21	0.40	0.43	0.67	0.33
Rufous hummingbird	*Selasphorus rufus*	0.17	0.38	0.00	0.18	0.00	0.14	0.00	0.12
Spotted towhee	*Pipilo maculatus*	0.00	0.13	0.33	0.15	0.00	0.00	0.00	0.09
Hammond's flycatcher	*Empidonax hammondii*	0.00	0.00	0.33	0.11	0.00	0.00	0.00	0.06
Cedar waxwing	*Bombycilla cedrorum*	0.33	0.00	0.00	0.11	0.00	0.14	0.00	0.08
Ruby-crowned kinglet	*Regulus calendula*	0.00	0.25	0.00	0.08	0.00	0.14	0.00	0.07
Red-breasted sapsucker	*Sphyrapicus ruber*	0.00	0.25	0.00	0.08	0.00	0.43	0.00	0.11
Northern pygmy-owl	*Glaucidium gnoma*	0.00	0.13	0.00	0.04	0.00	0.00	0.00	0.02
MacGillivray's warbler	*Oporornis tolmiei*	0.00	0.13	0.00	0.04	0.00	0.00	0.00	0.02
Hairy woodpecker	*Picoides villosus*	0.00	0.13	0.00	0.04	0.40	0.14	0.00	0.10
Barred owl	*Strix varia*	0.00	0.13	0.00	0.04	0.00	0.00	0.00	0.02
Red-tailed hawk	*Buteo jamaicensis*	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.02
Purple finch	*Carpodacus purpureus*	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.02

INDICATOR SPECIES

DARK-EYED JUNCO

TERRITORIES

SNF Plot—There were 13 registrations in 2013 and 25 in 2012. The distribution of registrations indicates that most of the plot was used by at least three breeding pairs of juncos both years (Figure 4). The pattern of 2013 and 2012 registrations suggest that there were probably the same number of breeding pairs on or near the plot during both seasons, but territory boundaries have shifted. Most of the registrations occurred within 15 m of forest edges or small canopy gaps, overlapping territories in the SW corner of the plot during 2012 and 2013 were dominated by shrubs and dense, pole-sized Douglas-firs.

City Plot— There were 13 registrations in 2013 resulting in two mapped territories and 27 registrations resulting in 5 territories during 2012 (Figure 4). Vegetation structure varied widely within the dark-eyed junco territories—from open forest understories in the south and central portions of the plot, to the dense, young stand in the north, and patches of tall shrubs on the west side of the plot. All of the territories had an abundance of ground-level hiding cover (e.g., low shrubs, sword fern, woody debris) that juncos prefer for nesting. Even though the species is usually considered an early-seral associate, only two registrations were located in the meadow.

HABITAT FACTORS

I compared the means of used and unused sampling points for eight habitat metrics associated with shrub and ground cover vegetation, the forest strata where dark-eyed juncos feed and breed. The exploratory species-habitat analysis revealed that 2 of the 8 habitat metrics were significantly different between locations used and unused by dark-eyed juncos. Used locations had greater tall shrub cover, and greater cover of grass than unused locations (Table 4). The locations on the SNF and City plots used by juncos were often near forest openings (Figure 4), where greater sunlight promotes growth of understory vegetation. These findings are in general agreement with previous studies that report juncos are associated with forest openings (Niehls 2006) and commercially-thinned forests (Hagar et al. 1996).

Although dark-eyed juncos are ground-feeders whose diet is primarily composed of seeds from forbs and grasses, the species was almost never observed in the large meadow on the City plot. The dominance of tall oatgrass (*Arrhenatherum elatius*) in the City meadow precludes much diversity of other plant species, and the height and density of the grass may be inhibiting foraging behavior by juncos.

The meadow restoration at the Pioneer Butte site is likely to have positive effects on the dark-eyed junco population and other ground-feeding birds if the plant community can be managed so as to provide a rich variety of native forbs and grasses as food sources. Vegetation height across the meadow should vary between short-stature plants for feeding and taller patches for nesting cover.

Figure 4. *2012 and 2013 Dark-eyed junco territories at the Pioneer Butte restoration site (SNF plot) and City of Corvallis meadow restoration site (City plot). Solid lines within plots denote movements of individual birds; dotted lines denote pairs of counter-singing males.*

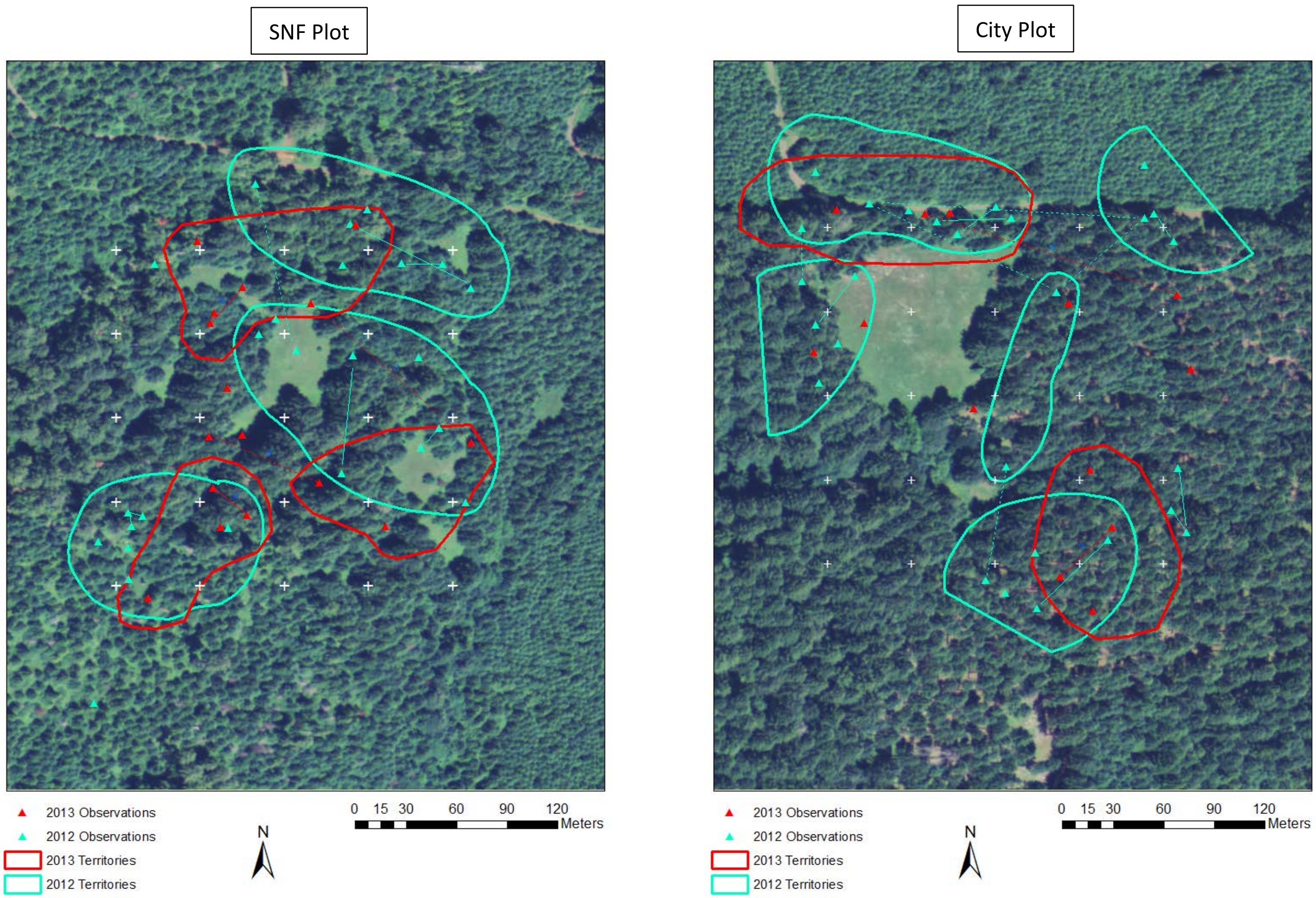


Table 4. *Habitat metrics estimated at plot locations used (n = 7) and unused (n = 6) by dark-eyed juncos. Data from SNF and City plots have been combined. Bold type indicates that difference between means is significant (95% confidence level).*

	Used		Unused		
	Mean	SD	Mean	SD	Prob<t
Tall Shrub	**0.195**	**0.332**	**0.001**	**0.003**	**0.0001**
Low Shrub	0.23	0.271	0.151	0.236	0.41
Forb	0.133	0.112	0.139	0.223	0.94
Grass	**0.512**	**0.503**	**0.18**	**0.363**	**0.05**
Fern	0.025	0.036	0.099	0.113	0.14
Wood	0.245	0.267	0.469	0.357	0.16
Moss	0.433	0.345	0.565	0.363	0.36
Bare	0.05	0.058	0.098	0.222	0.59

Hermit Warbler

Territories

***SNF Plot*—**There were 19 hermit warbler registrations resulting in three territories during 2013 and 18 registrations resulting in three territories during 2012 (Figure 5). Most registrations were of singing males among the tallest conifers on the plot. A visual examination of the territory maps indicates that there was considerable shifting in territory boundaries between 2012 and 2013, although singing males tended to use the tallest trees on the plot during both years.

City Plot—There were 23 registrations during 2013 resulting in four territories and 17 registrations resulting in three territories during 2012 (Figure 5). Clusters of registrations near the north boundary indicate that these individuals were using the dominant Douglas-firs near the meadow, as well as the younger and denser stand to the north.

Habitat Factors

Because hermit warblers are most strongly associated with upper- and mid-story forest canopies, the habitat factors analysis for this species only compared canopy cover, conifer and hardwood basal area, and tall shrub metrics. The locations used by hermit warblers had significantly greater conifer basal area , but no other factor was found to be statistically significant. However the hardwood basal area comparison is invalidated by the fact that hardwood trees did not occur on either the used or randomly selected unused points. Conifer basal area is correlated with tree age and density of large diameter trees (McArdle et al. 1995), thus hermit warblers are evidently using patches of larger trees on the plots. Hermit warblers are reported to prefer multi-layered forest canopies (Morrison 1982, Janes 2006) and the greater basal area at locations used by the species may also indirectly reflect canopy complexity.

Based on the pre-treatment data and information from other studies, the expansion of the meadow at Pioneer Butte will necessarily exclude hermit warblers and other canopy-dwelling species in the forest opening. However, the negative effect can be mitigated by silvicultural practices to maintain or promote canopy complexity in the surrounding forest, such as retaining trees among all crown classes and preserving existing hardwoods.

***Table 5**. Habitat metrics estimated at plot locations used (n = 7) and unused (n = 6) by hermit warblers. Data from SNF and City plots have been combined. Bold type indicates that difference between means is significant (p>0.05 confidence level).*

	Used		Unused		
	Mean	SD	Mean	SD	Prob<t
Canopy	90.8	6.8	66.5	42.0	0.22
Tall Shrub	0	0	0.091	0.152	…
BA Conifer	**251.4**	**90.8**	**100**	**74.8**	**0.004**
BA Hardwood	0	0	0	0	…

Pacific Wren

Territories

SNF Plot--There were seven registrations of Pacific wrens on or near the SNF plot in 2013, however the registrations were not spaced over a sufficient period of time (10 days minimum) nor was there adequate spatial clustering of registrations to identify territories (Figure 6). There were 11 registrations in 2012, resulting in two mapped territories. A 2012 territory near the SE corner of the plot was partially delineated based on a cluster of three registrations along a seasonal stream. The forest canopy above the cluster is dominated by Douglas-fir with hardwoods present in the lower canopy. Immediately E of the cluster is a much younger stand, but it is not known how far this territory extended beyond the plot boundary. The second 2012 territory lies on the W side of the SNF plot under some of the largest trees on the plot. There are many large diameter branches on the ground, evidently fallen from the old Douglas-firs above.

City Plot—There were 10 registrations in 2013, none of which could be grouped into territories. There were 27 registrations resulting in four territories during 2012 (Figure 6). A 2012 territory south of the meadow was associated with a shrubby riparian area. This territory included multiple sightings of mated pair.

A territory in the SW corner of the plot was delineated from three registrations; two of them were observations of a male counter-singing with the male in the territory to the immediate N. The understory was dominated by sword fern with scattered, small logs.

Two 2012 territories overlap the E boundary of the plot. This portion of the stand had been thinned during the same year that the meadow was expanded on the City plot. This area of the plot contains abundant, scattered slash and small logs on the ground. All of the 2012 registrations were of birds displaying from or moving among slash piles.

Figure 5. *2012 and 2013 hermit warbler territories at the Pioneer Butte restoration site (SNF plot) and City of Corvallis meadow restoration site (City plot). Solid lines within plots denote movements of individual birds; dotted lines denote pairs of counter-singing males.*

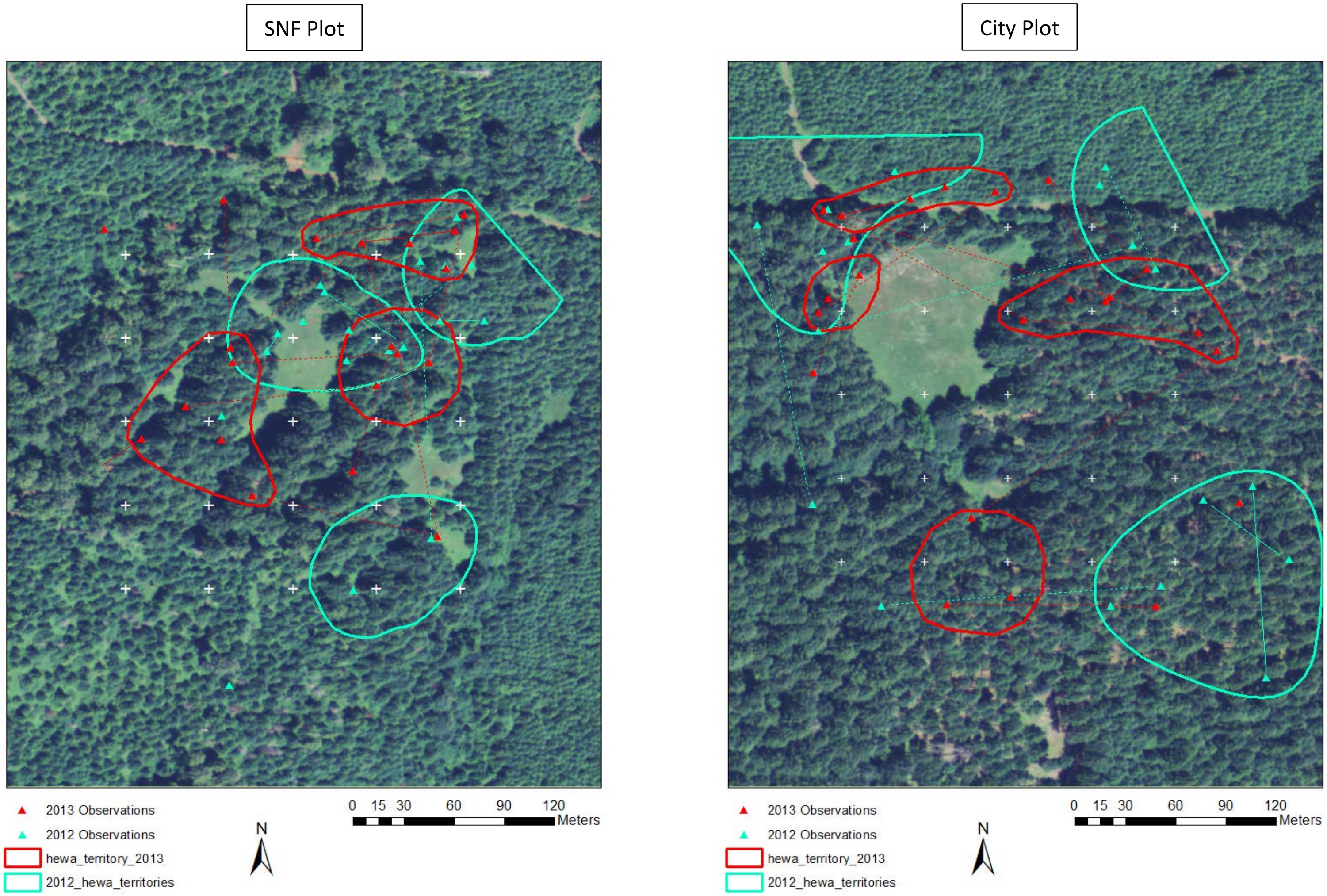
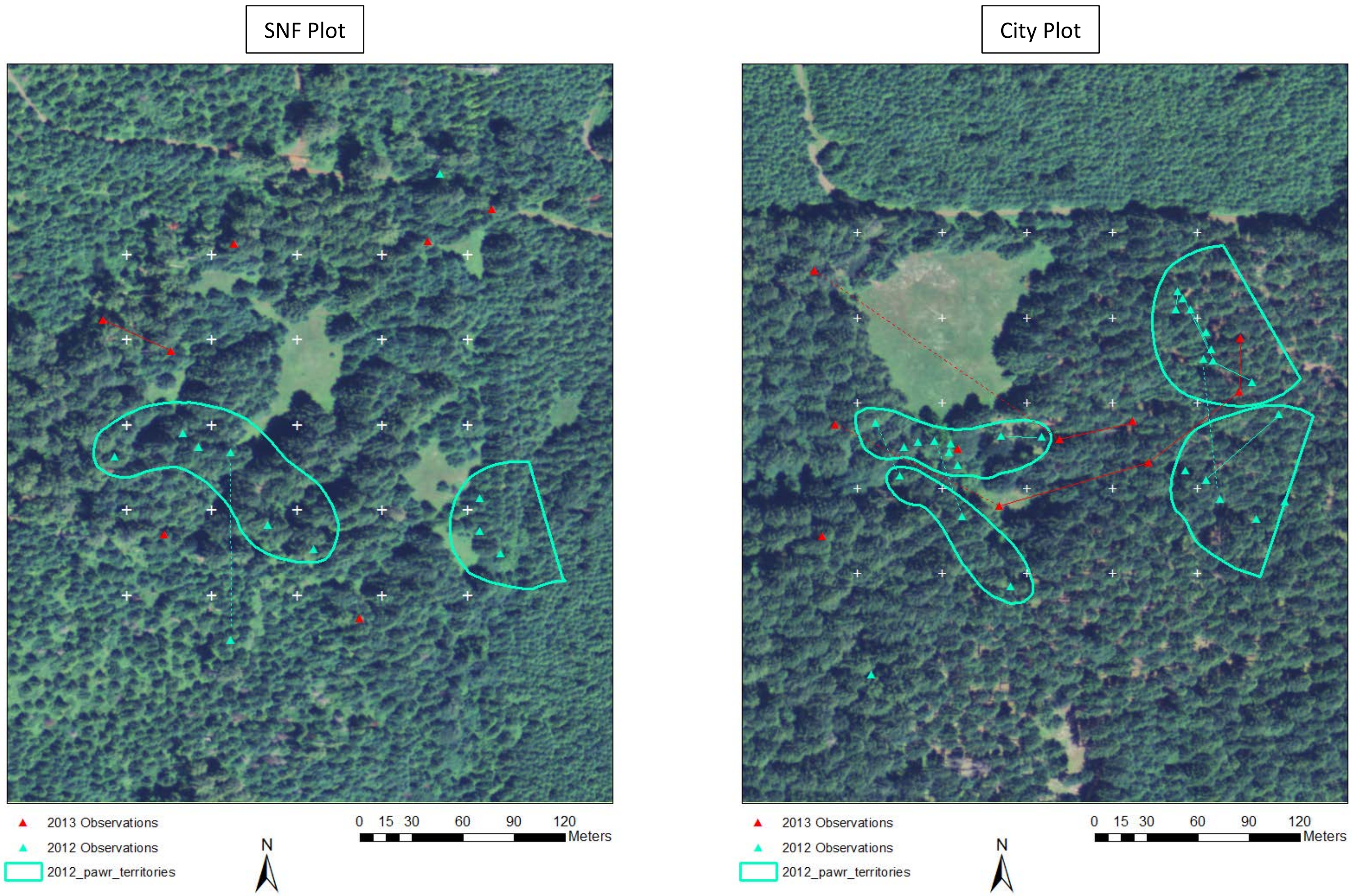


Figure 6. *2012 and 2013 Pacific wren territories at the Pioneer Butte restoration site (SNF plot) and City of Corvallis meadow restoration site (City plot). Solid lines within plots denote movements of individual birds; dotted lines denote pairs of counter-singing males.*



HABITAT FACTORS

Eight metrics characterizing forest understory vegetation were compared (Table 6). Pacific wrens used areas of the plot having greater cover of tall shrubs and forbs than at unused locations. Pacific wrens are ground-feeders with a diet primarily composed of invertebrate prey (Van Horne and Bader 1990). Tall shrubs support diverse assemblages of invertebrates, particularly lepidopteron species (Hagar 2003), and therefore Pacific wrens may be responding to the greater availability of food in shrubby patches. Pacific wrens have been referred to as "nook and cranny nesters", typically placing their nests under logs or in root wads and other forms of woody detritus on the forest floor (Weikel 2006). Fine- and coarse-wood cover is common at both used (52% cover) and unused (45% cover) locations, so suitable nesting habitat maybe widespread across the SNF and City plots for Pacific wrens. I did not classify woody cover by size class or types, which may have yielded clearer findings about the species' use of these habitat features.

The level of woody cover at the SNF plot is slightly lower than at the City plot (Appendix III). Pacific wrens would benefit by large, woody debris and slash piles on the forest floor surrounding the expanded meadow at the Pioneer Butte site. This material will be generated by tree falling during the restoration work and could be retained in the forest understory outside the meadow. Foraging habitat can be maintained or improved by preserving existing patches of shrubs and hardwoods in the forest surrounding the meadow.

Table 6. *Habitat metrics estimated at plot locations used (n = 6) and unused (n = 8) by Pacific wrens. Data from SNF and City plots have been combined. Bold type indicates that difference between means is significant (p>0.05 confidence level).*

	Used		**Unused**		
	Mean	SD	Mean	SD	Prob<t
Tall Shrub	**0.028**	**0.069**	**0.001**	**0.003**	**0.0001**
Low Shrub	0.135	0.132	0.158	0.213	0.77
Forb	**0.21**	**0.239**	**0.065**	**0.075**	**0.0009**
Grass	0.14	0.127	0.15	0.345	0.94
Fern	0.105	0.122	0.075	0.101	0.42
Wood	0.52	0.273	0.456	0.382	0.65
Moss	0.581	0.3	0.514	0.363	0.62
Bare	0.109	0.175	0.159	0.271	0.62

Special Status Species

Four species having special state or federal status were observed on or from one of the plots during the surveys.

Band-Tailed Pigeon

The band-tailed pigeon (*Patagioenas fasciata*) is listed as an Oregon Conservation Strategy Species (ODFW 2006). The species nests in closed canopy conifer forests and feeds on fruits and seeds, especially those of tall shrubs and hardwood trees. Mineral springs are reported to be an important factor limiting band-tailed pigeon populations. Foraging habitat could be sustained for the species if existing tall shrubs are preserved in the forest surrounding the meadow restoration area and important foods such as red or blue elderberry, cascara, and Oregon white oak are planted along the meadow boundary.

Pileated Woodpecker

The pileated woodpecker (*Dryocopus pileatus*) is listed as a state Sensitive-Vulnerable (ODFW 2008). The species was regularly heard calling and drumming near both plots all three years of pre-treatment surveys. The pileated woodpecker is an associate of mature Douglas-fir and mixed conifer/hardwood forests. Although the pileated woodpecker is not likely to directly benefit from the meadow restoration at Pioneer Butte, retention of very large existing snags (dbh >24"; height >40 ft) in the surrounding forest and creation of new snags would improve the availability of nest sites for the species.

Purple Martin

The purple martin (*Progne subis*) is listed as state Sensitive-Critical (ODFW 2008), an Oregon Conservation Strategy Species (ODFW 2006), and by the U.S. Forest Service/Bureau of Land Management Interagency Special Status/Sensitive Species Program (ISSSSP 2012). Purple martins were heard calling high overhead from the City plot during one survey in 2012 and heard during field work on the SNF plot in July 2013. The observations were during the purple martin nesting season so it is likely that these individuals were nesting in a colony near the plots. Purple martins are cavity-nesters that use snags located in burned areas, clearcuts, and large forest openings. They avoid nesting in close proximity to forest edges. Any opportunity to retain or create snags (dbh >15"; height >10 ft) in the meadow at least 100 ft from closed canopy forest will improve the availability of nest sites for purple martins.

Western Gray Squirrel

The western gray squirrel (*Sciurus griseus*) is listed as state Sensitive-Vulnerable (ODFW 2008) and as an Oregon Conservation Strategy Species (ODFW 2006). At least one individual squirrel was observed foraging in California hazel on the SNF plot on two consecutive days during fieldwork in July 2013. Western gray squirrels are particularly associated with Oregon white oak woodlands, but can also be common mixed Douglas-fir/hardwood forests. A map of nineteenth century vegetation patterns in Oregon (Tobalske 2002) indicates that there was extensive Douglas-fir/oak woodland and a small amount of oak savanna on the Pioneer Butte landscape prior to the expansion of conifer forest following Euro-American settlement in the Coast Range foothills (Figure 2). There is a single, large oak on the City plot that is a legacy of these past conditions. Given the greater presence of oaks on the historical landscape, habitat suitability for western grays squirrels at Pioneer Butte was probably greater during the nineteenth century than today.

Incidental Wildlife Observations

Black-tailed deer were regularly seen on both the SNF and City plots. Bedding areas of deer were observed in most of the forest openings at the two sites. Other mammals observed directly or whose presence can be inferred by signs (e.g., tracks, burrows, scat) are the coyote (*Canis latrans*), common raccoon (*Procyon lotor*), Douglas squirrel (*Tamiasciurus douglasii*), and brush rabbit (*Sylvilagus bachmani*). Herpetofauna observed were the rough-skinned newt (*Taricha granulosa*), Pacific treefrog (*Pseudacris regilla*), and northwestern garter snake (*Thamnophis ordinoides*).

CONCLUSIONS & RECOMMENDATIONS

The avian community on the SNF plot at Pioneer Butte is presently dominated by species typically associated with mid- to late-seral Douglas-fir forests. Examples include the golden-crowned kinglet, Pacific-slope flycatcher, and chestnut-backed chickadee. However, the occurrence of other species (e.g., Hutton's vireo, cedar waxwing) is certainly linked with big-leaf maples, chinquapin, and other hardwoods on the plot (Bunnell et al. 1997). It is unlikely that the Wilson's warbler or Swainson's thrush would be so common without widespread patches of tall shrubs on the plot (Hagar 2003). The incidence and abundance of all these species is likely to shift in the future, depending upon the response of each species to restoration treatments and stand maintenance.

One of the primary purposes of the Pioneer Butte restoration project is to expand the small, existing meadows and early seral plant community, habitat types that are increasingly uncommon on the SNF (Cindy McCain, pers. comm.). The City plot was included in this study to provide an opportunity to collect avian data at a site similar to the meadow being planned on the nearby SNF lands. Territory mapping clearly demonstrated that dark-eyed juncos avoided the meadow, which is unexpected based on its reported habitat relationships and my professional survey experience. Furthermore, none of the other species present on the plot used the meadow, even species that were present are typically associated with this habitat type (i.e., American robin and rufous hummingbird). The City meadow has a very simple plant species composition, is homogenous in vegetation structure, and is dominated by relatively tall grasses (stand height >1 m in early summer). The City meadow doesn't possess the habitat complexity of grass balds in the Oregon Coast Range (Franklin and Dryness 1988), nor does it have the diversity of forbs that characterize foothill prairies (USFWS 2010). Species that typically forage on the ground (e.g., dark-eyed juncos, American robins) are likely excluded by the density and height of the grass in the City meadow.

The forest opening created by the meadow has created a high-contrast edge and promoted a layer of tall shrubs in the forest understory. Territory mapping revealed that much of the forest/meadow edge on both the City and SNF plots were used during the breeding season by two of the indicator species, hermit warblers and dark-eyed junco. I also observed evidence of black-tailed deer regularly bedding in the City meadow and the site likely provides benefits to wildlife that were not subjects of this study.

The four special status species detected at Pioneer Butte (i.e. band-tailed pigeon, pileated woodpecker, purple martin, and western gray squirrel) are not likely to directly benefit from the meadow restoration and the SNF site, but project managers could enhance habitat suitability for these species by retaining snags, hardwoods, and tall shrubs in the surrounding forest.

Two other Oregon Strategy Species, the little willow flycatcher (*Empidonax traillii brewsteri*) and olive-sided flycatcher (*Contopus cooperi*) were not detected at Pioneer Butte during pre-treatment surveys, but probably are the Special Status avian species most likely to discover and inhabit the site. In Benton County, the little willow flycatcher is common in dense patches of shrubs, in both riparian and upland settings (Altman 2003a). Using a hierarchical wildlife community classification by Bunnell et al. (Appendix II, 1997), the species already occurring at

Pioneer Butte and with the most similar habitat associations to the little willow flycatcher are the MacGillivray's warbler and spotted towhee. Monitoring the response of these two species to the restoration treatments provides a strategy for assessing whether the little willow flycatcher is more or less likely to occur at Pioneer Butte in the future.

The olive-side flycatcher is widespread in Coast range forests, but typically occurs at low population densities (Altman 2003b). High-contrast edges, such as those between closed-canopy forest and meadows are among the species' preferred habitats (Altman 2003b). Using the same analysis by Bunnell et al. (2003, Appendix II), the common raven, Pacific-slope flycatcher, and golden-crowned kinglet, are the closest community associates to the olive-side flycatcher and are probably the best indicators to forecast its future occurrence on the site.

Based on the results of the pre-restoration surveys, I offer the following recommendations to the SNF managers planning the Pioneer Butte restoration:

- Maintain a range of native forbs in the meadow community to ensure a diversity invertebrate community, and consequently, abundant prey for insectivorous birds.
- Create habitat complexity within the meadow by maintaining patches of various vegetation heights, space between plants for ground-foraging birds, and singing perches (e.g. tall shrubs, snags).
- Create meadows with complex edges and having high ratios of edge-to-interior space. Increasing the amount of meadow/forest edge will maximize light penetration into the forest understory and promote the growth of shrubs, a habitat component that was greatly used by the avian community during pre-restoration surveys at Pioneer Butte. Furthermore, I posit that songbirds may have also avoided the interior of the meadow because of the almost certain (but admittedly unobserved) presence of forest hawks (*Accipiter* spp.) to which passerines would be vulnerable in openings.
- Maintain or create large-diameter snags during restoration treatments. Snags are common on meadows created by wildfire and are a crucial habitat element for woodpeckers and secondary cavity-nesters.
- To assess the short-term response of the avian community to the meadow restoration, post-treatment bird surveys should be conducted for a minimum of two years. The first survey should follow two years after completion of on-the-ground activities at the restoration site. Analysis of pre-treatment data indicates that a minimum of eight visits to the site are necessary to fully inventory the diurnal bird community.

While the small size of monitoring plots on which bird territories were mapped precluded population density estimation, the territory maps did provide an excellent resource for a qualitative assessment of habitat use by Pacific wrens, hermit warblers, and dark-eyed juncos. The method also lends itself very well to statistical comparisons of used and unused habitats when model-based habitat sampling is conducted on the territory mapping plots. Hopefully this will be considered for post-restoration monitoring.

Acknowledgements

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APPENDIX I: INDICATOR SPECIES ACCOUNTS

HERMIT WARBLER

This species is aneotropical migrant that arrives in Oregon in April. Hermit warblers are among the most common avian species during summer in western Oregon forests (Janes 2006). Population densities may reach 344 individuals/km^2 (Weins and Nussbaum 1975). The species is usually found in conifer-dominated stands but it also uses conifer-oak ecotone habitat in western Oregon (Morrison 1982). Hermit warbles prefer complex, multi-layered forest canopies (Morrison 1982, Janes 2006). Chambers et al. (1999) reported that hermit warbler abundance decreased when silvicultural treatments such as clearcutting or two-story harvesting reduced canopy complexity. In a study of songbird response to low-severity prescribed fire, hermit warbler counts decreased for 6 years following treatment (Bagne and Purcell 2011). Mean territory size in southwest Oregon was reported to be 0.65 ha (n = 8; Janes 2006).

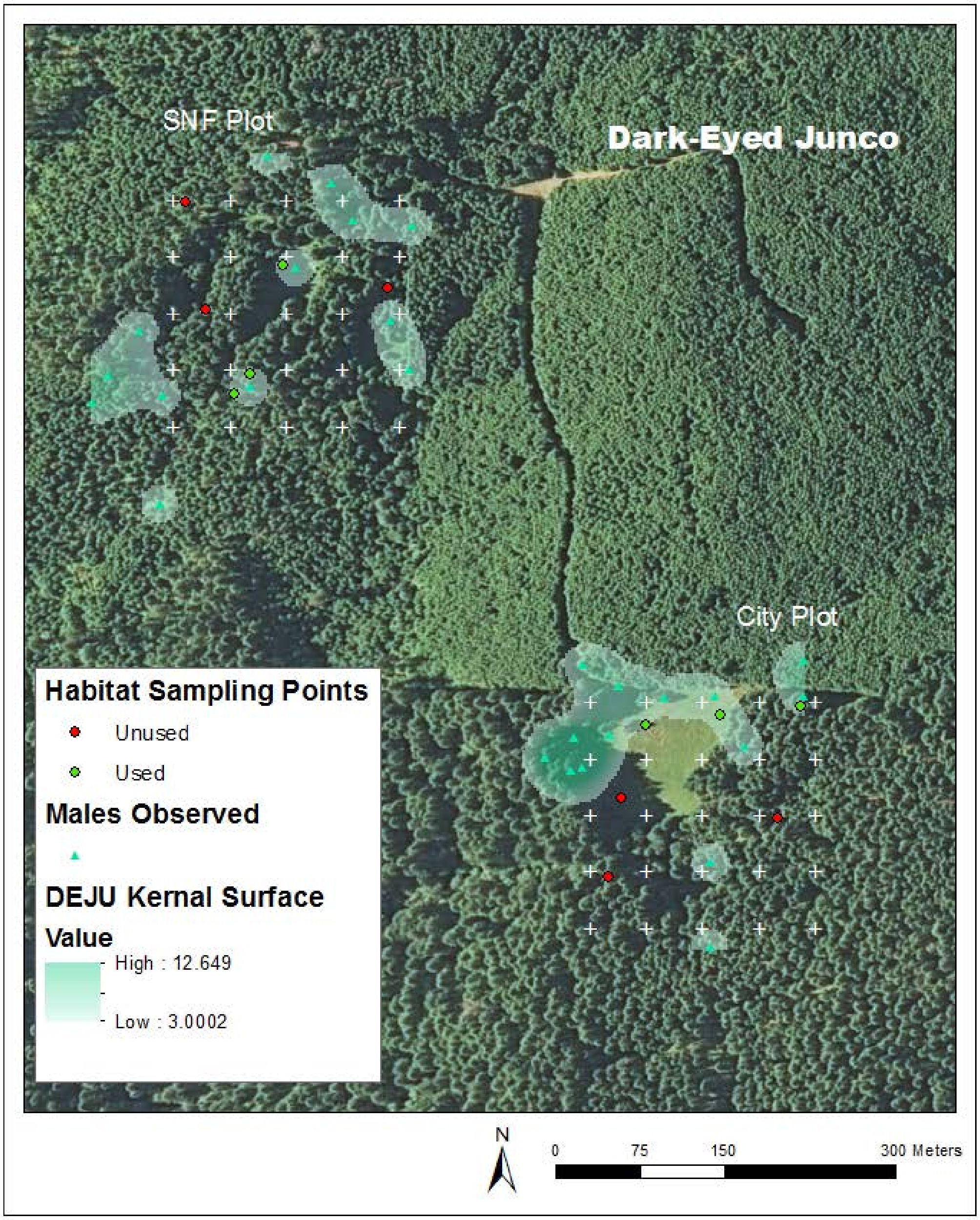
DARK-EYED JUNCO

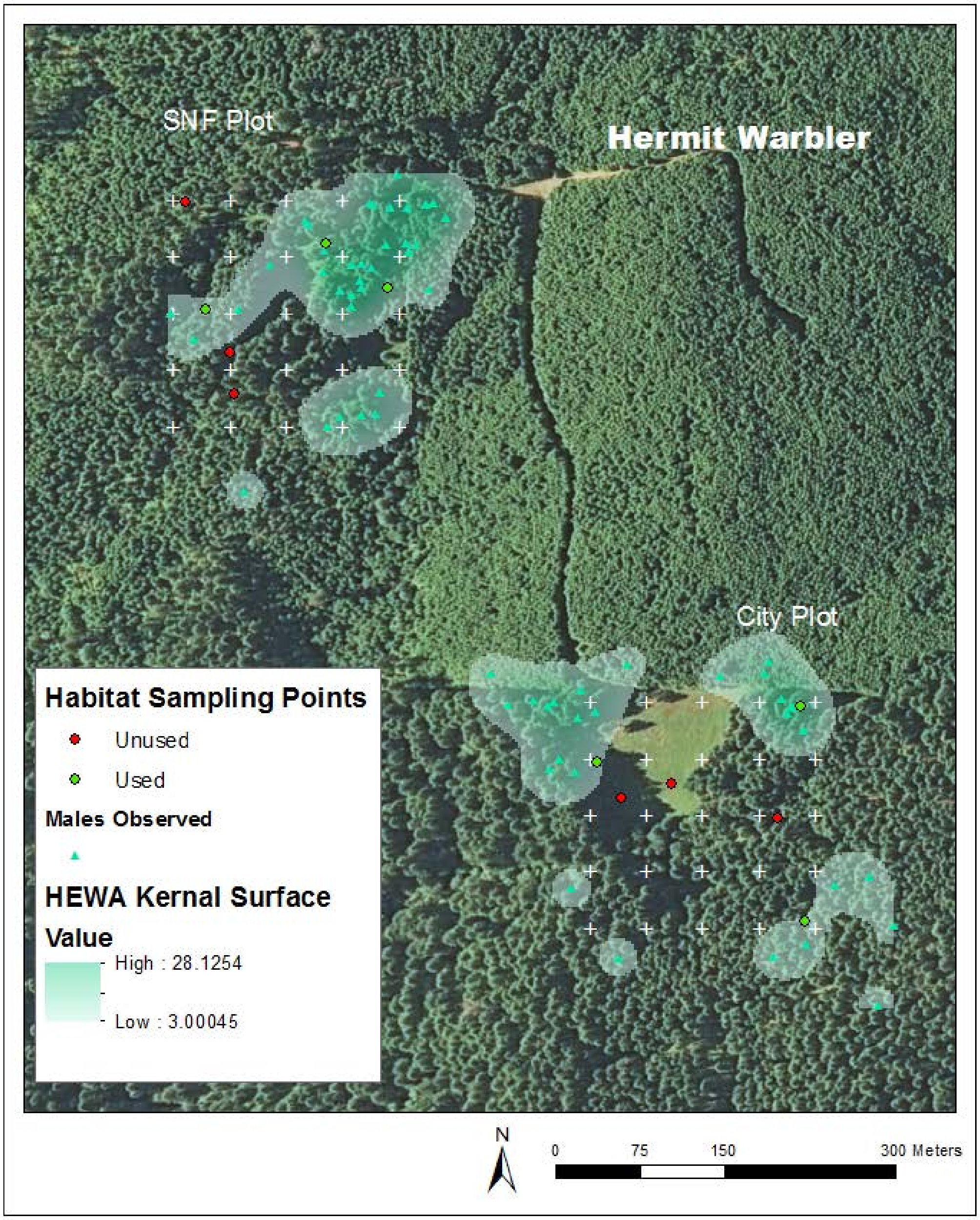
Dark-eyed juncos may be year-round forest residents, or short-distance migrants that overwinter in agricultural areas or cities and move to forests at higher elevations in the summer (Nehls 2006). Dark-eyed juncos are closely associated with forest openings and early-seral forest communities during the breeding season (Mannan and Meslow 1984). Hagar et al. (1996) reported that dark-eyed juncos were more abundant in thinned vs unthinned Douglas-fir forests. The species forages on or near the ground. Nests are typically constructed in a depression on the ground but are occasionally placed in a shrub (Nehls 2006). Territory size is reported to be 0.9 – 1.4 ha (Brown 1985).

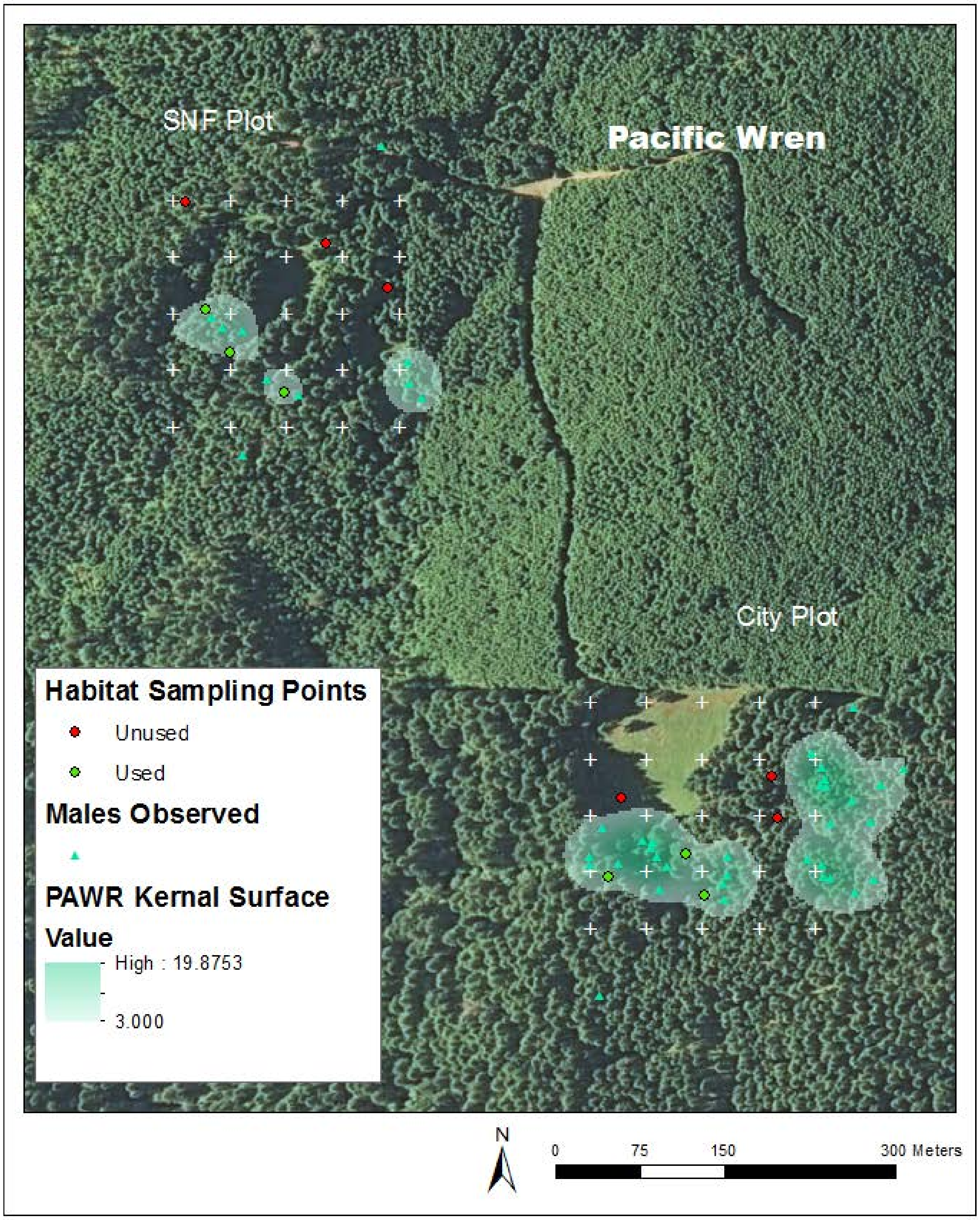
PACIFIC WREN

Previously named the winter wren (*Troglodytes troglodytes*). This resident species is associated with moist conifer forests, red alder stands, and Oregon white oak woodlands (Weikel 2006). In McDonald Forest (Benton County, Oregon), the abundance of Pacific wrens decreased following clear-cut harvesting, but not in small (0.2 ha) group selection cuts (Chambers et al. 1999). Two studies in the Oregon Coast Range reported greater abundance of the species in riparian areas than in adjacent upslope areas (Hagar 1999, McGarigal and McComb 1995). Downed logs, root wads, and residual woody debris are an important habitat element for Pacific wrens. Of 25 nests found during a study in the Oregon Coast Range, 16 were discovered under logs (Weikel 2006). Territory size ranges between 0.37 – 2.38 ha in British Columbia (Waterhouse 1998).

APPENDIX II: KERNAL DENSITY SURFACES AND HABITAT SAMPLING POINTS FOR THE DARK-EYED JUNCO, HERMIT WARBLER, AND PACIFIC WREN


SNF Plot
Dark-Eyed Junco
City Plot
Habitat Sampling Points
Unused
Used
Males Observed
DEJU Kernal Surface
Value
High : 12.649
Low : 3.0002
N
0
75
150
300 Meters


SNF Plot
Hermit Warbler
City Plot
Habitat Sampling Points
Unused
Used
Males Observed
HEWA Kernal Surface Value
High : 28.1254
Low : 3.00045
N
0
75
150
300 Meters


SNF Plot
Pacific Wren
City Plot
Habitat Sampling Points
Unused
Used
Males Observed
PAWR Kernal Surface
Value
High : 19.8753
3.000
N
0
75
150
300 Meters

Appendix III: Descriptive Statistics for Habitat Metrics Measured on the SNF and City Avian Survey Plots

Canopy (City)	
Mean	66.417
Standard Error	10.347
Median	89.000
Mode	94.000
Standard Deviation	35.842
Kurtosis	-1.157
Skewness	-0.913
Range	85.000
Minimum	9.000
Maximum	94.000
Count	12.000

Tall Shrub (City)	
Mean	0.000
Standard Error	0.000
Median	0.000
Mode	0.000
Standard Deviation	0.000
Kurtosis	0.000
Skewness	0.000
Range	0.000
Minimum	0.000
Maximum	0.000
Count	12.000

Low Shrub (City)	
Mean	0.142
Standard Error	0.058
Median	0.065
Mode	0.000
Standard Deviation	0.202
Kurtosis	1.526
Skewness	1.632
Range	0.572
Minimum	0.000
Maximum	0.572
Count	12.000

Canopy (SNF)	
Mean	86.556
Standard Error	5.982
Median	94.000
Mode	97.000
Standard Deviation	17.945
Kurtosis	3.502
Skewness	-1.951
Range	55.000
Minimum	45.000
Maximum	100.000
Count	9.000

Tall Shrub (SNF)	
Mean	0.150
Standard Error	0.092
Median	0.000
Mode	0.000
Standard Deviation	0.275
Kurtosis	4.095
Skewness	2.064
Range	0.802
Minimum	0.000
Maximum	0.802
Count	9.000

Low Shrub (SNF)	
Mean	0.234
Standard Error	0.082
Median	0.110
Mode	#N/A
Standard Deviation	0.245
Kurtosis	-0.241
Skewness	1.116
Range	0.654
Minimum	0.022
Maximum	0.676
Count	9.000

Forb (City)	
Mean	0.218
Standard Error	0.047
Median	0.155
Mode	#N/A
Standard Deviation	0.162
Kurtosis	2.532
Skewness	1.525
Range	0.574
Minimum	0.048
Maximum	0.622
Count	12.000

Grass (City)	
Mean	0.466
Standard Error	0.132
Median	0.237
Mode	#N/A
Standard Deviation	0.456
Kurtosis	-2.191
Skewness	0.304
Range	0.986
Minimum	0.014
Maximum	1.000
Count	12.000

Fern (City)	
Mean	0.060
Standard Error	0.017
Median	0.062
Mode	0.000
Standard Deviation	0.058
Kurtosis	0.418
Skewness	0.759
Range	0.188
Minimum	0.000
Maximum	0.188
Count	12.000

Forb (SNF)	
Mean	0.046
Standard Error	0.020
Median	0.012
Mode	0.000
Standard Deviation	0.060
Kurtosis	-0.150
Skewness	1.135
Range	0.156
Minimum	0.000
Maximum	0.156
Count	9.000

Grass (SNF)	
Mean	0.168
Standard Error	0.106
Median	0.034
Mode	0.000
Standard Deviation	0.317
Kurtosis	6.765
Skewness	2.547
Range	0.976
Minimum	0.000
Maximum	0.976
Count	9.000

Fern (SNF)	
Mean	0.078
Standard Error	0.043
Median	0.012
Mode	0.000
Standard Deviation	0.130
Kurtosis	0.630
Skewness	1.558
Range	0.312
Minimum	0.000
Maximum	0.312
Count	9.000

Moss (City)	
Mean	0.536
Standard Error	0.118
Median	0.676
Mode	0.000
Standard Deviation	0.407
Kurtosis	-1.692
Skewness	-0.474
Range	0.982
Minimum	0.000
Maximum	0.982
Count	12.000

Wood (City)	
Mean	0.413
Standard Error	0.102
Median	0.452
Mode	0.000
Standard Deviation	0.353
Kurtosis	-1.940
Skewness	-0.073
Range	0.846
Minimum	0.000
Maximum	0.846
Count	12.000

Bare (City)	
Mean	0.020
Standard Error	0.011
Median	0.005
Mode	0.000
Standard Deviation	0.038
Kurtosis	6.829
Skewness	2.538
Range	0.130
Minimum	0.000
Maximum	0.130
Count	12.000

Moss (SNF)	
Mean	0.411
Standard Error	0.085
Median	0.478
Mode	#N/A
Standard Deviation	0.254
Kurtosis	-0.917
Skewness	-0.277
Range	0.778
Minimum	0.000
Maximum	0.778
Count	9.000

Wood (SNF)	
Mean	0.367
Standard Error	0.102
Median	0.452
Mode	#N/A
Standard Deviation	0.305
Kurtosis	-1.554
Skewness	0.223
Range	0.810
Minimum	0.000
Maximum	0.810
Count	9.000

Bare (SNF)	
Mean	0.160
Standard Error	0.072
Median	0.078
Mode	#N/A
Standard Deviation	0.215
Kurtosis	1.213
Skewness	1.599
Range	0.592
Minimum	0.004
Maximum	0.596
Count	9.000

Conifer Basal Area (City)	
Mean	183.33
Standard Error	43.19
Median	170.00
Mode	0.00
Standard Deviation	149.63
Kurtosis	-1.37
Skewness	0.18
Range	420.00
Minimum	0.00
Maximum	420.00
Count	12.00

Hardwood Basal Area (City)	
Mean	1.67
Standard Error	1.67
Median	0.00
Mode	0.00
Standard Deviation	5.77
Kurtosis	12.00
Skewness	3.46
Range	20.00
Minimum	0.00
Maximum	20.00
Count	12.00

Conifer Basal Area (SNF)	
Mean	164.44
Standard Error	27.44
Median	160.00
Mode	160.00
Standard Deviation	82.33
Kurtosis	2.49
Skewness	0.94
Range	300.00
Minimum	40.00
Maximum	340.00
Count	9.00

Hardwood Basal Area (SNF)	
Mean	0
Standard Error	0
Median	0
Mode	0
Standard Deviation	0
Kurtosis	0
Skewness	0
Range	0
Minimum	0
Maximum	0
Count	9