Abundance of the Black-backed Woodpecker *(Picoides arcticus)* amid recent Mountain Pine Beetle *(Dendroctonus ponderosae)* Infestations within Crater Lake National Park, Oregon

Janel L. Lajoie

Crater Lake Science and Learning Center

Environmental Studies – Ecology and Conservation

ABSTRACT

The black-backed woodpecker (*Picoides arcticus*) is the first fire-dependent species to ever come under a full status review for inclusion in the Endangered Species Act. Mountain Pine Beetle (*Dendroctonus ponderosae*) infestations have been increasing over time, and a recent increase in mean temperatures have allowed beetle populations to persist in higher elevation forests. Black-backed woodpeckers rely upon sound, hard, large diameter snags – which are largely limited in intensely managed forests - for nesting habitat. This research was a baseline study to compare the baseline abundance of the black-backed woodpecker in areas that have and have not been affected by recent tree mortality due to the mountain pine beetle. We conducted repeat point counts with a variable distance broadcast survey for species absence/presence. We found that the black-backed woodpecker was most likely to be detected in lower elevation sites with a higher number of snags. The odds of detecting the black-backed woodpecker increased when the dominant vegetative species was either lodgepole pine or mountain hemlock.

Keywords: Black-backed woodpecker, mountain pine beetle, lodgepole pine, disturbance, habitat

INTRODUCTION

The black-backed woodpecker (BBWO) (*Picoides arcticus*) is an uncommon, inconspicuous, and non-migratory avian fire-specialist favoring northern coniferous forests of North America (Hutto and Woolf 2009). The BBWO's diet consists mainly of saproxylic insects such as wood-boring beetles and bark beetles which colonize readily in early post-fire habitats (Dudley 2005). Some saproxylic insects in the BBWO's diet can detect fire from up to fifty miles away, and will lay their eggs in still smoldering trees (Hutto and Woolf 2009). Likewise, the BBWO is nomadic and will move to inhabit recently burned forests (Hudec 2012). BBWOs are believed to be monogamous (Hudec 2012), and their populations are dangerously small, with local populations not at a size likely to be sustainable in the future. According to the Center for Biological Diversity, as of 2013 there were roughly 1,000 pairs in Oregon/California. The majority of research regarding the BBWO has been conducted in boreal forests. A small number of studies have been conducted in the Sierra Nevada of California due to candidacy of the BBWO to the California Endangered Species Act ("Protection sought for rare woodpecker" 2012). The occurrence of the BBWO is 16 times more likely to be detected in burned forest than other vegetation types regardless of the vegetative species, and they occur in increasing numbers as proximity to burned areas increases (Hutto 2008).

Under forest fire control and protection policies in Crater Lake National Park (CRLA), over approximately the last 100 years, lodgepole pine (*Pinus contorta*) has largely been replaced by Shasta fir (*Abies magnifica)*, red noble fir (*Abies procera*), mountain hemlock (*Tsuga mertensiana*), and white fir (*Abies concolor*) (Holleran 2008). Overall, land managers are

currently implementing forest practices aimed at eliminating stand-replacing fires (Hutto 2008), and attempting to return the forest to seral, pre-settlement conditions. Evidence suggests that the BBWO evolved over millions of years to become a key indicator species which has adapted to conditions that were abundant during its speciation – namely intense, severe, stand-replacing fire (Hutto 2008). If the current trend of restoration forestry is to continue, then "the ecological setting within which organisms evolved should receive considerable weight in the formulation of restoration goals" (Hutto 2008), and some consideration should be given to stand-replacement fire as a management practice (Duran 2009).

The BBWO is considered "vulnerable" by the Oregon Natural Heritage Program due to declines in range extent or population sizes (Adamus et al. 2013). The United States Fish and Wildlife Service (USFWS) announced in April 2013 that the genetically distinct populations of the BBWO in the forests of the Black Hills of South Dakota, and Oregon/California would receive a full status review to determine possible inclusion under the Endangered Species Act (ESA) (Center for Biological Diversity 2013). The petition filed by four conservation groups marks the first time in history that a status review has been conducted by the ESA to protect a fire dependent species (Center for Biological Diversity 2013). Studies show differing results for the length of time the BBWO can subsist in post-burned forests from 1-4 years (Hutto 2008), 2-3 years (Hudec 2012), 6-8 years (Dudley 2005), and 7-10 years (Center for Biological Diversity 2013). Suppression of the natural fire regime coupled with efforts to prevent backcountry fire, salvage logging, thinning, and large scale logging such as the Bybee project in the Rogue-River-Siskiyou National Forest (Fattig 2013), have greatly reduced the BBWO's already limited habitat. Though the BBWO is a fire-dependent, or burn-centric species, mountain pine beetle (MPB) (*Dendroctonus ponderosa*) infestations are considered to play an important role in habitat creation especially in the Black Hills and Cascade Mountains which are considered to be isolated populations (Rota et al. 2014).

Diet

The western United States and Canada contain hundreds of native bark beetle species, however, less than one percent have the ability to attack and reproduce in live trees and cause landscape scale tree mortality (Bentz et al. 2010). Insects account for 90 percent of tree mortality in the United States, and 60 percent of that is due to bark beetles (Leatherman 2012). MPB are a native species which evolved within western North American coniferous forests, and are a key disturbance agent (Bentz et al. 2010). MPB are found from southern California in elevations up to 11,000 feet, to northern British Columbia near sea level (Gibson et al. 2009). MPB outbreaks often occur in dense stands of medium to large diameter trees (Gibson et al. 2009). The major host species for MPB are alpine whitebark pine (*Pinus albicauli*), bristle cone pine (*Pinus aristata*), balfour pine (*Pinus balfouriana*), lodgepole pine (*Pinus contorta*),western white pine (*Pinus flexilis*), sugar pine (*Pinus lambertiana*), mountain white pine (*Pinus monticola*), and ponderosa pine (*Pinus ponderosa*) (Bentz et al. 2010). Of these species, alpine whitebark pine, lodgepole pine, ponderosa pine, and sugar pine predominate within CRLA (Holleran 2008). MPB is the most common cause of death for CRLA's signature species, the whitebark pine (Adamus et al. 2013).

MPB development is a four stage process: egg, larva, pupa, and adult, and all life stages of the beetle are spent beneath the bark of the tree (Gibson et al. 2009). Each August, newly formed adult female MPB will emerge from their host trees and travel to find new suitable pine hosts

(Leatherman 2012). When an appropriate tree is located, the females release a pheromone produced by modifying terpenes and other portions of the pine resin as they chew into the phloem and inner bark (Leatherman 2012). The pheromone attracts several hundred male and female MPB to the tree where they join in monogamous pairs and bore into the tree (Leatherman 2012). The process of boring creates more pheromones which, in turn, attract more beetles to neighboring trees. The female beetles construct vertical nuptial chambers, and after mating, construct straight, vertical galleries 4-48 inches in length in the phloem of the tree (Gibson et al. 2009). These galleries are packed with boring dust, or frass (Leatherman 2012), and tiny pearl white eggs are laid in niches along each side of the gallery (Gibson et al. 2009). The larva are white grubs which construct galleries at right angles to the egg gallery to feed in the phloem (Gibson et al. 2009). Larval development is highly dependent on temperature, and thus varies by year, elevation, and individual site (Gibson et al. 2009). In the final stage of larval development, an oval cell is excavated for pupation to occur (Gibson et al. 2009). When the immature adults emerge from pupation, they feed on fungal spores and free tissue, then emerge and locate their new host tree within 1-2 days (Gibson et al. 2009). The beetles introduce a combination of fungi, (*Ophiostoma* and *Ceratocystis*) collectively known as 'bluestain' (Leatherman 2012). These fungi spores provide enhanced nutritional content of the phloem by germinating and producing mycelium that colonizes both the phloem and the sapwood (Schalau n.d.). These fungi will stain the wood blue in a wedge-shaped pattern "due to the movement of hyphae along the rays from the outside of a log", and will eventually block the movement of water through the phloem and xylem columns of the tree (Schalau n.d.).

MPB can reproduce in any species of pine within their range, and tree mortality is hypothesized to occur in a three stage process. First, the water transport system in the trunk of the tree shuts down, which results in stomatal closure similar to the effects of drought (Edburg et al. 2012). The trees release abundant amounts of resin called pitch tubes, in an effort to eject the beetle or inhibit larval development (Casey et al. 2009). Second, the drop in stomatal conductance limits the capture of CO_2 which leads to a drop in the photosynthetic process (Edburg et al. 2012). The resulting mortality of the attacked trees is ultimately due to carbon starvation (Edburg et al. 2012), due to a lasting negative carbon balance.

Current outbreaks of MPB infestations have caused tree mortality to billions of coniferous trees over millions of hectares of land ranging from Mexico to Canada (Bentz et al. 2010). This largest ever recorded outbreak has been facilitated by a series of relatively mild winters which has reduced the mortality of beetle larvae over the winter months (Martin et al. 2006). Forest management practices are also believed to be a contributing factor in this record MPB outbreak (Drever et al. 2008). MPB thrive on forests which are under stress due to old age, excessive density, adverse weather, and fire (Leatherman 2012). MBP infestations are cyclical, occurring every 50-300 years on average, and lasting approximately 10 years locally (Leatherman 2012). MPB has caused episodic disturbance by infestation in a repeating pattern throughout CRLA (Adamus et al. 2013). Documented MPB outbreaks occurred in 1936, 1959, and 1980, and the current outbreak began in 2003 (Beck 2014).

Rota et al. report that the frequency and severity of MPB infestations are increasing over time, and insect outbreaks are "predicted to be affected dramatically by global warming" (Bentz et al. 2010). The mean annual temperature is expected to increase from 1.8ºC to 4ºC globally in the 21st century, and the mean increase at high latitudes and elevations in North America is expected

to be greater than the global mean (Bentz et al. 2010). Changes in the climate conditions over the next century are expected to significantly affect the productivity, distribution, condition and composition of many ecosystems (Bentz et al. 2010). Mortality from cold exposure is a key component in MPB population dynamics (Bentz et al. 2010), however, an increase in mean temperatures in recent years have allowed MPB to "shift and persist in higher elevation forests" (Adamus et al. 2013). Bentz et al. state that there is a higher probability of the success of the MPB population when there is a higher probability of low-temperature survival.

Habitat

BBWOs are a primary benefactor of population surges of MPB in our forests, and snags provide essential habitat for many species. Habitat selection varies by species, but it is generally a hierarchal process where choices at large scales constrain the choices made at smaller scales (George and Zack 2001). There is a four level system by which most species will select their habitat: first order selection refers to the geographical range of a particular species, second order refers to the home range of a social group or individual, third order refers to the way in which habitat elements are used within the home range (i.e., rest sites, nests, or foraging), and fourth order refers to which resources the animal chooses from those that are available (Figure 1) (George and Zack 2001). Although some processes that dictate habitat selection differ spatially, there is generally an association between temporal and spatial scales (George and Zack 2001). The current home range of the BBWO is within coniferous forests throughout most of Canada, Alaska, the Great Lakes region, and much of the northeast and northwest portions of the United States (Figure 2) (Dudley 2005).

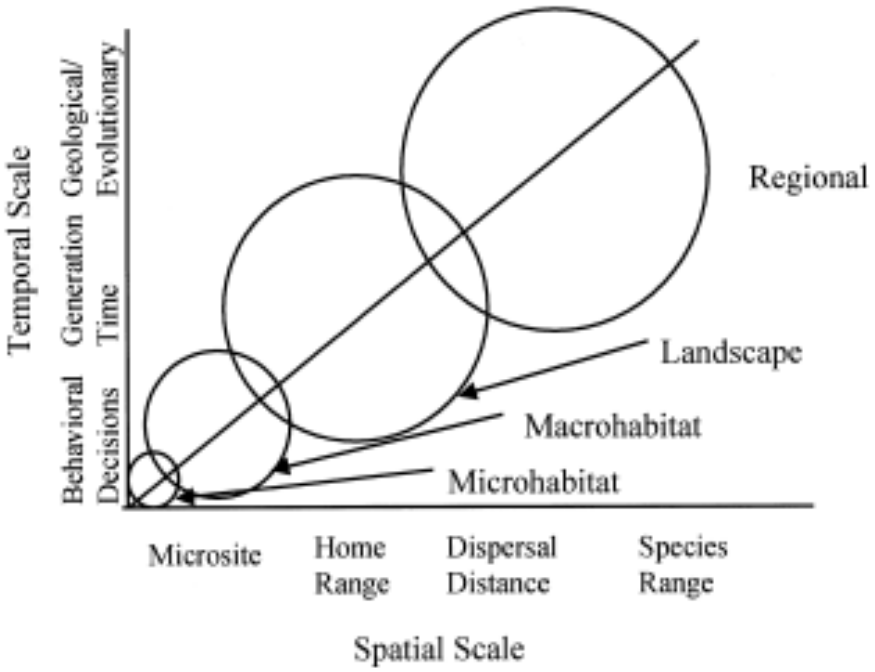

Figure 1. Relationship between spatial and temporal scales. Processes occurring at large spatial scales take place over long time periods, and processes that occur at micro-spatial scales take place over very short time periods. Source: George and Zack 2001.

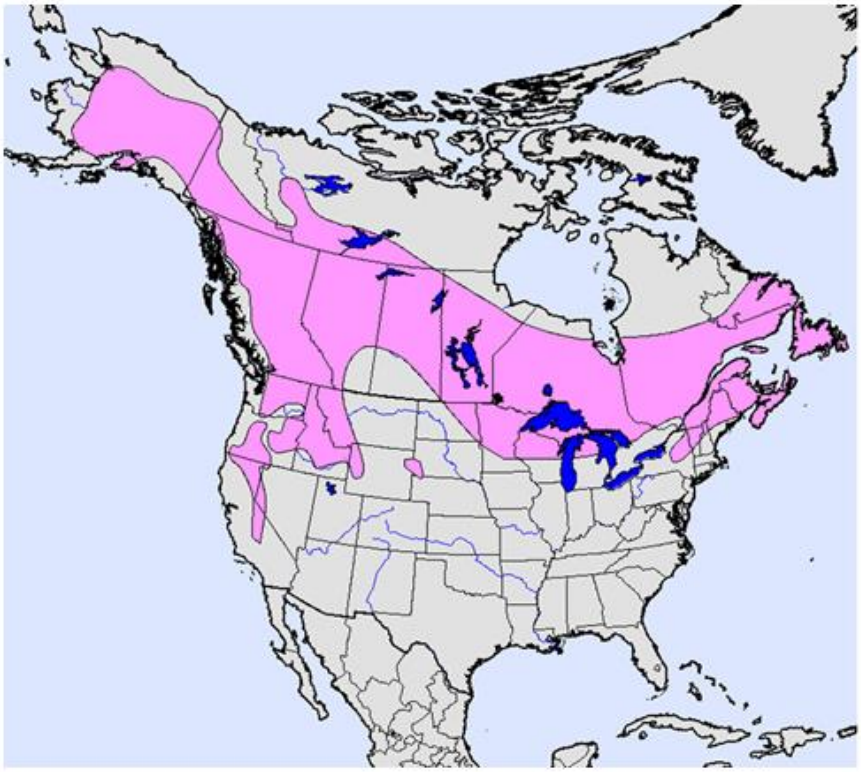

Figure 2. Home range of the BBWO. Source: Terry Sohl

BBWOs are primary cavity nesters and excavate their nests in snags. Once they have abandoned their nests, secondary cavity nesters will move in (Figure 3). Moreover, there are some species that are tertiary nesters. Of the 90 forest-dwelling vertebrate species in the Pacific Northwest listed as ‘sensitive’ or ‘at risk’, 30 are cavity nesters and 20 rely on downed wood (Bunnell et al. 2002). Due to the nest web created by the BBWO, it is considered a keystone species, and declines in woodpecker species would have cascading effects in the ecosystem. Woodpeckers use smaller diameter trees for foraging and larger diameter trees to excavate nests since cavity sites must be large enough to contain both the adult bird and its young (Bunnell et al. 2002). Prior to fire suppression, fires and bark beetles kept open forest understories with snag patches present in the forest (Casey et al. 2009). These created small areas of open canopy, and since the oldest trees were most susceptible to mortality, a consistent supply of large snags were created (Casey et al. 2009). In order to support populations of primary cavity nesters, snag resources must be adequate. Retention of hard, sound, large diameter snags provide the optimal habitat for the BBWO. Lack of appropriate cavity nesting sites has limited the abundance of some birds in “intensely managed forests” (Bunnell et al. 2002).

Primary cavity-nesters	Secondary cavity-nesters
Woodpeckers	*Ducks*
Red-naped sapsucker	Wood duck
Hairy woodpecker	Common goldeneye
Three-toed woodpecker	Barrow's goldeneye
Black-backed woodpecker	Bufflehead
Northern flicker	Common merganser
Pileated woodpecker	Hooded merganser
Downy woodpecker	
	Insectivorous Birds
Weak Excavators	Vaux's swift
Red-breasted nuthatch	Tree swallow
Mountain chickadee	Violet-green swallow
Black-capped chickadee	European starling
Boreal chickadee	House wren
	Mountain bluebird
	Birds of Prey
	American kestrel
	Flammulated owl
	Northern pygmy owl
	Northern saw-whet owl
	Boreal owl
	Northern hawk owl
	Barred owl
	Great-horned owl
	Mammals
	9 possible species of bat
	Bushy-tailed woodrat
	Red squirrel
	Northern flying squirrel

Figure 3. Examples of primary and secondary cavity nesters. Source: Martin et al. 2006.

This research is a pilot study to compare the difference in the baseline abundance of the BBWO in areas that have had outbreaks of the MPB and areas that have not been affected. Our study may have particular relevance from the perspective of management of CRLA. In the event that the BBWO is ultimately listed under the ESA, this baseline data will be beneficial to CRLA as necessary monitoring processes become established, and further preliminary studies and comparative analyses of population trends over time are conducted.

MATERIALS AND METHODS

Study areas and data collection

The study area is located at 42º86' to 43º09'N and -122º04' to -122º19'W with an elevation range of 5,953 to 6,594 feet above sea level, within the boundaries of CRLA, Oregon. Following review of several near passerine monitoring protocols, the primary method of data collection was repeat point counts using observation for absence/presence and playback of the BBWO drums and calls. Inventories, species absence/presence, and repeat point counts can be completed in one season (Nur et al. 1999), which is noteworthy due to park related time constraints. It is also significant to note that the National Monitoring Working Group of *Partners in Flight* recommends point counts as the preferred method of near passerine surveys (Nur et al. 1999).

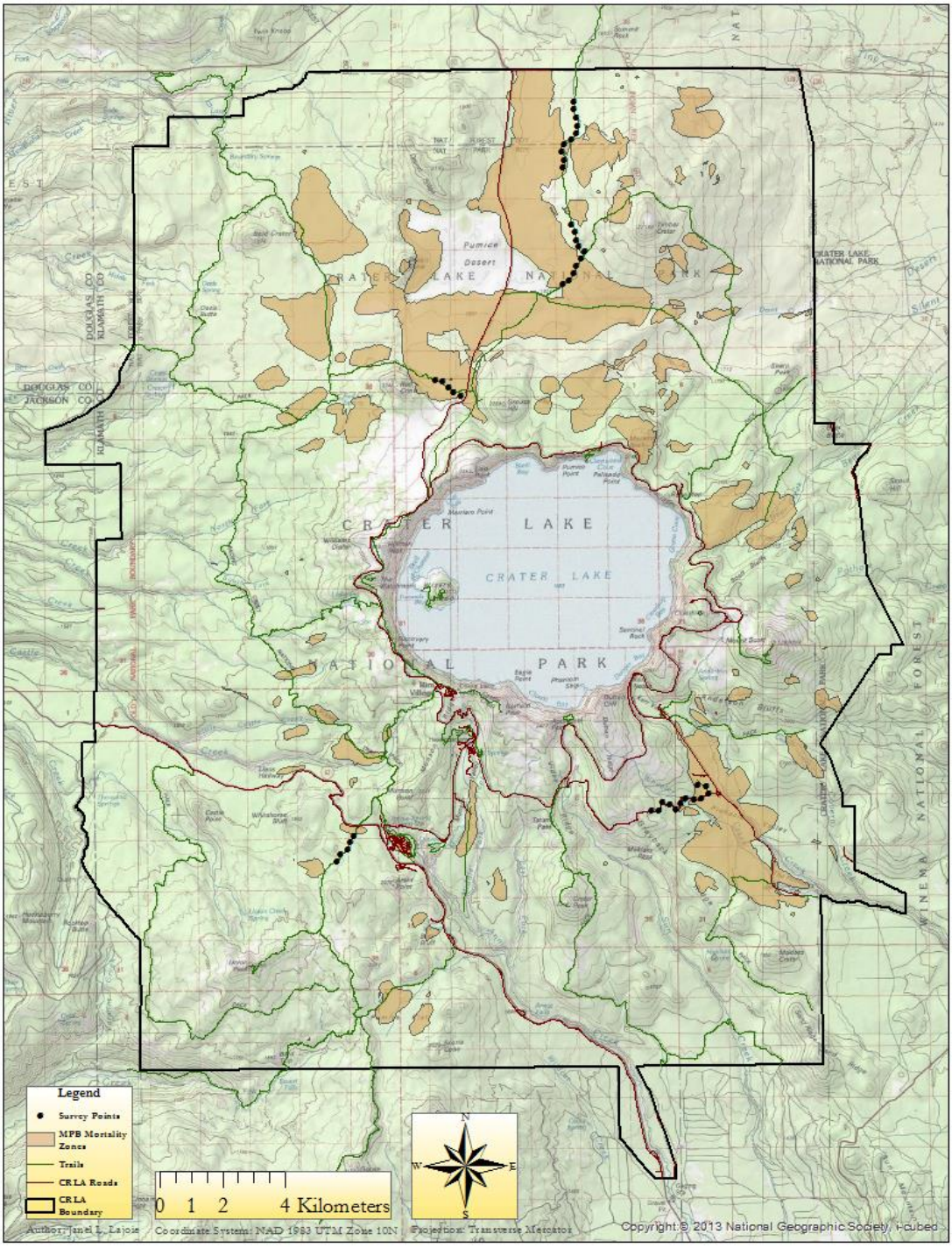

Figure 4. Data collection points throughout CRLA and MPB mortality zones.

Using United States Forest Service (USFS) aerial detection survey data (Forest Health Technology Enterprise Team n.d.) spanning five years (2008-2012), and ESRI's ArcGIS suite of software, a map was created of areas within the park boundary which have suffered a MPB

infestation in at least three of the five years (Figure 4). Those areas were then reduced to include only regions with an area over 125 hectares. Primary data collection points of similar elevation within the MPB mortality zones were selected on a closed road or a trail at least 250 meters from the nearest active road. A Garmin eTrex 20 GPS unit (<15 meter accuracy) was used to locate the primary point in the field, and repeat point counts were done at subsequent locations 250 meters apart.

BBWOs are quite vocal, territorial in nature, have a very sharp and distinct call (Hudec 2012), and playback can dramatically affect the detection of this species (Ralph et al. 1995). Between July 12 and August 4, 2014, we collected data at 42 study sites within CRLA including 20 points in MPB mortality zones and 22 control points. Each of the 42 points was surveyed three times by a pair of researchers. Pairs were used to strengthen the validity of observational findings by comparing field notes and to ensure safety. Data collection began within 10 minutes of local sunrise, Pacific Standard Time, and lasted no more than five hours with a mean of 214 minutes per day. Surveys were not conducted when precipitating or when wind speeds were excessive, as these conditions can limit detection ability. Time of day each point was visited was varied as much as possible within spatial constraints in an effort to minimize potential bias (Table 1).

Table 1. Sites visited, dates and local 2014 sunrise times at CRLA.

Site Number	Visit 1 Time	Visit 1 Date	Visit 1 Sunrise	Visit 2 Time	Visit 2 Date	Visit 2 Sunrise	Visit 3 Time	Visit 3 Date	Visit 3 Sunrise
101	5:55	7/12/2014	5:41	5:36	7/14/2014	5:42	6:20	8/3/2014	6:01
102	6:10	7/12/2014	5:41	5:47	7/14/2014	5:42	6:31	8/3/2014	6:01
103	6:25	7/12/2014	5:41	5:59	7/14/2014	5:42	6:41	8/3/2014	6:01
104	6:35	7/12/2014	5:41	6:08	7/14/2014	5:42	6:51	8/3/2014	6:01
105	6:45	7/12/2014	5:41	6:15	7/14/2014	5:42	6:59	8/3/2014	6:01
106	6:55	7/12/2014	5:41	6:26	7/14/2014	5:42	7:09	8/3/2014	6:01
107	7:05	7/12/2014	5:41	6:36	7/14/2014	5:42	7:24	8/3/2014	6:01
108	7:15	7/12/2014	5:41	6:46	7/14/2014	5:42	7:32	8/3/2014	6:01
109	7:28	7/12/2014	5:41	6:56	7/14/2014	5:42	7:43	8/3/2014	6:01
110	7:35	7/12/2014	5:41	7:06	7/14/2014	5:42	10:53	8/3/2014	6:01
111	8:25	7/12/2014	5:41	7:50	7/14/2014	5:42	10:20	8/3/2014	6:01
112	8:30	7/12/2014	5:41	8:00	7/14/2014	5:42	10:11	8/3/2014	6:01
113	8:42	7/12/2014	5:41	8:10	7/14/2014	5:42	10:05	8/3/2014	6:01
114	8:50	7/12/2014	5:41	8:18	7/14/2014	5:42	9:44	8/3/2014	6:01
115	9:00	7/12/2014	5:41	8:28	7/14/2014	5:42	9:34	8/3/2014	6:01
116	9:10	7/12/2014	5:41	8:38	7/14/2014	5:42	9:26	8/3/2014	6:01
117	9:21	7/12/2014	5:41	6:43	7/20/2014	5:47	9:11	8/3/2014	6:01
118	9:32	7/12/2014	5:41	6:30	7/20/2014	5:47	9:02	8/3/2014	6:01
119	9:41	7/12/2014	5:41	6:56	7/20/2014	5:47	8:56	8/3/2014	6:01
120	9:50	7/12/2014	5:41	7:05	7/20/2014	5:47	8:46	8/3/2014	6:01
121	7:57	7/13/2014	5:41	6:26	7/19/2014	5:46	6:04	8/2/2014	6:00
122	5:44	7/13/2014	5:41	6:36	7/19/2014	5:46	6:15	8/2/2014	6:00
123	5:53	7/13/2014	5:41	6:47	7/19/2014	5:46	6:23	8/2/2014	6:00

124	6:04	7/13/2014	5:41	6:57	7/19/2014	5:46	6:34	8/2/2014	6:00
125	6:16	7/13/2014	5:41	7:08	7/19/2014	5:46	6:45	8/2/2014	6:00
126	6:00	7/13/2014	5:41	7:21	7/19/2014	5:46	6:55	8/2/2014	6:00
127	6:39	7/13/2014	5:41	7:32	7/19/2014	5:46	7:05	8/2/2014	6:00
128	6:53	7/13/2014	5:41	7:44	7/19/2014	5:46	7:16	8/2/2014	6:00
129	7:04	7/13/2014	5:41	7:53	7/19/2014	5:46	7:26	8/2/2014	6:00
130	7:15	7/13/2014	5:41	8:05	7/19/2014	5:46	7:36	8/2/2014	6:00
131	8:04	7/13/2014	5:41	5:52	7/19/2014	5:46	8:16	8/2/2014	6:00
132	8:15	7/13/2014	5:41	6:07	7/19/2014	5:46	8:25	8/2/2014	6:00
133	9:35	7/13/2014	5:41	8:45	7/20/2014	5:47	8:09	8/4/2014	6:02
134	9:43	7/13/2014	5:41	8:36	7/20/2014	5:47	8:17	8/4/2014	6:02
135	9:56	7/13/2014	5:41	8:27	7/20/2014	5:47	8:28	8/4/2014	6:02
136	10:04	7/13/2014	5:41	8:16	7/20/2014	5:47	8:36	8/4/2014	6:02
137	10:13	7/13/2014	5:41	8:06	7/20/2014	5:47	8:45	8/4/2014	6:02
138	5:46	7/21/2014	5:48	5:55	7/21/2014	5:48	9:15	8/2/2014	6:00
139	5:57	7/21/2014	5:48	6:06	7/21/2014	5:48	9:23	8/2/2014	6:00
140	6:08	7/21/2014	5:48	6:20	7/21/2014	5:48	9:32	8/2/2014	6:00
141	6:17	7/21/2014	5:48	6:30	7/21/2014	5:48	9:41	8/2/2014	6:00
142	6:28	7/21/2014	5:48	6:41	7/21/2014	5:48	9:50	8/2/2014	6:00

At each survey point a six minute variable distance broadcast survey was conducted to elicit responses from the BBWO using a RCA MP3 player and a Philips SHOQBOX speaker. The survey began by broadcasting a portion of recording # 82357 (Macaulay Library 2014) at a standardized volume of the drums and calls of the BBWO for thirty seconds, quietly listening and observing for one and one-half minutes, and repeating the process two more times for a total of three broadcast/observation periods at each survey point. When BBWOs were detected, the initial distance, if known, bearing in relation to observation, age (adult, juvenile, or unknown), sex (male, female, or unknown), and whether the response was a drum or call was recorded. If there was visual confirmation, our best efforts to capture a photograph, including a date/time stamp, were made. At each visit the date, time, wind speed, and temperature were recorded. During the initial visit to each point, a vegetation survey was conducted to record elevation, dominant vegetative species, and a count of snags in three size classes relative to diameter at breast height (DBH), small (<6” DBH), medium (6”-15” DBH), and large (>15” DBH).

DATA ANALYSIS

We applied a logistic regression model to determine which variables (predictors) most significantly explain the presence/absence of the BBWO (response) in the study area. This model was chosen due to the dichotomous nature of the response variable, and has been successfully implemented in numerous absence/presence studies historically.

In order to effectively analyze the probability of the presence of the BBWO in areas with varying snag size, continuous data were transformed to a binary representation by determining the mean number of each size snag (small, medium, large) in each of the 42 research points, and sites were categorized into two bins. Sites with a quantity of snags less than the mean (small 8, medium 11, and large 4) were assigned a '0', and sites with a higher number of snags than the mean were assigned a '1'. To convert the recorded elevations to binary data, the median elevation was used, and an elevation bin was created. Sites with elevations lower than the median were assigned a '0', and sites with elevations higher than the median were assigned a '1' (Table 2). The final data set consisted of 126 total site visitations conducted during the summer of 2014 with a total of 15 detections of the BBWO, 6 each on the first and third visits and 3 on the second visit. The mean number of small snags recorded per site was 8.33, with a mean of 11.64 medium snags and a mean of 4.05 large snags per site. The median elevation across the surveyed sites was 6155.

Table 2. Description of the explanatory variables used in the logit models.

Variable	Definition
Presence	Presence of the BBWO =1, Absence =0
Small_Bin	Presence of >8 small snags per site = 1, otherwise =0
Med_Bin	Presence of >11 medium snags per site =1, otherwise =0
Large_Bin	Presence of >4 large snags per site =1, otherwise =0
Elev_Bin	Elevation >6155 ft. = 1, otherwise =0
MPB_Mort	Within USFS MPB mortality zone =1, otherwise =0
PICO_Dom	Dominant species in site is lodgepole pine =1, otherwise =0
TSME_Dom	Dominant species in site is mountain hemlock =1, otherwise =0
PSME_Dom	Dominant species in site is Douglas fir =1, otherwise =0

RESULTS

The results presented in Table 3 show that the most statistically significant variable in the model was presence of small snags (p-value 0.095, 95% confidence interval (CI)). The odds ratio for small snags is 3.57 which implies that the BBWO is 3.57 times more likely to be detected in a site with >8 small snags than it is in a site void of small snags. The goodness of fit range (0.331-0.384) indicates that we do not have sufficient evidence to claim that the model does not fit the data adequately.

Medium and large snags, while not statistically significant (P-value 0.484 and 0.746 respectively, CI 95%), do slightly suggest that the BBWO is 1.67 more likely to be found in sites with >11 medium snags and 1.27 times more likely to be detected in sites with >4 large snags. The goodness of fit range for medium and large snags, (0.250 - 0.384, and 0.238 - 0.384 respectively) do not provide sufficient evidence to suggest that the model does not fit the data adequately (Table 3).

Table 3. Parameter estimates of the binary logit model for factors influencing presence of the BBWO.

Variables	Constant Coefficient	Coefficient	SE	Significance (P-value)	Odds Ratio	Equation
Small_Bin	-1.609	1.273	0.763	0.095	3.57	Y'=-1.609+(1.273*Small_Bin)
Med_Bin	-1.386	0.511	0.730	0.484	1.67	Y'=-1.386+(0.511*Med_Bin)
Large_Bin	-1.253	0.241	0.745	0.746	1.27	Y'=-1.253+(0.241*Large_Bin)
Elev_Bin	-0.916	-0.531	0.736	0.471	0.59	Y'=-0.916+(-0.531*Elev_Bin)
MPB_Mort	-0.981	-0.405	0.736	0.582	0.67	Y'=-0.981+(-0.405*MPB_Mort)
PICO_Dom	-1.447	0.531	0.736	0.471	1.70	Y'=-1.447+(0.531*PICO_Dom)
TSME_Dom	-1.216	0.300	0.928	0.747	1.35	Y'=-1.216+(0.300*TSME_Dom)
PSME_Dom	-0.916	-0.875	0.871	0.315	0.42	Y'=-0.916+(-0.875*PSME_Dom)

There is a weak but positive relationship between the presence of lodgepole pine and mountain hemlock as the dominant vegetative species and the presence of the BBWO (Pearson correlation coefficient of 0.112 and 0.481 respectively). When lodgepole pine is found to be the dominant species in the area, the odds of detecting presence of the BBWO increase by a factor of 1.70, and when mountain hemlock is dominant the odds of detecting presence increase by a factor of 1.35.

Our results show a potentially negative effect of presence when analyzed with the elevation, mountain pine beetle mortality zones, and sites dominated by Douglas fir. As site elevation increases to over 6155 feet above sea level, the odds of detecting the presence of a BBWO decrease by a factor of 0.59.

I used the statistical software Minitab to run binary fitted line plots and binary logistic regression models on the probable presence of the BBWO in relation to each predictor variable (Figure 5).

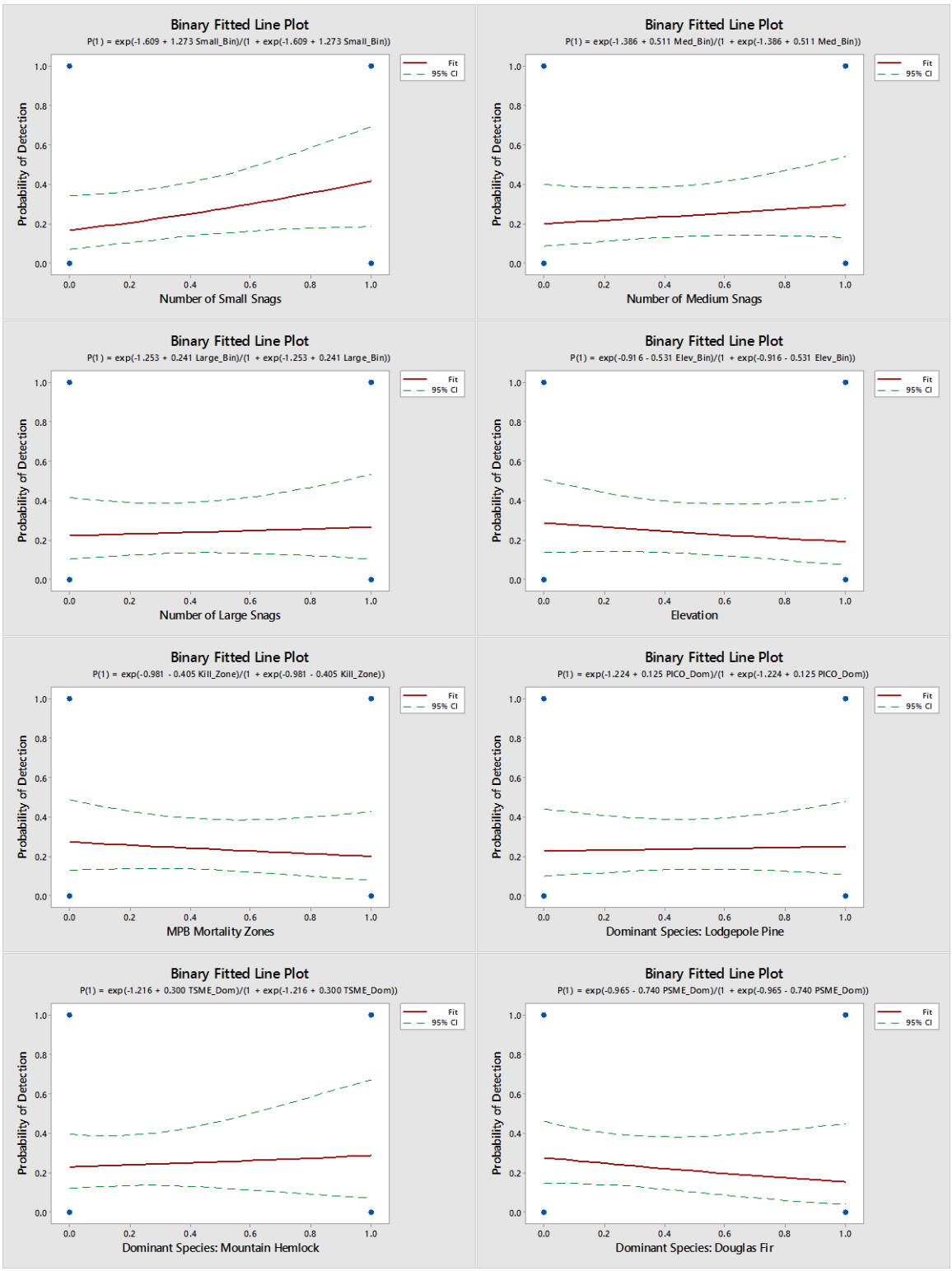

Figure 5. Individual binary fitted line plots for each variable included in the logit models.

DISCUSSION

Our study indicates that there is some correlation between the presence/absence of BBWO and the number of standing snags of different DBH within CRLA. Although a direct correlation was not found between the MPB mortality zones and the control plots we studied, there is evidence to suggest that presence of the BBWO is more likely to be detected in zones with a higher number of snags. Based on the odds ratio observed in the logit model, a higher number of snags of all sizes contribute to the presence of the BBWO (small 3.57, medium 1.67, large 1.27). While considering conservation management, thought must be given to both foraging requirements and nesting requirements since the birds use different diameter trees for different purposes (Bunnell et al. 2002). In order to support the BBWO population, snags of all sizes must be adequate enough throughout the forest. Based on this baseline study, we suggest that silvicultural treatments and management strategies used in CRLA mimic the natural forest mosaic as closely as possible.

There are many factors contributing to any environmental system, each functioning at individual temporal and spatial scales (Swannack et al. 2012). Ecological modeling is not an exhaustive, comprehensive, or rigorous process. Rather, it is a step-by-step progression in which we attempt to decipher small pieces of a particular system that we can then build upon to address challenges and incorporate new findings as they occur. The logit models provided by this pilot study evaluate a very small portion of the detection of absence/presence of the BBWO in CRLA and in the greater Cascade region. Further studies should include larger geographic areas over longer temporal periods to better quantify the absence/presence of BBWO. Tremblay et al. have conducted studies to measure foraging events for BBWO in unburned forest stands, and we suggest a similar study in CRLA may be beneficial to management strategies.

We did face one constraint during the course of this study. The equipment that was proposed was not delivered, so we lost several days in the field while we worked through some logistical complications – this limited the total number of sites we could visit in one season – which was already restricted by available time. The United States Forest Service aerial detection survey data used for the ESRI ArcGIS map layers for recent MPB mortality zones within CRLA were somewhat dated (2008-2012), so it is possible that there was some existing overlap in control and study zones observed in the field which could be a source of uncertainty.

ACKNOWLEDGEMENTS

I would like to thank Dr. Gregory Jones, Southern Oregon University Director: Division of Business, Communication, and the Environment for being an excellent mentor and answering my emails even when he was half a world away. Funding for this project was provided by The Oregon Institute of Technology, The Crater Lake Science and Learning Center, and The Ronald E. McNair Post-Baccalaureate Achievement Program. Southern Oregon University Assistant Professor Dr. David Kramar was instrumental in assistance with data analysis and revisions. Jen

Beck, Chris Wayne, and Jherime Kellerman with Crater Lake National Park contributed mapping and vegetation assistance as well as brainstorming during the inception of this research. Assistant Professor Dee Southard and the Southern Oregon University McNair program provided countless hours of guidance, recommendations, and much appreciated moral support. I would like to thank my four sons for patience during innumerable hours of research. I would like to offer never-ending thanks to my partner, and Head Research Assistant Brian Mayfield for being a fantastic photographer, indefatigable hiker, burly gear-mule, and unrelenting cheerleader.

REFERENCES

Adamus, P. R., D. C. Odion, G. V. Jones, L. C. Groshong, and R. Reid. 2013. Crater Lake National Park Natural Resource Condition Assessment. Natural Resource Report, National Park Service, Fort Collins, Colorado.

Beck, J. 2014, July 24. Crater Lake Biological Data.

Bentz, B. J., J. Régnière, C. J. Fettig, E. M. Hansen, J. L. Hayes, J. A. Hicke, R. G. Kelsey, J. F. Negrón, and S. J. Seybold. 2010. Climate Change and Bark Beetles of the Western United States and Canada: Direct and Indirect Effects. BioScience 60:602–613.

Bunnell, F. L., I. Houde, B. Johnston, and E. Wind. 2002. How Dead Trees Sustain Live Organisms in Western Forests. Pages 291–318. USDA Forest Service Gen. Tech. Rep.

Casey, D., B. Altman, and D. Stringer. 2009. Snags, Bark Beetles, and Cavity-Nesting Birds: Conservation and Management in Ponderosa Pine Forests of the Pacific Northwest. Pages 1–16.

Center for Biological Diversity. 2013, April 9. . http://www.biologicaldiversity.org/news/press_releases/2013/black-backed-woodpecker-04-08-2013.html.

Drever, M. C., K. E. H. Aitken, A. R. Norris, and K. Martin. 2008. Woodpeckers as reliable indicators of bird richness, forest health and harvest. Biological Conservation 141:624–634.

Dudley, J. G. 2005, April. Home range size and foraging habitat of Black-baced Woodpeckers. Boise State University, Boise, ID.

Duran, L. 2009. Undersatanding the Influence of Local and Landscape Conditions on the Occurence and Abundance of Black-Backed Woodpeckers in Burned Forest Patches. Brief.

Edburg, S. L., J. A. Hicke, P. D. Brooks, E. G. Pendall, B. E. Ewers, U. Norton, D. Gochis, E. D. Gutmann, and A. J. Meddens. 2012. Cascading impacts of bark beetle-caused tree mortality on coupled biogeophysical and biogeochemical processes. Frontiers in Ecology and the Environment 10:416–424.

Fattig, P. 2013, September 24. Forest Service OKs logging in the controversial Bybee project. http://www.mailtribune.com/apps/pbcs.dll/article?AID=/20130924/NEWS/309240319.

Forest Health Technology Enterprise Team. (n.d.). . http://www.fs.fed.us/foresthealth/technology/ads_standards.shtml.

George, T. L., and S. Zack. 2001. Spatial and Temporal Considerations in Restoring Habitat for Wildlife. Restoration Ecology 9:272–279.

Gibson, K., S. Kegley, and B. Bentz. 2009. Mountain Pine Beetle. Pages 1–12. Forest Insect & Disease Leaflet, United States Department of Agriculture, Forest Service.

Holleran, P. 2008. Crater Lake National Park. Crater Lake National Park. http://www.shannontech.com/ParkVision/CraterLake/CraterLake23.html.

Hudec, L. 2012. Picoides arcticus. http://animaldiversity.ummz.umich.edu/accounts/Picoides_arcticus/.

Hutto, R. L. 2008. The ecological importance of severe wildfires: some like it hot. Ecological Applications: A Publication of the Ecological Society of America 18:1827–1834.

Leatherman, D. 2012, January. Mountain Pine Beetle. Colorado Birds 46:33–40.

Macaulay Library. 2014. . http://macaulaylibrary.org/field-recording.

Martin, K., A. Norris, and M. Drever. 2006. Effects of bark beetle outbreaks on avian biodiversity in the British Columbia interior: Implications for critical habitat management. Journal of Ecosystems and Management 7.

Nur, N., S. L. Jones, and G. R. Geupel. 1999. Statistical Guide to Data Analysis of Avian Monitoring Programs. Pages 1–55. Biological Technical Publication, U.S. Fish & Wildlife Service, Point Reyes Bird Observatory, Stinson Beach, CA 94970.

Protection sought for rare woodpecker. 2012, May 3. News 24.

Ralph, C. J., S. Droege, and J. R. Sauer. 1995. Managing and Monitoring Birds Using Point Counts: Standards and Applications 149:1–187.

Rota, C. T., M. A. Rumble, J. J. Millspaugh, C. P. Lehman, and D. C. Kesler. 2014. Space-use and habitat associations of Black-backed Woodpeckers (Picoides arcticus) occupying recently disturbed forests in the Black Hills, South Dakota. Forest Ecology and Management 313:161–168.

Schalau, J. (n.d.). Blue Stain Fungi - Field Guide to Insects and Diseases of AZ and NM Forests. http://www.fs.fed.us/r3/resources/health/field-guide/sds/bluestain.shtml.

Swannack, T. M., J. C. Fischenich, and D. J. Tazik. 2012. Ecological Modeling Guide for Ecosystem Restoration and Management. Pages 1–61. Environmental Benefits Analysis Program, U.S. Army Engineer Research and Development Center, Environmental Laboratory.

Tremblay, J. A., J. Ibarzabal, J.-P. L. Savard, and S. Wilson. 2014. Influence of old coniferous habitat on nestling growth of Black-backed Woodpeckers Picoides arcticus. ACTA Ornithologica 49:273–279.