Effectiveness of Management Actions Intended to Benefit Wildlife Populations on the Craig Mountain Wildlife Management Area

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Authorization to Submit Thesis

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Abstract

We evaluated the effectiveness of management efforts on Craig Mountain Wildlife Management Area in northern Idaho. We used variable circular plot surveys to estimate the extent to which breeding density of 3 target bird species (Pileated Woodpeckers, Yellow Warblers, and Black-capped Chickadees) changed during the past 21 years of management. We used both correlative and quasi-experimental approaches to examine the effects of 3 timber harvest prescriptions (partial removal cuts, regeneration cuts, and fuel reduction cuts) on breeding density of Pileated Woodpeckers. Results suggest that the management actions and land uses implemented within the management area have not led to declines in density for the 3 target bird species. However, breeding density of Pileated Woodpeckers was negatively correlated with timber harvest intensity, breeding density of Pileated Woodpeckers was 81% lower in areas that had received fuel reduction cuts compared to areas with no recent harvest, and breeding density of Pileated Woodpeckers declined 86% following regeneration cuts.

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Dedication

I would like to dedicate this work to my wonderful family. Thank you Ember, Lucy, and baby Clara.

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Overview

The Idaho Department of Fish and Game (IDFG) manages 32 Wildlife Management Areas (WMA) throughout Idaho. Management of these WMAs is intended to benefit wildlife populations, but quantitative evaluations to determine whether individual WMAs are meeting their goals are not available. Craig Mountain Wildlife Management Area (CMWMA), for example, has been managed by IDFG for over 20 years, but a quantitative analysis of the effectiveness of the management actions that have been implemented has never been conducted. Determining whether current management actions help to achieve the stated goals of a WMA is a critical component of successful management.

We evaluated the effectiveness of current and past management efforts on 3 target bird species on CMWMA. This evaluation will inform CMWMA managers on future actions needed to best achieve CMWMA's intended goals. In addition to informing management decisions on CMWMA, our goal was to also provide important information to IDFG's WMA network by providing an example of how past data can be combined with new data to evaluate management actions. CMWMA is the largest of the 32 WMAs in Idaho, consisting of approximately 60,000-ha. One of CMWMA's main goals is to protect and enhance wildlife populations and their habitats, especially for 6 target species: Yellow Warbler (*Dendroica petechia*), Black-capped Chickadee (*Poecile atricapillus*), Pileated Woodpecker (*Dryocopus pileatus*), White-tailed Deer (*Odocoileus virginianus*), Rocky Mountain Elk (*Cervus elaphus*), and River Otter (*Lontra canadensis*). Our evaluation focuses on the 3 target bird species. Baseline wildlife surveys were conducted for these species on CMWMA in 1993 and 1994 (Cassirer 1995). During the baseline wildlife survey effort, bird survey transects were established in both upland forest and riparian/grassland systems. These transects were established specifically to survey Pileated Woodpeckers, Yellow Warblers, and Black-capped Chickadees. However, observers recorded all bird species detected during these survey efforts. Some of the bird survey transects were re-surveyed in 1997 (Karl 1998) and again in 2002 (Idaho Department of Fish & Game 2002). We re-surveyed the original baseline transects in 2013 and 2014, and estimated how density of these 3 species changed since IDFG began managing a large portion of CMWMA in 1992.

We were interested in these 3 target bird species for this evaluation for 3 reasons. First, IDFG already conducts population estimates or hunter harvest trends for both deer and elk. In contrast, neither population estimates nor trends are available for the 3 target bird species. Second, the 3 target bird species are associated with several vegetative communities on CMWMA and range from the lowest to highest elevations of CMWMA. River Otters are restricted to a narrow portion of the WMA along the Snake and Salmon rivers. Hence, by focusing on the 3 target bird species, we were able to evaluate the effects of management actions across a large portion of CMWMA. Third, by combining data from the original survey effort (1993-94), data from 1997 and 2002 surveys, and data from our survey efforts in 2013 and 2014, we have the opportunity to quantify changes in density of these 3 target bird species across 4 different time periods between 1993 and 2014.

Although bird surveys were conducted 3 previous times (1993-94, 1997, and 2002) on the CMWMA bird survey transects, a comparison of these data across these 3 survey periods had not been conducted. After locating, organizing, and combining the data from these 3 previous survey efforts, we compared the average number of the 3 target bird species detected per survey. Based on these raw counts, Yellow Warbler detections increased, Black-capped Chickadee detections remained relatively stable, and Pileated Woodpecker detections decreased from 1993 to 2002 (Fig. 1).

The decline in Pileated Woodpecker detections was disconcerting given that this species was 1 of only 6 target species on CMWMA. We tested 2 alternatives that we thought might explain the observed longitudinal changes in the average number of birds detected per survey point for the 3 target species.

1) Change in Density: Density of the 3 target bird species has changed over the 3 survey periods.

- Changes in raw counts of the 3 target bird species may represent changes in density of the 3 target bird species since the baseline surveys in 1993-94.

2) Change in Detection Probability: Detection probability differed among the 3 survey periods for the 3 target bird species.

- The 1993-94 surveys within conifer forests on CMWMA were conducted between late March and May (Cassirer 1995), whereas the 1997 (Karl 1998) and 2002 (Idaho Department of Fish & Game 2002) surveys were conducted between late May and July. Hence, differences in detection probability among the 3 survey efforts (1993-94, 1997, and 2002) may explain the observed differences in numbers detected per survey point among the 3 survey periods.

Objectives

1. Estimate the extent to which the density of 3 target bird species has changed since private lands on Craig Mountain were converted to a Wildlife Management Area.
2. Determine if densities of Pileated Woodpeckers vary among different types of timber harvest on CMWMA.
3. Determine how much forest cover has changed in areas of timber harvest.

Chapter 1 addresses Objective #1; we compared density of 3 target bird species between the early 1990s (prior to when the area that is now CMWMA was managed by IDFG) and 2013-2014. We documented changes in bird density at the WMA scale to determine if CMWMA is meeting its goals for the 3 target species. We also examined the effects of survey date on detection probability of Pileated Woodpeckers to help interpret data from past survey efforts and to help inform optimal timing for future bird surveys on CMWMA.

Chapter 2 addresses Objectives #2 and #3; we examined the effects of timber harvest on the density and distribution of Pileated Woodpeckers on CMWMA. We also used NAIP (National Agriculture Imagery Program) imagery to estimate the extent to which forest cover has changed on CMWMA over a 9-year period that included numerous timber harvests.

Chapter 1: Effectiveness of a Wildlife Management Area: changes in breeding density of three target species

Introduction

As of 2012, 14% of the world's terrestrial areas and territorial waters are in protected status (World Database on Protected Areas 2013). These protected areas are often considered the cornerstone of conservation efforts and one of our best methods of preserving biodiversity (Aycrigg et al. 2013, Fuller et al. 2010, Stokes et al. 2012, Baeza and Estades 2010, Caro et al. 2009, Hockings 2003). However, converting lands to protected status is often controversial, and decisions regarding which activities are allowed and which are prohibited within protected areas are often contentious. Hence, estimates of the effectiveness of protected areas and estimates of the effects of management actions within protected areas are needed to help inform these debates.

Approximately 20% of the terrestrial land in the United States is protected from development (United States Geological Survey 2012). These public lands are an integral part of the North American model for wildlife conservation (Beuchler and Servheen 2008). Many consider the U.S. a leader in land conservation, but the U.S. is also an example of the challenges facing the future of conservation. The value of public lands has recently been questioned in the U.S. and, hence, their value needs to be demonstrable. Are protected areas achieving their stated goals? Are protected areas maintaining biodiversity and improving persistence of target species? Would easing restrictions on extractive land uses detract from the ability of protected areas to meet their intended objectives? Public land managers need to be able to provide the answers to these questions to help justify the maintenance and management of public protected areas. In addition, public land managers need to monitor the effectiveness of their management actions so they can identify problems and focus their limited resources accordingly and thereby maintain the value of the protected areas they manage (Hockings 2003).

Broad-scale evaluations of the utility of protected lands in the U.S. have provided insights into the general effectiveness of protected areas as a whole (Aycrigg et al. 2013, Albano 2015, Jenkins et al. 2015, Dietz et al. 2015). However, site-specific evaluations of individual protected areas are needed because stated goals can differ widely among the thousands of protected areas in the U.S. Unfortunately, many protected area managers are not able to adequately monitor the effectiveness of their actions or inactions (Hockings et al. 2000). Furthermore, many protected areas are lacking long-term data which would allow others to conduct a rigorous assessment of whether their actions are meeting the intended goals.

The Idaho Department of Fish and Game (IDFG) manages 32 Wildlife Management Areas (WMA) and a broad-scale evaluation of all 32 WMAs has been conducted (Karl et al. 2005), but the 32 WMAs have different objectives and site-specific quantitative evaluations of individual WMAs are lacking. Craig Mountain Wildlife Management Area (CMWMA), for example, is the largest WMA in Idaho and has been managed by IDFG for over 20 years but we lack any quantitative analysis of the effectiveness of the management actions deployed at CMWMA.

We conducted an evaluation of the effectiveness of management efforts on CMWMA. This evaluation is a critical step in the management of CMWMA that will help managers make better decisions regarding how best to achieve the explicit management goals on CMWMA. We conducted our evaluation of CMWMA management efforts by estimating the change in density of 3 bird species (Yellow Warbler, Black-capped Chickadee, and Pileated Woodpecker) between 1993-2014. The protection and enhancement of the populations and habitat of these 3 species are main objectives of CMWMA (they are 3 of 6 target species that were identified in the goals of CMWMA). We used distance estimation to estimate density for these 3 target species for 4 survey efforts and compared the change in density for these 3 species on CMWMA to the trends reported by the North American Breeding Bird Survey for these 3 species in Idaho. We also examined the effects of survey date on detection probability of Pileated Woodpeckers and the effect of survey duration and the detection of close distance observations on density estimates.

Methods

Study Area

The Craig Mountain Wildlife Management Area (CMWMA) is located in north central Idaho, approximately 40 km south of Lewiston, Idaho in southern Nez Perce and southwest Lewis counties. CMWMA is north of the confluence of the Salmon and Snake rivers and elevations range from 244 m to 1637 m. The lower elevations are primarily steep canyon grasslands mixed with rimrock and talus slopes. As elevation increases, northern aspects have canyon forests with Douglas fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*) and southern aspects support shrubfields and grasslands. A large forested plateau at the upper elevations (1370 m-1637 m) of CMWMA supports grand fir (*Abies grandis*), lodgepole pine (*Pinus contorta*), Douglas fir, ponderosa pine, and western larch (*Larix occidentalis*).

CMWMA is the largest of 32 WMAs in Idaho, and is considered a status type 2 protected area (U.S. Geological Survey 2012). Status type 2 protected areas have permanent protection from the conversion of their natural land cover and have a mandated management plan to ensure that the area is maintained in a primarily natural state, but they allow management practices that may potentially degrade the quality of existing natural communities, including suppression of natural disturbances (U.S. Geological Survey 2012). The Craig Mountain area consists of approximately 60,000 ha of lands owned by Idaho Department of Fish and Game (IDFG), Bureau of Land Management (BLM), The Nature Conservancy (TNC), Idaho Department of Lands (IDL), and the Nez Perce Tribe (NPT). More than half (33,600 ha) of the Craig Mountain area is owned and managed by IDFG. The majority of the IDFG lands (24,281 ha) at Craig Mountain were purchased by Bonneville Power Administration (BPA) in 1992 and then transferred to IDFG. The primary objective of the 24,281-ha purchase by BPA was to mitigate for the loss of wildlife habitat from the inundation of Dworshak reservoir (in Clearwater County, 56 km northeast of CMWMA).

As part of the management plan of the mitigation acres, 6 species were identified by IDFG and BPA as 'target species' toward which land management on CMWMA would be directed: Yellow Warbler (*Setophaga petechia*), Black-capped Chickadee (*Poecile atricapillus*), Pileated Woodpecker (*Dryocopus pileatus*), White-tailed Deer (*Odocoileus virginianus*), Rocky Mountain Elk (*Cervus elaphus*), and River Otter (*Lontra canadensis*). These 6 target species were selected because they were species that had high priority for state, federal, or tribal wildlife programs at the time, or they were considered indicators of the ecosystems most impacted by the construction of Dworshak Dam (Hansen and Martin 1989).

IDFG has implemented numerous management actions on CMWMA since BPA transferred ownership of the mitigation lands to them in 1992. These actions include additional land acquisitions, land trades, timber harvest, control of noxious weeds, elimination of livestock grazing on 90% of the IDFG lands, and the closure of approximately 150 km of open roads. CMWMA has also had changes in temperature and precipitation regimes, several wildfires, an increase in noxious weeds, mountain and western pine beetle (*Dendroctonus ponderosae* and *D. brevicomis*) infestations, and increased recreational use. The effects of these changes on the 6 target species have not been explicitly documented.

Study Species

The Pileated Woodpecker is the largest woodpecker in the United States. Pileated Woodpeckers are regarded as a keystone species that play an important role in forested ecosystems; they excavate large holes in trees that provide shelter and nest sites for various birds and mammals (Bull and Jackson 2011, Bull et al. 1997, Bonar 2000, Aubry and Raley 2002). The Pileated Woodpecker was chosen as an indicator of mature or old-growth coniferous forest in the wildlife impact assessment for Dworshak Dam (Hansen and Martin 1989) and occurs in forested systems throughout North America (Hoyt 1957). Pileated woodpeckers feed primarily on insects and may utilize fruit and mast of wild nuts when available. In northeastern Oregon, a landscape similar to CMWMA, Pileated Woodpeckers forage primarily in mature grand fir forests and maintain year-round territories. Pileated

Woodpeckers usually excavate nest cavities in tall (x-bar = 13.7 m), dead ponderosa pine or western larch trees greater than 58.8-cm (22 in) in diameter (Bull 1987). Nest excavation begins in April, incubation occurs in early to mid-May, and fledging occurs from late June to mid-July (Bull 1980). Pileated woodpeckers only produce one brood per season, but may re-nest if their first attempt fails early in the season (Truslow 1966, Bull and Jackson 2011). Data from the North American Breeding Bird Survey suggests that abundance of Pileated Woodpeckers in Idaho has remained stable or increased slightly from 1993 to 2013 and rangewide has increased 1.8% annually since 1993 (Sauer et al. 2014).

The Black-capped Chickadee is a small songbird found throughout much of Canada and the northern two thirds of the United States. Black-capped chickadees are often year-round residents throughout their range and prefer deciduous and mixed deciduous-coniferous forests, riparian areas, and shrublands. In mountainous areas such as CMWMA, chickadees may move to lower elevations during winter months (Foote et al. 2010). They feed primarily on insects, pine seeds, and berries and they typically nest in cavities excavated in broken-top deciduous trees that are in advanced stages of decay (Runde and Capen 1987). Black-capped chickadees typically only produce one brood per year, but will often re-nest within a few days if the first nest fails (Foote et al. 2010, Smith 1991, Ramsay et al. 2007). Data from the North American Breeding Bird Survey suggest Black-capped Chickadees have declined 0.7% annually in Idaho from 1993 to 2013 but rangewide has increased 1.0% annually over that same time period (Sauer et al. 2014).

The Yellow Warbler is a neotropical migratory bird that breeds throughout most of North America. Yellow warblers are a medium-sized wood-warbler and are considered a riparian generalist, focusing on areas with willows (*Salix* spp.). Yellow warblers winter in

Central America and arrive in Idaho in late April or May. They nest throughout Idaho, constructing a cup nest in trees or shrubs (Cassirer 1995). They feed primarily on insects and other arthropods, but occasionally feed on wild fruits (Lowther et al. 1999, Stevenson and Anderson 1994). Normally Yellow Warblers only produce one brood per year (Lowther et al. 1999). Numbers of Yellow Warblers in the western U.S. have declined, especially in areas where livestock grazing has reduced or removed willows along riparian areas (Taylor and Littlefield 1986, Ohmart 1994). Numbers of Yellow Warblers declined 1.2% annually in Idaho from 1993 to 2013 and have declined 0.3% annually rangewide over that same time period based on data from the North American Breeding Bird Survey (Sauer et al. 2014).

Bird Surveys

Baseline wildlife surveys were conducted on CMWMA in 1993 and 1994 (Cassirer 1995) shortly after BPA transferred the mitigation lands to IDFG. Bird survey transects were established in both upland forest and riparian/grassland areas (Fig. 2). The upland forest transects were established to sample the abundance of Pileated Woodpeckers and included 134 survey points along 14 transects. The upper plateau was divided into 5 segments of similar size bounded by drainages, roads, or topography and 2 to 4 transects were established in each of the 5 segments (Fig. 3). Seven of the 14 transects included 8-10 survey points in areas of CMWMA considered to have the least influence from roads. Distance between adjacent survey points on these 7 transects averaged 248 m (range 192-333 m). The other 7 transects paralleled roads (some that remained open and some that were closed) with survey points placed 100 m away from the adjacent road. Three of the 7 roaded transects paralleled open roads and consisted of 8-10 survey points with an average of 994 m (range 464-2725 m) between adjacent points. The remaining 4 roaded transects paralleled closed roads and consisted of 8-10 survey points with an average of 337 m (range 193-857 m) between adjacent points.

The riparian/grassland transects were established to sample abundance of Yellow Warblers and included 211 survey points along 26 transects. The riparian/grassland transects were established along 3 major drainages on CMWMA with 7-12 survey points per transect. Survey points on the riparian/grassland transects averaged 302 m (range 96-909 m) apart along an elevation gradient ranging from 305 m to 1524 m. Some of these 345 points were re-surveyed in 1997 (Karl 1998) and 2002 (Idaho Department of Fish & Game 2002).

To estimate changes in density of the 3 target bird species over the past 21 years, we surveyed 39 of the original 40 CMWMA bird transects (335 of the 345 survey points) in both 2013 and 2014 (Appendix 1 is a CMWMA bird survey sheet used during surveys). We were able to find the original rebar that marked the exact locations of the survey points for the majority of points (334 of 338) within 39 of the original transects. We were unable to find the rebar for 6 out of 7 points for 1 riparian/grassland transect (we did not conduct surveys for this transect). We conducted surveys from early April until early July to ensure that we conducted surveys on dates similar to those from all 3 prior survey efforts. Hence, the number of times that transects were surveyed in 2013-14 varied from 2 to 8 per year. We employed 8 surveyors during the 2013-14 survey effort (Appendix 2 shows the surveyors, years they completed surveys, and number of surveys completed). We used the bird survey protocol developed by Cassirer (1995) and the USDA Forest Service Northern Region Landbird Monitoring Program field methods (Hutto et al. 2002). Both methods rely on variable-circular survey plots and instruct surveyors to count all birds seen or heard during a survey and to estimate distance to each bird (Reynolds et al. 1980). Surveyors alternated the chronological order in which they visited points along a transect each time a transect was surveyed. Surveyors waited 3 minutes at each point before surveys began. All birds seen or heard were recorded during a 10-minute survey and the minute of initial detection was recorded for each bird. Recording the minute of initial detection allowed us to compare our survey results with all 3 prior survey efforts because survey duration differed among survey efforts. On the riparian/grassland transects, surveys were 5 minutes in 1993 and 10 minutes in 1994, 1997, and 2002. On the forested transects, surveys were 5 minutes in 1993-94 and 10 minutes in 1997 and 2002. Similar to past survey efforts on CMWMA, we recorded all birds heard or seen during each survey regardless of distance. In addition to bird species, minute of initial detection, and distance to each bird, we also recorded the type of detection (aural or visual), activity of the bird, time the survey started, wind conditions (Beaufort scale), stream noise, temperature, and general weather conditions. Surveys of transects were alternated by observer, so each transect was surveyed by more than one observer.

All surveyors were trained in distance estimation and bird identification by sight and sound. Bird call CDs, MP3s, and field guides were used to help surveyors identify unknown calls. Laser rangefinders were used to estimate distance to each bird. Each surveyor was also required to practice bird identification with an expert. The expert decided when surveyors were sufficient in bird identification and allowed to perform surveys.

Trends from Three Prior Surveys

Prior to conducting field work for this project, we examined raw counts from the 3 prior survey efforts to view possible trends in the 3 target mitigation bird species. We calculated the average number of Black-capped Chickadees, Yellow Warblers, and Pileated Woodpeckers detected per point surveyed for each of the 3 initial bird survey efforts at CMWMA (in 1993-94, 1997, and 2002). We examined trend in raw counts over the 10-year period (1993-2002) for each species.

Estimating Density

We used Program Distance 6.0 Release 2.0 (Thomas et al. 2009) to calculate true density estimates for each of the 3 target bird species for each of the 4 time periods (1993-94, 1997, 2002, and 2013-14). Program Distance is a Windows-based computer package designed to analyze data from distance sampling surveys. This program uses robust semi-parametric methods to model probability of detection as a function of distance from the surveyor (Thomas et al. 2009). Several models are provided for the analysis of distance data. The models used in Program Distance have 3 important properties. First, these models are robust and flexible enough to fit a wide variety of the possible shapes of a detection function (Buckland et al. 2001, Burnham et al. 1980). Second, the models have a shape criterion that has a shoulder near the zero point (near the surveyor). Third, the model that fits the data best can provide precise estimates of density (Buckland et al. 2001). In order to meet the 3 model criteria mentioned above, Program Distance uses models that have a parametric key function combined with a series expansion.

Program Distance offers several analysis engines for analyzing distance data. We used the Conventional Distance Sampling (CDS) analysis option to estimate density for the 4 survey periods (1993-94, 1997, 2002, and 2013-14). We decided to model data from these 4 survey periods separately for 2 reasons. First, each survey period included different surveyors and may have different optimal truncation distances best modeled by different key functions and series expansions. Second, CMWMA has experienced many changes in management since IDFG acquired the mitigation lands and changes in vegetation structure and background noise can affect the shape of the detection function. We first examined data from each of the 4 survey periods to determine optimal truncation distances (outliers), evidence of heaping, and evidence of evasive movement. We used histograms of distance data, divided into a large number of distance intervals, for data exploration. We found evidence of heaping in all data sets and we chose distance intervals to eliminate prominent heaps. We truncated all data sets; we eliminated at least 10% of the detections with the largest distance estimates (Buckland et al. 2001). Once we truncated data and selected distance intervals, we began model selection for each data set.

We compared the applicability of 6 types of models to determine which best fit the detection function for each of the 3 species and 4 survey periods: the half-normal key with cosine adjustments (HnCo), the half-normal key with hermite polynomial adjustments (HnHp), the uniform key with cosine adjustments (UnCo), the uniform key with simple polynomial adjustments (UnSp), the hazard-rate key with cosine adjustments (HzCo), and the hazard rate key with simple polynomial adjustments (HzSp). We stratified estimates by transect. We used the all-selection method option to identify adjustment terms (maximum number of terms set to 5) and used AIC as the selection criterion. We used the estimate variance empirically option to estimate encounter rate variance. We validated models based on 5 criteria: AIC, χ^2 goodness of fit, coefficient of variance, and visual inspection of both the estimated detection function and the detection probability plot.

The number of transects surveyed varied during each of the 4 survey periods: 40 transects were surveyed in 1993-94, 20 of the 40 were re-surveyed in 1997, 35 of the 40 were re-surveyed in 2002, and 39 of the 40 were re-surveyed in 2013-14. We excluded the 1997 surveys when estimating density of Yellow Warblers and Black-capped Chickadees to compare the largest number of transects over the 4 survey efforts. The 1997 survey effort included only 8 of the 26 grassland/riparian transects. By focusing on 1993-94, 2002, and 2013-14 survey efforts, we were able to compare bird density among these 3 survey periods with data from 23 of the original 26 grassland/riparian transects. In addition, only a portion of the forested transects were completed in 1997 (12 forested transects) and 2002 (11 forested transects). Of those, only 9 transects were completed both years. Few Pileated Woodpeckers were detected in 1997 (10 detections) and 2002 (8 detections). The low number of Pileated Woodpecker detections in 1997 and 2002 produced large confidence intervals when calculating density of Pileated Woodpeckers. Limiting the analysis of Pileated Woodpecker density to the 9 transects completed during all 3 survey efforts would have provided only 5 Pileated Woodpecker detections in 1997. Because detections of Pileated Woodpeckers were already low in 1997 and 2002, producing a wide confidence interval, we chose to use data from all surveyed transects to estimate density for each survey period regardless of how many transects were completed. Thus, we used data from all 14 forested transects to calculate density of Pileated Woodpeckers in 1993-94 and 2013-14 and used data from 12 and 11 forested transects to calculate density of Pileated Woodpeckers in 1997 and 2002, respectively.

Survey Duration

Surveys on the grassland/riparian transects in 1993 were only 5-minutes in duration whereas subsequent surveys on those transects were 10-minutes in duration. In 1994, the surveyors recorded which birds were detected during the 0-5 minute and the 5-10 minute intervals. In both 1997 and 2002, the surveyors did not record when (within the 10-minute interval) birds were detected. The surveys on the forested transects were 5 minutes in duration in both 1993 and 1994, but were 10 minutes in duration in 1997 and 2002. In 2013 and 2014, we recorded when (within the 10-minute survey) each bird was initially detected. Recording when each bird was initially detected (i.e., which minute within the 10-minute survey period) allowed us to document the percentage of detections within each distance interval that occurred during the survey. If the majority of bird detections close to the survey point occur during the initial 5-minutes of the 10-minute survey, then the detection function (and hence density estimates) generated from Program Distance are likely to be similar regardless of whether a survey is 5-minutes or 10-minutes in duration. We estimated density of the 3 target bird species during both 5-minute and 10-minute survey durations.

To determine which distances would be considered “close distance” detections, we used the method proposed by Mollon (2010) to determine “near” (observations that influence density estimates) distance observations. Mollon (2010) uses the Effective Detection Radius (EDR) calculated in Program Distance as the cut-off for “near” distance observations. EDR is the distance from the survey point at which the probability of detecting an individual equals the probability of missing that individual (Mollon 2010). We used EDR as the cut-off for "close distance" (detections that influence density estimates) detections.

Change in Detection Probability

When we conducted initial analyses of the data from the 3 previous survey efforts (1993-94, 1997, 2002), we discovered that the dates of the surveys differed among survey efforts on the forested transects. The forested transects were surveyed from early-April through mid-May in 1993-94 to coincide with the first half of the Pileated Woodpecker breeding season (Cassirer 1995). In contrast, the forested transects were surveyed from mid-May through early-July in 1997 and 2002. Hence, we split the 2013-14 survey data into the two time frames: early (April 2 – May 16) and late (May 20 – July 3). We surveyed the forested transects during both of these timeframes in 2013 and 2014 so that we could determine whether survey timing affected detection probability (and hence whether raw counts can be reliably compared for surveys with different survey dates). At the end of the 2013 field season, we compared the average number of Pileated Woodpeckers detected per point between the early and late timeframes. We also compared the average number of Pileated Woodpeckers detected per point separately for each month in 2013 (April, May, June).

At the end of the 2014 field season, we combined both the 2013 and 2014 survey data and used the CDS analysis engine in Program Distance to estimate detection probability and density for Pileated Woodpeckers during both the early and late survey timeframes. We used the hazard rate key function with a simple polynomial adjustment (HzSp) and analyzed the two timeframes separately in the CDS engine. HzSp was the best model for our 2013-14 Pileated Woodpecker data and estimates were stratified by transect.

Results

Trends in Counts from Three Prior Surveys

Our preliminary analysis of raw counts for the 1993-94, 1997, and 2002 surveys suggested that Black-capped Chickadee detections had not changed significantly from 1993-2002, Yellow Warbler detections had increased, and Pileated Woodpecker detections had decreased (Fig. 1). This purported decline in counts of Pileated Woodpeckers was cause for concern.

Surveys

In total, we conducted 3,275 bird surveys, detected 132 bird species, and recorded 32,273 bird detections (including multiple-observer surveys) during point-count surveys in 2013-14. The 32,273 bird detections included 556 Pileated Woodpecker detections, 331 Yellow Warbler detections, and 154 Black-capped Chickadee detections during surveys in 2013 and 2014 (Table 1). Ninety-six of the 132 bird species had $\geq$10 detections (Appendix 3 includes the number of detections for each bird species). We measured vegetation plots from July 8th – September 16th 2014 at 354 survey points (locations of all point-count bird surveys in 2013-14) and took and stored digital photos at each survey point for future reference (Appendix 4 provides the vegetation survey sheets used).

Survey Duration

Of the 154 Black-capped Chickadee detections, 66 were within 34 m of the survey point (EDR of Black-capped Chickadees). Sixty-four percent of the 66 Black-capped Chickadee detections that were within the EDR occurred within the first 5 minutes of the 10-minute survey (Table 2 and Fig. 4). Of the 331 Yellow Warbler detections, 159 were within 35 m (EDR of Yellow Warblers) of the survey point. Seventy-two percent of the 159 Yellow Warbler detections that were within the EDR occurred within the first 5 minutes of the 10-minute survey (Table 3 and Fig. 5). Of the 556 Pileated Woodpecker detections, 246 were within 188 m (EDR of Pileated Woodpeckers) of the survey point. Seventy-one percent of the 246 Pileated Woodpecker detections that were within the EDR occurred within the first 5 minutes of the 10-minute survey (Table 4 and Fig. 6).

We failed to detect a difference in density of the 3 target bird species between 5-minute and 10-minute survey durations. However, density estimates for all 3 species were higher when we used data from the full 10-minute survey. Black-capped chickadees had a 21% non-significant increase in density when survey duration was increased from 5 minutes to 10 minutes (Fig. 7). Yellow warblers had a 26% non-significant increase in density when survey duration was increased from 5 minutes to 10 minutes (Fig. 8). Pileated woodpeckers had a 15% non-significant increase in density when survey duration was increased from 5 minutes to 10 minutes (Fig. 9).

Density of Three Target Bird Species

Black-capped Chickadee density 1993-94:

We truncated detections that were beyond 80 m of the surveyor (the furthest 10% of the 93 detections) and split the detections into 6 distance bins. Among the 6 models tested (HnCo, HnHp, UnCo, UnSp, HzSp, HzCo), we identified 2 competing models (HnCo and HnHp) with a ΔAIC < 2.0 (Table 5). We used HnCo to model the detection function for Black-capped Chickadees in the 1993-94 survey effort. The HnCo model had a ΔAIC of 0.00, a χ^2 *p*-value of 0.563, a coefficient of variation of 0.142, and both the detection function and detection probability plots were reasonable. Density of Black-capped Chickadees in 1993-94 was 0.158 birds/ha (95% confidence interval = 0.119 – 0.209 birds/ha).

Black-capped Chickadee density 2002:

We truncated detections beyond 70 m of the surveyor (the furthest 22% of the 29 detections) and split the detections into 7 distance bins. Among the 6 models tested (HnCo, HnHp, UnCo, UnSp, HzSp, HzCo), we identified 4 competing models (HnCo, HnHp, UnCo, UnSp) with a ΔAIC < 2.0 (Table 6). We used UnSp to model the detection function for Black-capped Chickadees in the 2002 survey effort. The UnSp model had a ΔAIC of 0.00, a χ^2 *p*-value of 0.959, a coefficient of variation of 0.147, and both the detection function and detection probability plots were reasonable. Density of Black-capped Chickadees in 2002 was 0.108 birds/ha (95% confidence interval = 0.080 – 0.146 birds/ha).

Black-capped Chickadee density 2013-14:

We truncated detections beyond 80 m (the furthest 10% of the 129 detections) and split detections into 5 distance bins. Among the 6 models tested (HnCo, HnHp, UnCo, UnSp, HzSp, HzCo), we identified 5 competing models (HnCo, HnHp, UnCo, HzSp, HzCo) with a ΔAIC < 2.0 (Table 7). We used HnCo to model the detection function for Black-capped Chickadees in the 2013-14 survey effort. The HnCo model had a ΔAIC of 0.00, a χ^2 *p*-value of 0.487, a coefficient of variation of 0.206, and both the detection function and detection probability plots were reasonable. Density of Black-capped Chickadees in the 2013-14 survey effort was 0.148 birds/ha (95% confidence interval = 0.099 - 0.223 birds/ha).

Trend in density of Black-capped Chickadees on CMWMA:

After accounting for variation in detection probability across the 4 survey efforts, we failed to detect a significant change in density of Black-capped Chickadees during the 21 years of management on CMWMA (Fig. 10). The 95% confidence interval for all 3 density estimates overlapped.

Yellow Warbler density 1993-94:

We truncated detections beyond 40 m of the survey point (the furthest 10% of the 89 detections) and split the detections into 5 distance bins. Among the 6 models tested (HnCo, HnHp, UnCo, UnSp, HzSp, HzCo), we identified 3 competing models (HnCo, HnHp, UnSp) with a ΔAIC < 2.0 (Table 8). We used UnSp to model the detection function for Yellow Warblers in the 1993-94 survey effort. The UnSp model had a ΔAIC of 0.00, a χ^2 *p*-value of 0.863, a coefficient of variation of 0.084, and both the detection function and detection probability plots were reasonable. Density of Yellow Warblers in 1993-94 was 0.351 birds/ha (95% confidence interval = 0.297 – 0.415 birds/ha).

Yellow Warbler density 2002:

We truncated detections beyond 48 m (the furthest 10% of the 42 detections) and split the detections into 4 distance bins. Among the 6 models tested (HnCo, HnHp, UnCo, UnSp, HzSp, HzCo), we identified 4 competing models (HnCo, HnHp, UnCo, UnSp) with a ΔAIC < 2.0 (Table 9). We used UnSp to model the detection function for Yellow Warblers in the 2002 survey effort. The UnSp model had a ΔAIC of 0.00, a χ^2 *p*-value of 0.994, a coefficient of variation of 0.209, and both the detection function and detection probability plots were reasonable. Density of Yellow Warblers in 2002 was 0.466 birds/ha (95% confidence interval = 0.306 – 0.709 birds/ha).

Yellow Warbler density 2013-14:

We truncated detections beyond 75 m of the survey point (the furthest 10% of the 295 detections) and split the detections into 5 distance bins. Among the 6 models tested (HnCo, HnHp, UnCo, UnSp, HzSp, HzCo), we identified 3 competing models (HnCo, HnHp, UnCo) with a ΔAIC < 2.0 (Table 10). We used HnCo to model the detection function for Yellow Warblers in the 2013-14 survey effort. The HnCo model had a ΔAIC of 0.00, a χ^2 *p*-value of 0.573, a coefficient of variation of 0.087, and both the detection function and detection probability plots were reasonable. Density of Yellow Warblers in 2013-14 was 0.634 birds/ha (95% confidence interval = 0.534 – 0.753 birds/ha).

Trend in density of Yellow Warblers for CMWMA:

After accounting for variation in detection probability across the 4 survey efforts, we failed to detect a significant change in Yellow Warbler density during the 21 years of management on CMWMA (Fig. 11). Although the point estimate for density of Yellow Warblers increased over time by ~20%, the 95% confidence interval of all 3 density estimates overlapped.

Pileated Woodpecker density 1993-94:

We truncated detections beyond 210 m (the furthest 10% of the 64 detections) and split the detections into 6 distance bins. Among the 6 models tested (HnCo, HnHp, UnCo, UnSp, HzSp, HzCo), we identified 5 competing models (HnCo, HnHp, UnCo, HzSp, HzCo) with a ΔAIC < 2.0 (Table 11). We use HzSp to model the detection function for Pileated Woodpeckers in the 1993-94 survey effort. The HzSp model had a ΔAIC of 1.00, a χ^2 *p*-value of 0.577, a coefficient of variation of 0.228, and both the detection function and detection probability plots were reasonable. Density of Pileated Woodpeckers in 1993-94 was 0.03 birds/ha (95% confidence interval = 0.019 – 0.047 birds/ha).

Pileated Woodpecker density 1997:

We truncated detections beyond 200 m (the furthest 10% of the 11 detections) and split detections into 3 distance bins. Among the 6 models tested (HnCo, HnHp, UnCo, UnSp, HzSp, HzCo), we identified 4 competing models (HnCo, HnHp, UnCo, UnSp) with a ΔAIC < 2.0 (Table 12). We used HnCo to model the detection function for Pileated Woodpeckers in the 1997 survey effort. The HnCo model had a ΔAIC of 0.00, a χ^2 *p*-value of 0.639, a coefficient of variation of 0.378, and produced the best plots for both the detection function and detection probability. Density of Pileated Woodpeckers in 1997 was 0.020 birds/ha (95% confidence interval = 0.009 – 0.045 birds/ha). The number of detections (11) for this data set is low and, hence, we have limited confidence in the estimate.

Pileated Woodpecker density 2002:

Only 8 Pileated Woodpeckers were detected in 2002; Program Distance gave a warning that results may be unreasonable. We truncated detections beyond 90 m (the furthest 10% of the 8 detections) and split the 8 detections into 3 distance bins. Among the 6 models tested (HnCo, HnHp, UnCo, UnSp, HzSp, HzCo), we identified 3 competing models (HnHp, UnCo, UnSp) with a ΔAIC < 2.0 (Table 13). We used HnHp to model the detection function for Pileated Woodpeckers in the 2002 survey effort. The HnHp model had a ΔAIC of 1.82, a χ^2 *p*-value of 0.970, a coefficient of variation of 0.620, and produced the most reasonable plot for both the detection function and detection probability. Density of Pileated Woodpeckers in the 2002 survey effort was 0.039 birds/ha (95% confidence interval = 0.010 – 0.149 birds/ha). The number of detections (8) for this data set is low and, hence, we have limited confidence in the estimate.

Pileated Woodpecker density 2013-14 (10-minute survey):

We truncated detections beyond 300 m (the furthest 10% of the 472 detections) and split the remaining detections into 6 distance bins. Among the 6 models tested (HnCo, HnHp, UnCo, UnSp, HzSp, HzCo), we identified 4 competing models (HnCo, UnCo, HzSp, HzCo) with a ΔAIC < 2.0 (Table 14). We used HzSp to model the detection function for Pileated Woodpeckers in the 2013-14 survey effort. The HzSp model had a ΔAIC of 0.00, a χ^2 *p*-value of 0.874, a coefficient of variation of 0.169, and both the detection function and detection probability plots were reasonable. Density of Pileated Woodpeckers in the 2013-14 survey effort was 0.026 birds/ha (95% confidence interval = 0.019 – 0.036 birds/ha).

Trend in density of Pileated Woodpeckers for CMWMA:

After accounting for variation in detection probability across the 4 survey efforts, we failed to detect a significant change in density of Pileated Woodpeckers over the 21 years of management on CMWMA (Fig. 12).

Change in Detection Probability

We detected more Pileated Woodpeckers during the early timeframe (early-April through mid-May) compared to the late timeframe (mid-May through early-July) (Fig. 13). Pileated woodpecker detections declined linearly as the nesting season progressed (Fig. 14). These changes reflect a seasonal decrease in detection probability; detection probability decreased from 41% during the early survey timeframe to 31% during the late survey timeframe within the 2013-14 survey effort (Fig. 15). We were able to account for the seasonal decline in detection probability because we used distance estimation and Program Distance; density estimates for Pileated Woodpeckers on CMWMA were nearly identical for the two survey timeframes (Fig. 16). The similarity of these 2 estimates was expected given that Pileated Woodpeckers are year-round residents (and both timeframes were within the breeding season). Hence, the similarity of the 2 density estimates (despite the difference in detections) gave us confidence in our methods and the density estimates we generated because we would not expect any substantive change in density from April to June at the same survey points during the same year.

Discussion

What is the value of our public protected areas? Are these areas meeting management objectives? Are establishment and maintenance of protected areas the most efficient approach for meeting those objectives? And more importantly, what are the consequences of allowing certain activities on public protected areas? These are important questions given the recent efforts to sell or transfer ownership of our public protected areas.

Efforts to evaluate management of protected areas have focused on comparing the current status (population levels, habitat condition, amount and type of habitat in protection, etc.) of protected areas against the original goals (population levels, condition of habitat, amount and type of habitat in protection, etc.) of those protected areas (Gaston et al. 2008). A common problem with attempts to evaluate the effects of management actions on public protected areas is the lack of long-term data. We were fortunate to obtain survey data from the past 21 years of management for 3 of the target species at CMWMA (species that are considered indicators of habitat types designated for protection on CMWMA). We replicated point-count surveys on CMWMA that had been surveyed on 3 previous occasions and, after accounting for variation in survey duration and survey timing, examined temporal changes in breeding densities of 3 target bird species during 21 years of state management on CMWMA. Our results suggest that densities of the 3 target species have not changed over the past 21 years, and that the changes over time in raw counts that we noticed at the outset of our study reflected differences in detection probability rather than density.

Survey Duration

Three assumptions are critical to obtain reliable estimates of density from distance sampling. First, detection probability is 100% at distance zero (i.e., at the survey point). Second, objects are detected at their initial locations (prior to any observer-induced movement). And third, estimates of distance are exact. Survey duration could potentially affect the first 2 assumptions. Short-duration surveys may miss inconspicuous birds that are on or near the point, but long-duration surveys may be more likely to detect birds that have moved away from their initial location or increase the possibility of double counting individual birds. Distance sampling performs best when a "shoulder" in detectability exists near the point (Buckland et al. 2001). In other words, detections closest to the survey point are crucial for estimating the detection curve. We documented the effects of increased survey duration on the number of close-distance bird detections, by documenting the initial minute of detection for each bird detected during the 2013-14 survey effort.

During our survey effort in 2013-14, the majority of close distance detections for the 3 target bird species occurred during the initial 5 minutes of the 10-minute survey. In addition, we failed to detect a difference in density of the 3 target bird species when we compared estimates based on detections from the first 5 minutes of surveys and those based on detections from the full 10-minute survey. In other words, new bird detections later in the survey period tend to be further from the survey point and, hence, have less influence on density estimates. Indeed, the number of new detections far from the survey point also increased near the end of the survey in other studies (Lee and Marsden 2008, Gates 1995). These results suggest that the first 5 minutes of a survey is the most influential on density estimates and the additional 5 minutes added to the CMWMA surveys in 1997 and 2002 may not do much to improve density estimates.

Despite the fact that adding an additional 5 minutes of survey duration did not significantly improve density estimates, other factors must be considered when choosing appropriate survey duration. The number of close distance detections of Black-capped Chickadees and Pileated Woodpeckers increased again slightly during the last minute of the 10-minute survey. One explanation for this increase in close-distance detections during the last minute of the survey is that the likelihood of double counting increases at the end of a 10-minute survey, thus violating the second assumption of distance sampling. Although we failed to detect significant differences in density estimates between 5- and 10-minute surveys for all 3 target species, density estimates were 15-26% higher on 10-minute surveys compared to 5-minute surveys. Longer duration surveys have yielded higher density estimates in several other studies (Peak 2011, Mollon 2010, Cimprich 2009). Longer survey durations increase the risk of detecting the same bird at several locations (i.e., increasing the likelihood of double counting an individual bird; Scott and Ramsey 1981). Furthermore, birds whose initial location was beyond the observer's range of detection, or birds detected away from their initial location, increases with count duration (Granholm 1983). Shorter duration surveys also allow surveyors to visit more survey points each day, which is important given that detection probability of most birds declines rapidly as the morning progresses (Shields 1977, Smith and Twedt 1999, Robbinson 1981, Skirvin 1981). We suggest that future bird surveys on CMWMA record the initial minute of detection for each bird detected (as we did in our 2013-14 surveys) and that 5-minute surveys are more efficient than 10-minute surveys for estimating density or trend in these 3 species.

Change in Detection Probability

The survey dates for the grassland and riparian survey transects (where most Black-capped Chickadees and Yellow Warbler were detected) were similar among the prior 3 survey efforts on CMWMA. However, the survey dates for the forested transects (where most Pileated Woodpeckers were detected) varied by ~1.5 months among the 3 prior survey efforts. At the outset of this study, we noticed what appeared to be a negative trend in breeding density of Pileated Woodpeckers when we examined raw counts from the 3 prior survey efforts. This pattern was troubling given that Pileated Woodpeckers are 1 of only 6 target species for which CMWMA was established to protect. We designed this study to determine whether this pattern was real or was an artifact of the differences in survey timing among the prior survey efforts. Did the changes in survey date lead to a decrease in detectability of Pileated Woodpeckers? Hence, we wanted to explicitly investigate the effects of survey timing on the detectability of Pileated Woodpeckers on CMWMA.

The combination of distance estimation and Program Distance allowed us to calculate detection probability for all surveys (regardless of survey date) and incorporate those estimates into the density estimates. Detection probability of Pileated Woodpeckers decreased from 41% to 31% (a 25% decline) from April to July. Despite these seasonal changes in detection probability, we obtained the same density estimate for Pileated Woodpeckers for both spring and summer surveys in 2013-2014. The similarity in density estimates lends credence to our methods and suggests that Program Distance allowed us to correct for imperfect detection probability (regardless of survey date). Our results suggest that detectability (drumming and vocalizations) of Pileated Woodpeckers is highest in April and decreases linearly through early-July on CMWMA. Similar to our results, Pileated

Woodpeckers maximized drumming and vocalizations just prior to breeding activities and decreased acoustic signals throughout the breeding season in the panhandle of Florida (Tremain et al. 2008). Indeed, seasonal variation in acoustic signals is common in many species of birds (Rotella and Ratti 1988, Valentin et al 2004, Eens et al 1994, Merila and Sorjonen 1994, Greig-Smith 1982) and amphibians (Bridges and Dorcas 2000, Wells 1977).

Changing the timing of a survey from year to year does not violate distance sampling assumptions because distance sampling allows the analyst to calculate, and incorporate, a unique detection probability for each year. However, conducting surveys during times when detection probability is low may not produce a sufficient number of bird detections to rigorously estimate the detection function. Both the 1997 and 2002 surveys efforts on CMWMA used the later survey timeframe (in addition to a lower survey effort than 1993-94) and thus had a very low number of Pileated Woodpecker detections and, hence, imprecise density estimates.

The use of adjusted versus raw counts has been highly debated. Some scientists have advocated the use of raw counts unadjusted for detection probability (Hutto and Young 2003, Johnson 2008, Engeman 2003). However, others have argued that survey efforts that do not account for detection probability yield unreliable results (Anderson 2001, Ellingson and Lukacs 2003, Thompson 2002). When we originally analyzed raw counts from the 3 prior survey efforts on CMWMA we were unaware of the ~1.5 month variation in seasonal timing of past surveys on the forested transects. Our initial summary of the raw counts led to inaccurate conclusions regarding temporal trends in density of Pileated Woodpeckers. Hence, our study illustrates benefits of using adjusted counts. First, survey methods and survey timing may not always be consistent among survey efforts that span decades; these changes often compromise the utility of long-term data. Our results demonstrate how using distance sampling can account for variation in detection probability (caused by variation in survey timing). Second, our results show that detectability of Pileated Woodpeckers decreases during the breeding season, and comparisons of unadjusted counts from surveys conducted during different survey dates may not be valid. Our results demonstrate the utility of distance sampling to correct for differences in detectability; incorporation of distance sampling led to different conclusions from those based on our initial summary of unadjusted counts.

Change in Density of the Three Target Bird Species

The mitigation acres on CMWMA have seen many changes since they were converted to protected status in the early 1990s. Protected areas are often considered areas where very few activities are allowed, but CMWMA is a type 2 protected area which allows considerable flexibility regarding how the area is managed. CMWMA management activities include suppression of natural disturbance events, extraction of timber to meet management goals, livestock grazing in some areas, and enhancing recreational opportunities such as hunting and fishing. How do these management actions affect the primary goal of CMWMA (protect and enhance populations and habitat of the 6 target mitigation species)?

Yellow warblers are one of the most widespread and abundant warblers in North America (Lowther et al. 1999). Densities of Yellow Warblers vary widely from 0.7 (Briskie 1995) to 14.4 (Gossen and Sealy 1982) pairs/ha (Lowther et al. 1999). Our estimates of breeding Yellow Warbler densities on CMWMA are at the lower range of reported Yellow

Warbler densities. Breeding densities of Black-capped Chickadees also vary widely from 0.06 (Smith 1967) to 0.30 (Smith 1991) pairs/ha (Foote et al. 2010). Our estimates of breeding densities of Black-capped Chickadees on CMWMA are at the upper range of reported densities. Numbers of Black-capped Chickadees and Yellow Warblers have declined in Idaho from 1993-2013 based on data from the North American Breeding Bird Survey (Sauer et al. 2014). Our results show that breeding densities of both Yellow Warblers and Black-capped Chickadees have remained stable on CMWMA from 1993-2014. When Cassirer (1995) completed the baseline survey effort at CMWMA in 1993-94, she noted that the elimination of livestock grazing in the lower elevations of CMWMA may help riparian bird species. The subsequent elimination of livestock grazing in the lower elevation riparian areas of CMWMA may explain why breeding density of Black-capped Chickadees and Yellow Warblers have remained stable on CMWMA while populations of these 2 species have declined throughout Idaho during the same timespan. Frequency of grazing was correlated to decreases in shrub volume, shrub height, and bird abundance in riparian areas in Oregon (Taylor 1986). Moreover, increases in bird abundance were correlated with the length of time since a riparian area was last grazed (Taylor 1986). The health of riparian areas on CMWMA is extremely important to both Yellow Warblers and Black-capped Chickadees. Future management of riparian areas on CMWMA should continue the current restrictions on livestock grazing in low elevation riparian areas because these efforts presumably have benefited Yellow Warblers and Black-capped Chickadees.

Estimates of Pileated Woodpecker densities vary greatly at least partially due to variation in survey methods (Bull and Jackson 2011). In northeast Oregon (in a landscape similar to CMWMA), breeding density of Pileated Woodpeckers was estimated at 0.002

pairs/ha, estimates were obtained using a combination of call surveys and nest searching (Bull et al. 2007). Our survey results suggest a population size of 267 (range 170 – 413) total Pileated Woodpeckers on CMWMA and 0.03 pairs/ha. The large difference in Pileated Woodpecker densities between our study and that of Bull et al. (2007) may reflect differences in survey methods. Density estimates from point-count surveys conducted in the study area used by Bull et al. (2007) would put the CMWMA estimates into the proper perspective. Pileated Woodpeckers have increased throughout Idaho from 1993-2013 based on North American Breeding Bird Survey data (Sauer et al. 2014), while breeding densities on CMWMA have remained stable during the same timespan. Hence, management actions on CMWMA do not appear to be causing declines in Pileated Woodpecker densities, but management actions are not promoting the increase in density seen throughout much of Idaho. The current management action that is most likely to affect Pileated Woodpeckers on CMWMA is timber harvest. Extensive timber harvest can negatively affect Pileated Woodpeckers (Bull et al. 2007), but the effects of timber harvest likely depend on the prescriptions used, the frequency of harvest, and the protocols for dealing with snags, down logs, and slash. We recommend future studies investigate habitat use and the effects of different types of timber harvest on Pileated Woodpecker populations on CWMA. The second chapter of this thesis examines the effects of timber harvest on Pileated Woodpeckers.

In addition to providing an evaluation of CMWMA, this study also provides an example of how past data can be combined with new data to provide a long-term data set. Unfortunately, long-term data sets are often compromised by longitudinal changes in methods. While the past survey data that we used could have easily been abandoned because of changing survey methods, we corrected for differences in survey timing and investigated effects of differing survey duration. If we had not accounted for these differences, we would not have been able to evaluate CMWMAs effectiveness at meeting its goals for the 3 target bird species. The power of legacy data is immense because these data provide a historical perspective that is not possible without them.

Idaho's network of wildlife management areas support breeding habitat for 98.4% of Idaho's wildlife, including all federal- and state-listed threatened, endangered, and candidate terrestrial vertebrates (Karl 2005). This high percentage implies that Idaho's network of WMAs benefits wildlife populations. However, evaluation of explicit management actions on these individual WMAs is necessary to ensure that WMAs are meeting their intended goals. Protected areas are often considered a cornerstone of efforts to conserve wildlife populations (Aycrigg et al. 2013, Fuller et al. 2010, Stokes et al. 2012, Baeza and Estades 2010, Caro et al. 2009, Hockings 2003). Quantifying the effectiveness of protected areas is important given the large investment (including forgone opportunities for other kinds of land use) required to establish and maintain protected areas (Gaston et al. 2008). Wildlife Management Areas (along with other type 2 and type 3 public protected areas) are often assumed to have less value for biodiversity conservation (because these areas allow the sustainable use of natural resources) (Gaston et al. 2008). Our results suggest that populations of Yellow Warblers and Black-capped Chickadees are doing better than they are elsewhere in Idaho and do not appear to be adversely affected by the management actions employed and land uses allowed on the WMA. Furthermore, Pileated Woodpecker densities have remained stable on CMWMA (whereas their densities have increased in other areas of Idaho).

Determining what land uses are allowed in protected areas will be determined by managers based largely on societal opinions. The needs and opinions of the public typically determine what occurs on the landscape (Dale et al. 2000). Scientists can influence those opinions by documenting the benefits and limitations of protected areas. In addition, scientists can help managers and the public make informed decisions by documenting the consequences and benefits of different actions within protected areas. Can renewable resources be extracted without compromising the objectives of protected areas? What uses are appropriate within protected areas? Our results suggest that the management actions and land uses on CMWMA seem to be compatible with the goals of CMWMA (for the 3 target species that we examined).

Chapter 2: Effects of Three Timber Harvest Prescriptions on Breeding Density of Pileated Woodpeckers

Introduction

Woodpeckers (family *Picidae*) are often used as indicators of forest health or forest conditions (Bull 1987, Drever et al. 2008). For example, Pileated Woodpeckers (*Dryocopus pileatus*) are often used as an indicator species for mature or old-growth forest conditions (Bull et al. 2007, Bull and Holthausen 1993, Hansen and Martin 1989). Pileated woodpeckers are also a species of conservation concern and are considered a keystone species because the cavities they excavate provide nesting and roosting sites for many birds and mammals (Aubry and Raley 2002, Bull et al. 2007). Hence, declines in Pileated Woodpecker populations could have cascading effects on forest biodiversity (Bull et al. 2007). Although Pileated Woodpeckers enhance species diversity in forested systems, forest management practices are often implemented without fully understanding their effect on Pileated Woodpeckers.

Many forest management plans include Pileated Woodpeckers as a focal species. For example, Craig Mountain Wildlife Management Area (CMWMA) in northern Idaho includes Pileated Woodpeckers as 1 of 6 target (focal) mitigation species because they are indicators of mature and old-growth forest conditions (Hansen and Martin 1989). In 1992, >12,000 hectares of privately owned forest was purchased and added to the CMWMA, and baseline surveys were conducted in 1993-94 (Cassirer 1995) to document the abundance of Pileated Woodpeckers and other target species within CMWMA. Prior to 1993, only the most merchantable trees were removed (Cassirer 1995). Since 1993, 200 timber harvest operations have been implemented on CMWMA, most of which were intended to improve forest health and fire safety (through fuels reduction). The prescriptions for these 200 timber harvests have varied substantially. Hence, we have a unique opportunity to examine how different timber harvest practices have affected the density of Pileated Woodpeckers.

Previous studies in northeast Oregon have found that Pileated Woodpeckers select old-growth grand fir (*Abies grandis*) forests with > 60% canopy closure and unaffected by recent timber harvest (Bull and Holthausen 1993). Furthermore, density of Pileated Woodpeckers was negatively correlated with regeneration cuts and nesting success was negatively correlated with the amount of timber harvest in northeastern Oregon (Bull et al. 2007). Timber harvest operations which focus on the salvage of dying and dead trees are detrimental to most woodpeckers because trees removed during salvage operations are frequently the trees used by woodpeckers for nesting and foraging (Scott 1979). However, not all timber harvest operations are similar (prescriptions can vary widely) and we know little about how densities of Pileated Woodpeckers are affected by other types of timber harvest. Additionally, we lack information on how timber harvest affects the distribution of Pileated Woodpeckers.

We used both correlative and quasi-experimental approaches to examine the effects of 4 different timber harvest practices on density of Pileated Woodpeckers. For the correlative approach, we identified all timber harvests on CMWMA over the past 20 years and assigned them to 1 of 4 timber harvest categories and then we compared breeding densities of Pileated Woodpeckers (based on surveys conducted during 2013-14) among areas within those 4 categories. For the quasi-experimental approach, we compared changes in breeding density of Pileated Woodpeckers between 1993-94 (pre-harvest) and 2013-14 (post-harvest) among the 4 timber harvest categories. We also documented forest canopy cover both pre and post-harvest among 3 timber harvest categories. Finally, we documented changes in Pileated Woodpecker density and distribution on CMWMA over the past 21 years (i.e., since 1993 when CMWMA became established and a management plan was developed).

Methods

Study Area

The Craig Mountain Wildlife Management Area (CMWMA) is located in north central Idaho, approximately 40 km south of Lewiston, Idaho in southern Nez Perce and southwest Lewis counties. CMWMA is north of the confluence of the Salmon and Snake rivers and elevations range from 244 m to 1637 m. The lower elevations are primarily steep canyon grasslands mixed with rimrock and talus slopes. As elevation increases, northern aspects have canyon forests with Douglas fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*) and southern aspects support shrubfields and grasslands. A large forested plateau at upper elevations (1370m-1637m) supports lodgepole pine (*Pinus contorta*), Douglas fir, ponderosa pine, and western larch (*Larix occidentalis*).

CMWMA is the largest of 32 WMAs in Idaho, and is considered a status type 2 protected area (U.S. Geological Survey 2012). Status type 2 protected areas have permanent protection from the conversion of their natural land cover and have a mandated management plan to ensure that the area is maintained in a primarily natural state, but they allow management practices that may potentially degrade the quality of existing natural communities, including suppression of natural disturbances (U.S. Geological Survey 2012). The Craig Mountain area consists of approximately 60,000 ha of lands owned by Idaho

Department of Fish and Game (IDFG), Bureau of Land Management (BLM), The Nature Conservancy (TNC), Idaho Department of Lands (IDL), and the Nez Perce Tribe (NPT). More than half (~33,600 ha) of the Craig Mountain area is owned and managed by IDFG. The majority of the IDFG lands (24,281 ha) on Craig Mountain were purchased by Bonneville Power Administration (BPA) in 1992 and then transferred to IDFG to mitigate for the loss of wildlife habitat from the inundation of Dworshak reservoir 56 km to the northeast in Clearwater County.

As part of the mitigation purchase, 6 species were identified by IDFG and BPA as ‘target species’ toward which land management on CMWMA would be directed: Yellow Warbler (*Setophaga petechia*), Black-capped Chickadee (*Poecile atricapillus*), Pileated Woodpecker, White-tailed Deer (*Odocoileus virginianus*), Rocky Mountain Elk (*Cervus elaphus*), and River Otter (*Lontra canadensis*). These 6 target species were selected because they were species that had high priority for state, federal, or tribal wildlife programs at the time, or they were considered indicators of the ecosystems most impacted by the construction of Dworshak Dam (Hansen and Martin 1989).

IDFG has implemented numerous management actions on CMWMA since the transfer of the mitigation acres in 1992, including additional land acquisitions, land trades, timber harvest, control of noxious weeds, elimination of livestock grazing on 90% of the IDFG lands, and the closure of approximately 150 km of open roads. CMWMA has also had changes in temperature and precipitation regimes, several wildfires, an increase in noxious weeds, mountain and western pine beetle (*Dendroctonus ponderosae* and *D. brevicomis*) infestations, and increased recreational use.

Bird Surveys

Point-count surveys for birds were conducted on CMWMA in 1993 and 1994 shortly after the mitigation lands were transferred to IDFG. Point-count survey transects were established in both upland forest and riparian/grassland areas (Fig. 2). The upland forest transects were established to sample the relative abundance of Pileated Woodpeckers and included 134 survey points along 14 transects. The upper plateau of CMWMA was divided into 5 segments of similar size bounded by drainages, roads, or topography and 2 to 4 transects were established in each of the 5 segments (Fig. 3). Seven of the 14 transects included 8-10 survey points in areas of CMWMA considered to have the least influence from roads. Distance between adjacent survey points on these 7 transects averaged 248 m (range 192-333 m). The other 7 transects paralleled roads (some that remained open and some that were closed) with survey points placed 100 m away from the adjacent road. Three of the 7 roaded transects paralleled open roads and consisted of 8-10 survey points with an average of 994 m (range 464-2725 m) between adjacent points. The remaining four roaded transects paralleled closed roads and consisted of 8-10 survey points with 337 m (range 193-857 m) between adjacent points. Cassirer (1995) conducted the point-count surveys of the 134 forested points in 1993 and 1994 and these surveys helped document baseline conditions of the area when IDFG first took ownership of the BPA lands.

To estimate changes in relative abundance of the target bird species over the past 21 years, we surveyed all 14 of the original CMWMA upland forest transects in both 2013 and 2014. We were unable to locate the original rebar marker for 4 points and thus surveyed 130 of the 134 original survey points. We also established and surveyed 2 additional transects in the upland forests of CMWMA in 2014 to increase sample sizes within timber harvests. Both of the new transects consisted of 10 points, were located in or near recent timber harvests, and paralleled closed roads (all points were located 100 m from roads). Distance between adjacent survey points on these 2 transects averaged 334 m (range 254 – 439 m). All bird surveys in 2013 and 2014 were conducted from early April until early July to replicate the survey dates from prior years. We surveyed the 16 forest transects 2 to 10 times per year. We used the bird survey protocol developed by Cassirer (1995) and the USDA Forest Service Northern Region Landbird Monitoring Program field methods (Hutto et al. 2002). Both methods rely on variable-circular plot point-count surveys, where surveyors count all birds seen or heard during a survey and estimate distance to each bird (Reynolds et al. 1980). Surveys were conducted from sunrise until 10:00am. Surveyors alternated the chronological order in which they visited points along a transect each time a transect was surveyed. Surveyors waited 3 minutes at each point before surveys began. All birds seen or heard were recorded during a 10-minute survey and the minute of initial detection was recorded for each bird. Recording the 1-minute segment when each bird was initially detected allowed us to compare our survey data to the data from the 5-minute surveys conducted in 1993-94 and to data from other survey efforts that used 10-minute survey durations. All birds heard or seen were recorded regardless of distance from the surveyor. In addition to bird species and minute of initial detection, we also recorded distance to bird, type of detection (audial or visual), activity of the bird, time the survey started, wind conditions (Beaufort scale), stream noise, ambient temperature, and other weather conditions. All surveyors were trained in distance estimation and bird identification by sight and sound. Bird call CDs, MP3s, and field guides were used to help surveyors identify unknown calls. Laser rangefinders were used to estimate distance to each bird.

Each observer was also required to practice bird identification with an expert. The expert decided when surveyors were sufficient in bird identification and allowed to perform surveys.

Estimating Density

We used Program Distance 6.0 Release 2.0 (Thomas et al. 2009) to calculate density estimates for the 1993-94 and 2013-14 survey efforts. Program Distance is a Windows-based computer package designed to analyze data from distance sampling surveys. This program uses robust semi-parametric methods to model probability of detection as a function of distance from the surveyor (Thomas et al. 2009). Several models are provided for the analysis of distance data. The models used in Program Distance have 3 important properties. First, these models are robust and flexible enough to fit a wide variety of the possible shapes of a detection function (Buckland et al. 2001, Burnham et al. 1980). Second, the models have a shape criterion that has a shoulder near the zero point (near the surveyor). Third, the model that fits the data best can provide precise estimates of density (Buckland et al. 2001). In order to meet the 3 model criteria mentioned above, Program Distance uses models that have a parametric key function combined with a series expansion.

Program Distance offers several analysis engines for analyzing distance data. We used the Conventional Distance Sampling (CDS) analysis engine to estimate density for both survey periods (1993-94 and 2013-14). We decided to model data from these 2 survey periods separately because each survey period may have different optimal truncation distances best modeled by different key functions and series expansions, and because CMWMA has experienced many changes in management since IDFG acquired the mitigation lands. We first examined data from each of the 2 survey periods to determine optimal truncation distances (outliers), evidence of heaping, and evidence of evasive movement. We used histograms of distance data, divided into a large number of distance intervals, for data exploration. Evidence of heaping was found in all data sets and distance intervals were chosen to eliminate prominent heaps. All data sets were truncated; we eliminated at least 10% of the detections with the largest distance estimates (Buckland et al. 2001).

One of the important features of distance sampling is to effectively model the shape of the detection function (i.e., the precise manner in which detection probability changes with distance). To do that, we compared the applicability of 6 types of models and used model selection to determine which best fit the detection function for each of the 2 survey periods: the half-normal key with cosine adjustments (HnCo), the half-normal key with hermite polynomial adjustments (HnHp), the uniform key with cosine adjustments (UnCo), the uniform key with simple polynomial adjustments (UnSp), the hazard-rate key with cosine adjustments (HzCo), and the hazard rate key with simple polynomial adjustments (HzSp). Estimates were stratified by transect. We used the all-selection method option (maximum number of terms set to 5) to identify adjustment terms and used AIC as the model selection criterion. We used the estimate variance empirically option to estimate encounter rate variance. We used AIC, χ^2 goodness of fit, coefficient of variance, and visual inspection of both the estimated detection function and the detection probability plot to evaluate the validity of models.

Distribution

We investigated possible changes in the distribution of Pileated Woodpeckers on CMWMA to determine if spatial variation in densities of Pileated Woodpeckers had changed over the past 20 years on CMWMA due to management practices. We investigated changes in distribution by splitting the forest transects into subsets based on 2 criteria. First, we split the forest transects into 2 subsets based on latitude: North (north of the head of Eagle Creek) and South (south of the head of Eagle Creek). We used Program Distance to estimate densities for both the North and South subsets of transects in 1993-94 and 2013-14 (we used detections from the first 5 minute of each survey) to evaluate whether temporal changes in breeding densities differed between the 2 areas over the 21-year time period. Second, we split the forest transects into 5 segments that Cassirer (1995) identified because they are of similar size that are naturally bounded by roads, drainages, or topography, with 2 to 4 transects located in each of the 5 segments (Cassirer 1995). We used Program Distance to estimate breeding density of Pileated Woodpeckers in the 5 segments in 1993-94 and again in 2013-14 (again, we used detections from the first 5 minute of each survey) to evaluate whether changes in breeding densities differed among the 5 segments over the 21-year time period.

Classification of Timber Harvest

Since 1993, 200 timber harvests have been implemented by 3 different agencies (IDFG, IDL, and NPT) in the Craig Mountain area. These 200 timber harvest treatments averaged 22 ha in size (range 0.13 – 473 ha). In our analysis, we only included timber harvest treatments that were within 300 m (farthest truncation distance of Pileated Woodpecker detections) of $\geq$1 of the CMWMA forested survey points. Sixty-two of the 200 timber harvests were within 300 m of ≥1 of the CMWMA forested survey points. These 62 timber harvest treatments averaged 32 ha in size (range 0.70 – 270 ha). We split these 62 timber harvests into 3 categories based on a method previously used to document the influence of disturbance on Pileated Woodpeckers (Bull 2007): partial removal cuts (55 harvests), regeneration cuts (4 harvests), and fuel reduction cuts (3 harvests). Partial removal cuts included salvage cuts, sanitation cuts, commercial thinning, and selection cuts. Regeneration cuts included clearcuts, shelterwood removal cuts, overstory removal cuts, seed tree cuts with reserved trees, and shelterwood seed cuts. Fuel reduction cuts included hazardous fuel treatments where the objective was to create fire breaks within the wildland/urban interface by removing ladder fuels, dead trees, and downed material (but few green trees). Survey points that have not received recent timber harvest (or were ≥ 300 m from a timber harvest) were classified as a 4^{th} harvest category: not recently harvested. Not recently harvested points included those that were in areas that we had no record of being harvested within the last 20 years. We consulted with the managers of the 62 timber harvests to determine which category each harvest fell within. In addition, we completed vegetation surveys at all forested points to characterize each harvest category (Table 15 and 16).

Effects of Timber Harvest on Pileated Woodpeckers

We used 2 approaches to assess the effects of different types of timber harvest on density of Pileated Woodpeckers: 1) a correlative approach where we compared density of Pileated Woodpeckers in 2013-14 among points in areas that had experienced the 4 different types of timber harvest (we used 10-minute point-count data for this comparison); and 2) a quasi-experimental approach where we compared the change in density of Pileated Woodpeckers (from 1993-94 through 2013-14) among points in areas that had experienced the 4 different types of timber harvest during the intervening 20 year period (we used 5-minute point-count data for this comparison). We used 2 approaches (liberal and conservative) to assign the survey points to 1 of the 3 timber harvest categories: 1) for the liberal approach, any survey points within 300 m of the boundary of a timber harvest that occurred between 1993-2013 were assigned to that harvest category; and 2) for the conservative approach, only survey points that were within the boundary of a timber harvest that occurred between 1993-2013 were assigned to that harvest category. We included points within 300 m of the boundary of timber harvests (for the liberal approach) because we used a 300 m truncation distance in some of our detection functions and, hence, some of the Pileated Woodpeckers that we detected were as much as 300 m from the survey point.

Creation of Forest Cover Layer

We used NAIP images of CMWMA from 2004 (1 meter resolution) and 2013 (0.5 meter resolution) to create forest cover layers. We used ENVI version 5.0 (Exelis Visual Information Solutions, 2013) to process and analyze the NAIP imagery. We used the georeferenced mosaicking function to create seamless NAIP images of CMWMA. We used ENVI's classification workflow function to categorize pixels in the NAIP images to create a forest cover layer for the 2004 and 2013 images. We used the supervised minimum distance method to classify the 2004 and 2013 images. We classified each pixel within the NAIP images into 1 of 3 categories: forest, non-forest, and shadow (tree, topography, and cloud shadow). We set no thresholds in the standard deviations from mean or maximum distance error options. Eliminating the use of thresholds requires ENVI to classify each pixel in the image.

After creating the 2004 and 2013 forest cover layers, we used ArcMap version 10.1 (ESRI 2013) to mask both images to the boundaries of 24 timber harvests that were performed between 2006 and 2012 and were located within 300 m of at least 1 of the 150 forest survey points (original 134 forested points plus 20 additional points from 2014). We eliminated 2 areas from the analysis because they were obscured by cloud cover or cloud shadow in the 2004 NAIP image: 1 timber harvest was eliminated (leaving 23 timber harvests) and another timber harvest was clipped to eliminate 173 ha of the harvest area that was obscured by cloud cover and cloud shadow. We then compared both forest cover layers side by side with their corresponding NAIP image. The comparison of forest cover layers to the NAIP images revealed 16 ha of non-forest that was misclassified as forest due to topography shadow. We used the corresponding NAIP image to reclassify areas of topography shadow to determine which class (forest or non-forest) was contained in the area of topography shadow. Once topography shadow was removed, 87 ha of tree shadow in the 2004 image and 141 ha of tree shadow in the 2013 image remained. We considered forest cover to be the combination of the forest cover and tree shadow cover layers (because tree shadow is caused by trees and is, hence, forested).

Results

Density of Pileated Woodpeckers from Two Time Periods

Pileated woodpecker density 1993-94:

We only used detections that were < 210 m from the survey point (we truncated the data to remove the furthest 10% of the 64 detections; Buckland et al. 2001) and split the remaining detections into 6 distance bins. Among the 6 models tested (HnCo, HnHp, UnCo, UnSp, HzSp, HzCo), we identified 5 competing models (HnCo, HnHp, UnCo, HzSp, HzCo) with a ΔAIC < 2.0 (Table 11). We used HzSp to model the detection function for Pileated Woodpeckers in the 1993-94 survey effort. The HzSp model had a ΔAIC of 1.00, a χ^2 *p*-value of 0.577, a coefficient of variation of 0.228, and both the detection function and detection probability plots looked reasonable. Breeding density of Pileated Woodpeckers in 1993-94 was 0.03 birds/ha (95% confidence interval = 0.019 – 0.047 birds/ha).

Pileated woodpecker density 2013-14:

We only used detections that were < 300 m from the survey point (we truncated the data to remove the furthest 10% of the 304 detections) and split the remaining detections into 6 distance bins. Among the 6 models tested (HnCo, HnHp, UnCo, UnSp, HzSp, HzCo), we identified 4 competing models (HnCo, UnCo, HzSp, HzCo) with a ΔAIC < 2.0 (Table 17). We used HzSp to model the detection function for Pileated Woodpeckers in the 2013-14 survey effort. The HzSp model had a ΔAIC of 0.00, a χ^2 *p*-value of 0.870, a coefficient of variation of 0.217, and both the detection function and detection probability plots looked reasonable. Breeding density of Pileated Woodpeckers based on the 2013-14 survey effort was 0.022 birds/ ha (95% confidence interval = 0.014 – 0.034 birds/ha).

Trend of Pileated Woodpecker density between 1993-94 and 2013-14 surveys:

We failed to detect a statistically significant (95% confidence intervals overlap) change in density of Pileated Woodpeckers on CMWMA between the 1993-94 and 2013-14 surveys (Fig. 17). Although not statistically significant, density of Pileated Woodpeckers decreased by 27% between 1993-94 and 2013-14.

Effects of Timber Harvest on Density of Pileated Woodpeckers in 2013-14:

We combined data from the original forested survey points and the 2 additional transects established in 2014 to compare densities of Pileated Woodpeckers between the 4 timber harvest categories in 2013-14. We found a significant difference in Pileated Woodpecker density at points within areas that had received fuel reduction cuts (Fig. 18) when compared to the 3 other harvest categories in 2013-14 (using the 2 additional transects established in 2014). We detected a similar difference when we assigned points within 300 m to harvest categories (Fig. 19). Breeding density of Pileated Woodpeckers was 81% lower at points within fuel reduction cuts compared to points that had not been recently harvested. Only 1 Pileated Woodpecker was detected within an area that had experienced a fuel reduction cut (and only 1 was detected within 300 m of a fuel reduction cut).

We detected no significant difference in breeding density of Pileated Woodpeckers between the other 3 timber harvest categories (not recently harvested, partial removal cuts, and regeneration cuts). However, breeding density of Pileated Woodpeckers appeared to decline as the intensity of harvest increased (Fig. 18). Breeding density of Pileated Woodpeckers was 8% lower at points within partial removal cuts and 27% lower at points within regeneration cuts compared to points in areas that had not been recently harvested.

When we assigned points within 300 m of a timber harvest to that harvest category (liberal approach), we found a similar relationship; breeding density of Pileated Woodpeckers appeared to decline as intensity of harvest increased. Breeding density of Pileated Woodpeckers was 11% lower at points within 300 m of partial removal cuts and 36% lower at points within 300 m of regeneration cuts compared to points in areas that had not been recently harvested (those greater than 300 m from any timber harvests).

The distances from the survey point at which Pileated Woodpeckers were detected differed among the timber harvest categories in a predictable manner. Regeneration cuts had the highest average detection distance (251 m from the surveyor; Table 18). Partial removal cuts and areas that had not been recently harvested had similar average detection distances (184 m and 185 m, respectively; Table 18). Only 1 Pileated Woodpecker was detected within a fuel reduction cut and was 120 m from the survey point.

Change in Breeding Density of Pileated Woodpeckers by Timber Harvest Type:

We failed to detect a significant temporal change in breeding density of Pileated Woodpeckers between 1993-94 and 2013-14 at points that had not been recently harvested (Fig. 20), at points that had received partial removal cuts (Fig. 20), or at points within 300 m of partial removal cuts (Fig. 21). In contrast, we detected a significant temporal change in breeding density of Pileated Woodpeckers between 1993-94 and 2013-14 at points that had received regeneration cuts and at points within 300 m of regeneration cuts (Figs. 20 and 21). Breeding density at points that received regeneration cuts decreased 86% between 1993-94 and 2013-14. Although we failed to detect a significant temporal change, breeding density of Pileated Woodpeckers decreased by 49% at points that had received partial removal cuts.

We were unable to estimate temporal changes in breeding density of Pileated Woodpeckers at points within fuel reduction cuts because so few woodpeckers were detected in these areas. Only 1 of the original 134 CMWMA forested points fell within a fuel reduction cut and only 2 points were within 300 m of a fuel reduction cut. No Pileated Woodpeckers were detected at these points in 1993-94.

Temporal Change in Forest Cover Between 2004 and 2013 by Three Harvest Types:

Forest cover declined by 19% within partial removal cuts, by 25% within regeneration cuts, and by 2% within fuel reduction cuts between 2004 and 2013(Fig. 22).

Change in Distribution of Pileated Woodpeckers After 21 Years of Management:

We failed to find a temporal shift in the distribution of Pileated Woodpeckers between the North and South transects on CMWMA (Fig. 23). Results from our 2013-14 surveys suggest that the North transects had a 29% non-significant decrease in density and the South transects had a 37% non-significant decrease in density since the 1993-94 survey effort. Although not statistically significant, the fact that the density estimate of Pileated Woodpeckers has declined in both the North and South transects and overall on CMWMA (27% non-significant decline overall; Fig. 17) warrants additional monitoring and further study.

Breeding density of Pileated Woodpeckers in segment 2 of CMWMA increased 162% between 1993-94 and 2013-14 (Fig. 24). Temporal changes in breeding density within the other 4 segments were not statistically significant: 13% increase in segment 3; 15% decrease in segment 4; 41% decrease in segment 1; and a 53% decrease in segment 5.

Although not statistically significant (95% confidence intervals overlap), the large decreases in density (41% and 53%) of Pileated Woodpeckers in segments 1 and 5 warrant further study.

Discussion

Pileated woodpeckers are considered keystone species (Aubry and Raley 2002, Bull and Jackson 2011) because their excavations are important for various secondary cavity-users. Pileated woodpeckers were chosen as 1 of 6 target mitigation species on CMWMA because they are considered indicators of mature and old-growth forest conditions (Hansen and Martin 1989). Hence, understanding the effects of forest management practices on Pileated Woodpeckers is crucial to the future management of Pileated Woodpeckers on CMWMA and throughout the inland Pacific Northwest. Our results suggest that Pileated Woodpecker density is negatively correlated with timber harvest intensity. The negative correlation between Pileated Woodpecker density and harvest intensity was evident regardless of the criteria we used to assign survey points to harvest categories (liberal and conservative) and was evident in both our correlative and quasi-experimental approaches. Our results corroborate those from northeast Oregon where Pileated Woodpecker densities declined in areas with extensive timber harvest, breeding density of Pileated Woodpeckers was negatively correlated with the amount of regeneration cuts, and nesting success of Pileated Woodpeckers was lower in areas with regeneration cuts (Bull et al. 2007).

Density of Pileated Woodpeckers was lowest in fuel reduction cuts compared to the other 3 harvest categories. Fuel reduction cuts reduced canopy cover only slightly (2% reduction) compared to the other 2 types of harvest, so why would Pileated Woodpecker densities be lower within fuel reduction cuts? Fuel reduction cuts may cause declines in

Pileated Woodpecker density because these types of cuts typically reduce the number of snags, logs, and woody debris; features that are important habitat components for Pileated Woodpeckers (Bull et al. 2005). Results from our vegetation surveys suggest that the number of large snags utilized by Pileated Woodpeckers for nesting and foraging habitats were lower within fuel reduction cuts, but the amount of woody debris was actually higher in fuel reduction cuts compared to the 3 other harvest types. In addition to a reduction in large diameter snags, another possible cause of low Pileated Woodpecker densities within fuel reduction cuts is that these types of cuts are often located around the wildland/urban interface. Many western states are focused on fuel reduction and forest restoration. Nationally, measures like the Healthy Forest Restoration Act (HFRA 2003) encourage fuel reduction treatments. Foraging habitat for Pileated Woodpeckers will likely be suboptimal in fuel reduction cuts for decades after treatment (Bull et al. 2007). Ants (*Camponotus*) are a primary food source of Pileated Woodpeckers in northeast Oregon (Bull et al. 1992) and ant densities were higher in unharvested areas compared to areas treated with fuel reduction cuts (Bull et al. 2005). While fuel reduction is an important part of protecting personal property in the wildland/urban interface of CMWMA, managers may wish to be prudent in how and where fuel reduction treatments occur so as not to negatively impact Pileated Woodpecker habitat. Our results suggest that reductions in the forest canopy may not reduce habitat quality for Pileated Woodpeckers as much as reductions in large diameter snags. Although Pileated Woodpeckers are often considered indicators of old-growth forest, our results suggest that Pileated Woodpeckers may be compatible with timber harvest as long as snags, logs, and woody debris are left in sufficient numbers. Additional studies are needed to better quantify the ability of Pileated Woodpeckers to tolerate timber removal when snags, logs, and woody debris are not removed.

Although we detected substantive declines in Pileated Woodpecker densities in response to regeneration cuts and at points that received partial removal cuts, the 27% decline in Pileated Woodpecker densities over the 21 years of management on CMWMA was not statistically significant. Despite the lack of statistical significance, this temporal change in Pileated Woodpecker breeding density warrants further investigation into the status of Pileated Woodpeckers on CMWMA. The 95% confidence intervals of our density estimates are wide and, hence, we had limited power to detect a change in density. Cassirer (1995) also reported wide confidence intervals when estimating density of Pileated Woodpeckers on CMWMA in 1993-94; she concluded that changes in density of <50% would be difficult to detect. More survey transects are needed to more rigorously document changes in Pileated Woodpecker density on CMWMA.

The suggested home range size of Pileated Woodpeckers in northeast Oregon was 364 ha (Bull and Holthausen 1993). Breeding pairs of Pileated Woodpeckers are territorial and defend territory boundaries (Mellen et al. 1992). In northeast Oregon breeding pairs of Pileated Woodpeckers were found to avoid overlap of home ranges, while single birds had larger home ranges and some overlap of home ranges (Bull and Holthausen 1993). The forested portion of CMWMA is approximately 12,141 ha. Following the guidelines of Bull and Holthausen (1993), we would expect CMWMA to support approximately 66 Pileated Woodpeckers if the average home range for a pair on CMWMA is 364 ha, home ranges do not overlap, and all of the 12,141 ha of forested area on CMWMA is Pileated Woodpecker habitat. Results from our 2013-14 surveys estimate the population size of Pileated

Woodpeckers on CMWMA at 267 (range 170 – 413) total birds. Our results from the 1993-94 survey effort estimate the population size of Pileated Woodpeckers on CMWMA at 364 (range 230 – 570) total birds. The large difference in Pileated Woodpecker densities between our study and the suggestions of Bull and Holthausen (1993) could reflect either: 1) much smaller home ranges on CMWMA, 2) much more overlap among home ranges on CMWMA, or 3) differences in methods used to estimate density. Density estimates generated from point-count surveys within the study area used by Bull and Holthausen (1993) would help determine whether the differences in density between CMWMA and northeastern Oregon are real or merely reflect differences in methods used to generate density estimates. This would be informative for putting the CMWMA estimates into proper perspective with the work completed in northeastern Oregon. CMWMA does not currently have old-growth forests that are often associated with Pileated Woodpeckers, but it does have many dead, diseased, and dying trees (standing and down) and substantial mature forest. Any efforts to improve forest "health" conditions on CMWMA (i.e., removal of trees with disease or insect damage) may have negative effects on Pileated Woodpecker populations if large snags are not retained.

Although Pileated Woodpecker densities appear to be high on CMWMA, there are several points and recommendations that should be considered if managers wish to manage forests on CMWMA to maintain or increase Pileated Woodpecker populations. First, some timber harvest practices are detrimental to Pileated Woodpeckers, particularly regeneration cuts and fuel reduction cuts. These prescriptions should be used sparingly in areas with the highest densities of Pileated Woodpeckers if managers wish to maintain high breeding densities on CMWMA. Second, mixed-conifer forests are better for Pileated Woodpeckers than stands dominated by ponderosa pine presumably because stands of pure ponderosa pine typically lack sufficient snags and downed wood necessary for foraging habitat (Bull et al. 2007). Although Pileated Woodpeckers may often prefer western larch and ponderosa pine for nest sites (McClelland and McClelland 1999, Bull 1987), mixed-conifer stands provided the best foraging habitat for Pileated Woodpeckers in northeast Oregon (Bull 1987). Additional studies are needed on CMWMA to determine whether these recommendations from northeast Oregon are relevant in Idaho (where breeding densities appear to be higher). Third, IDFG is not the only management agency that performs timber harvest operations in the Craig Mountain area. If managers wish to ensure the persistence of high breeding densities of Pileated Woodpeckers, we recommend identifying areas of high-quality Pileated Woodpecker habitat where timber harvest operations would be restricted to ensure that habitat quality remains high after harvest. Fourth, Pileated Woodpeckers are an important species that provide resources for various other species in forested systems. Declines of Pileated Woodpeckers could have a negative cascading effect on species that utilize Pileated Woodpecker cavities and subsequently result in a decline of forest biodiversity (Bull et al. 2007). Finally, while Pileated Woodpeckers are a target mitigation species on CMWMA, we need to remember that CMWMA has 5 other target mitigation species, plus various other species which must be considered when managing CMWMA. Often management of these various species may be of competing interest.

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Figures

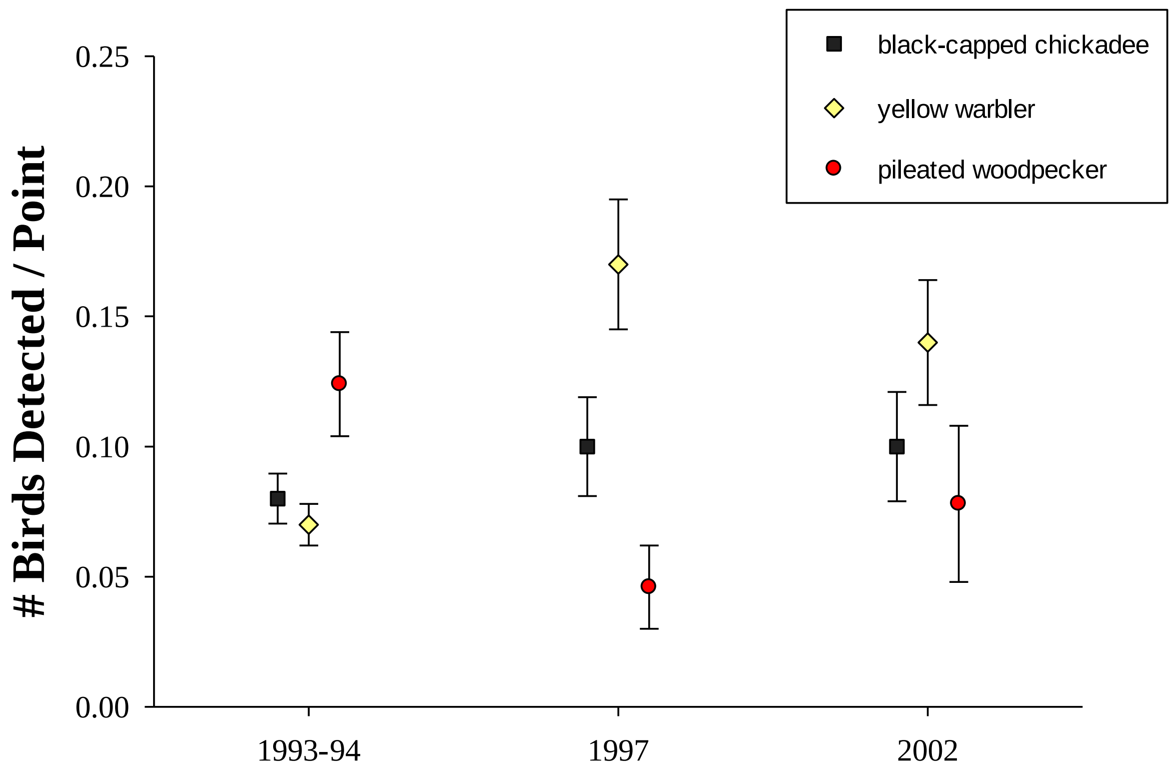

Figure 1. Average number of Black-capped Chickadees, Yellow Warblers, and Pileated Woodpeckers detected per point surveyed during the three prior (1993-94, 1997, 2002) survey periods on Craig Mountain WMA. Numbers are based on raw counts from variable-circular plot point-count surveys. Error bars represent the standard error.

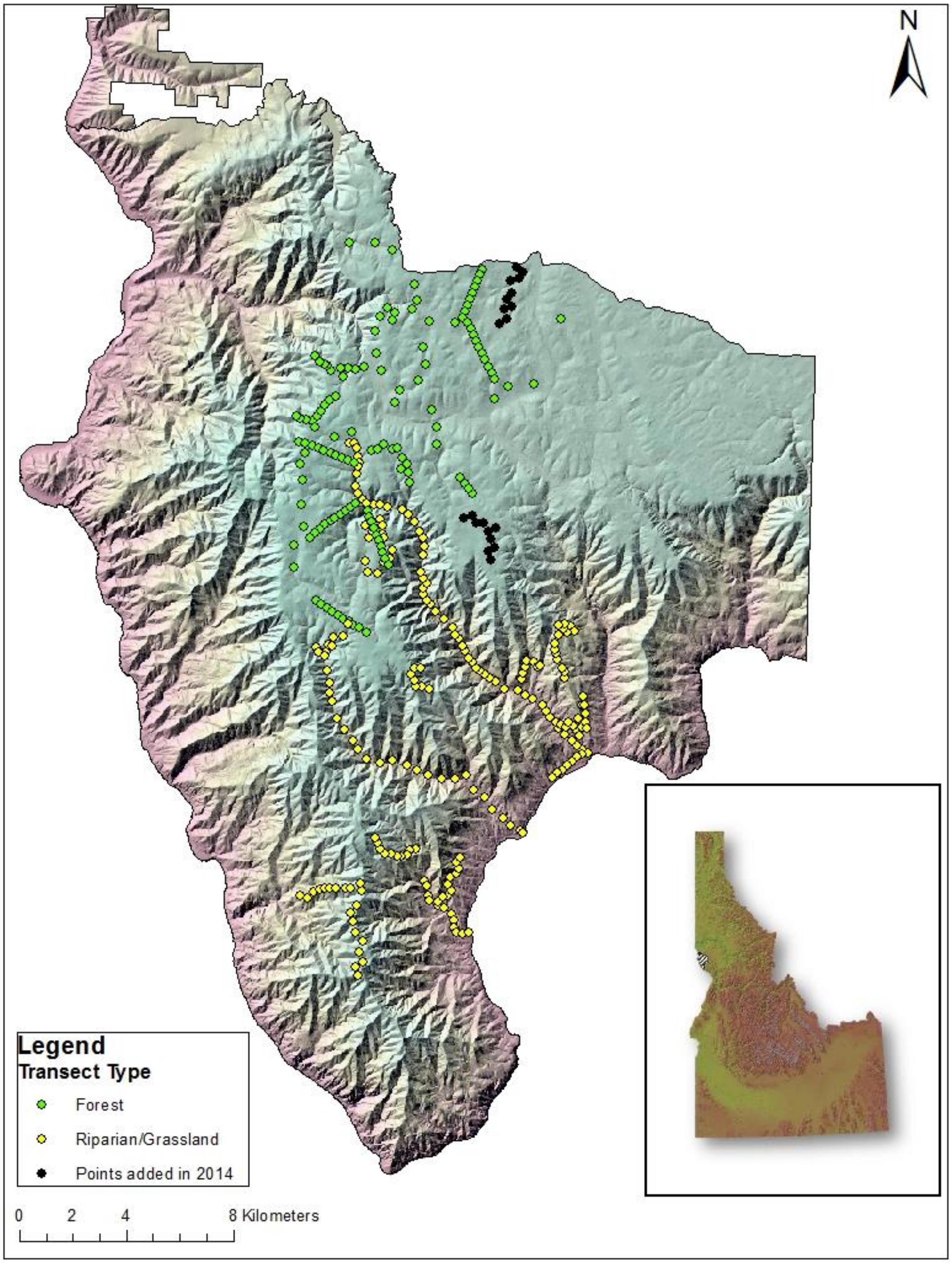

Figure 2. Map of Craig Mountain Wildlife Management Area bird survey transects.

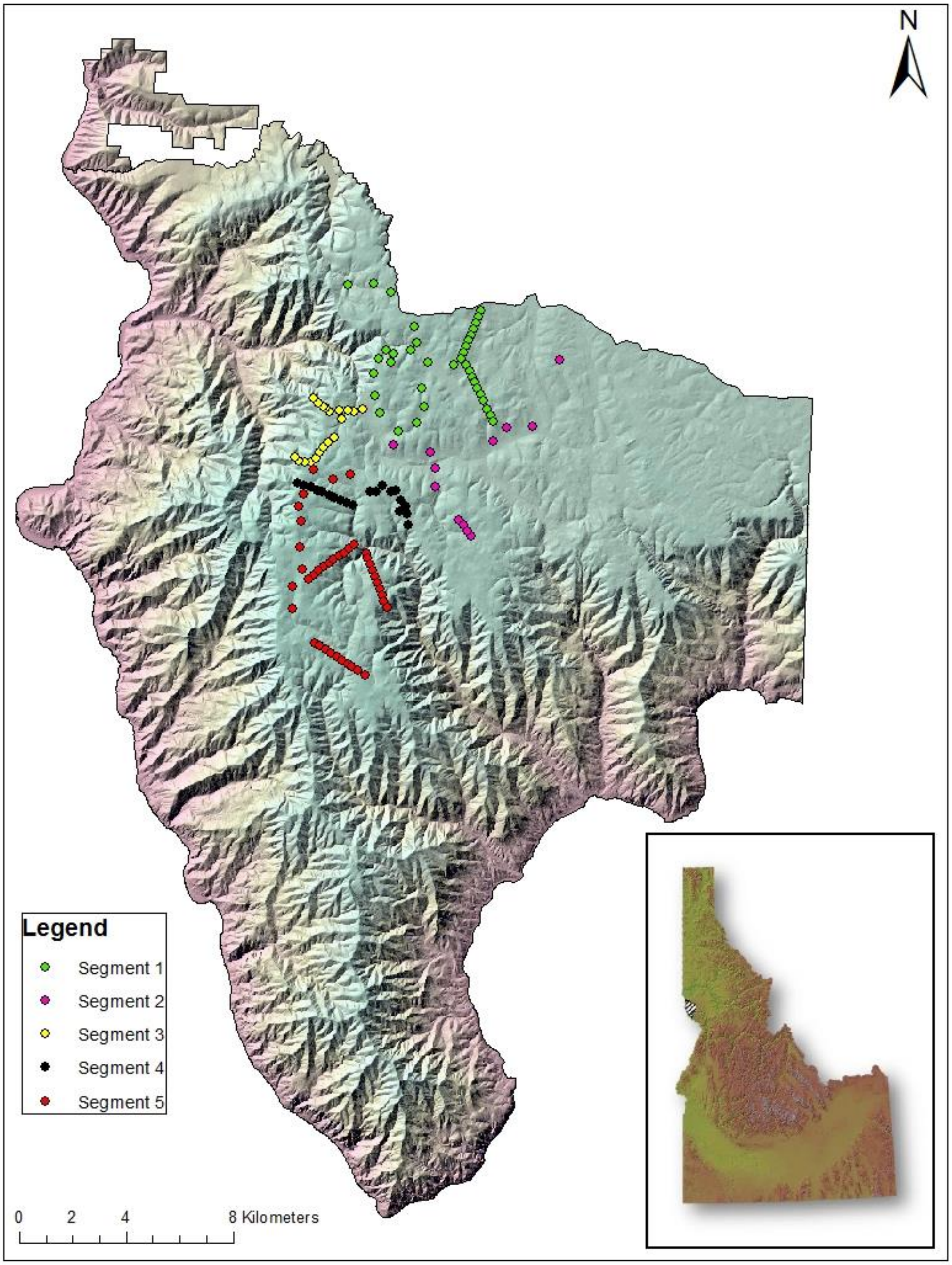

Figure 3. Map of Craig Mountain Wildlife Management Area transects by segment.

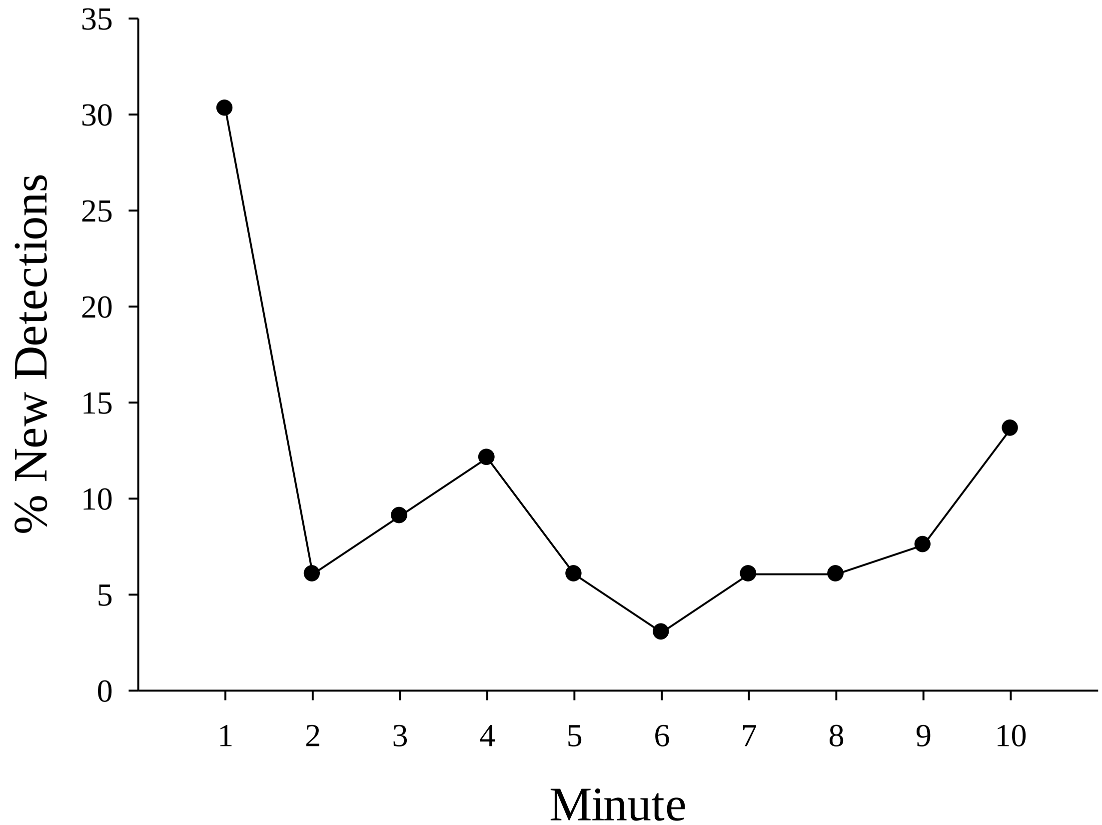

Figure 4. Percent of Black-capped Chickadees within 34 m (Effective Detection Radius) of the surveyor that were initially detected within each 1-min interval during the 2013-14 survey effort at Craig Mountain Wildlife Management Area in northern Idaho.

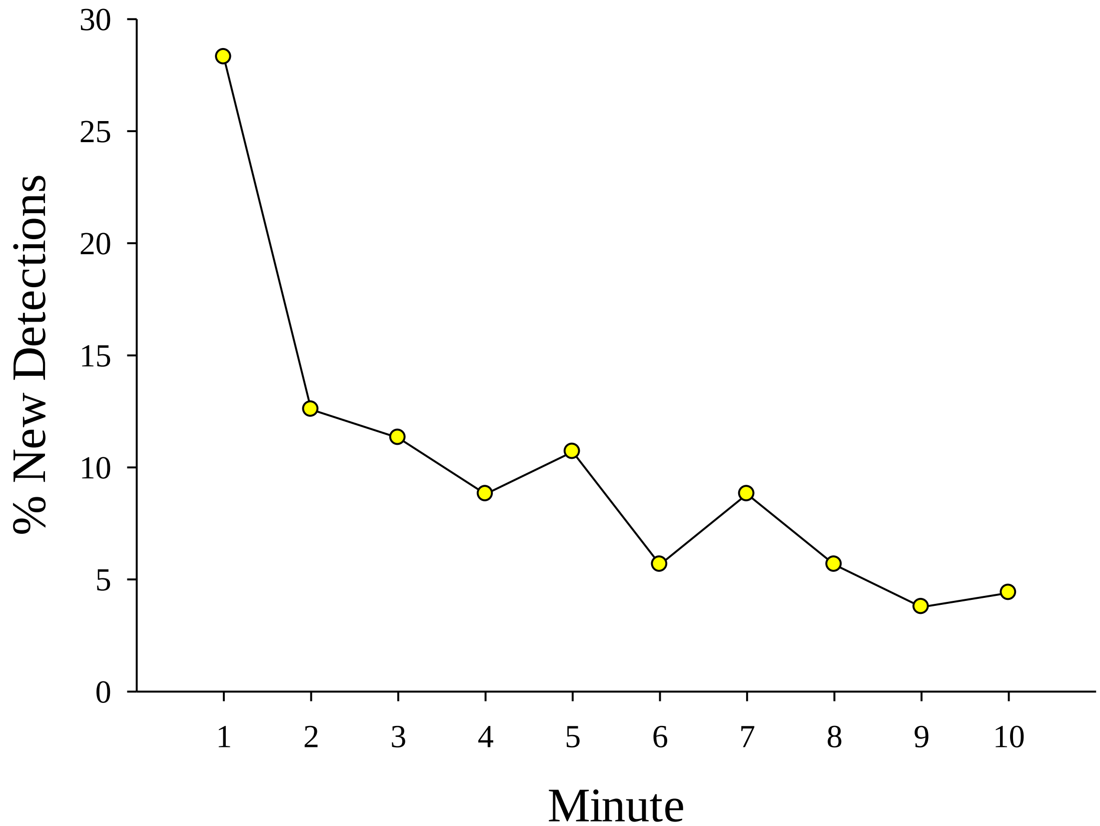

Figure 5. Percent of Yellow Warblers within 35 m (Effective Detection Radius) of the surveyor that were initially detected within each 1-min interval during the 2013-14 survey effort at Craig Mountain Wildlife Management Area in northern Idaho.

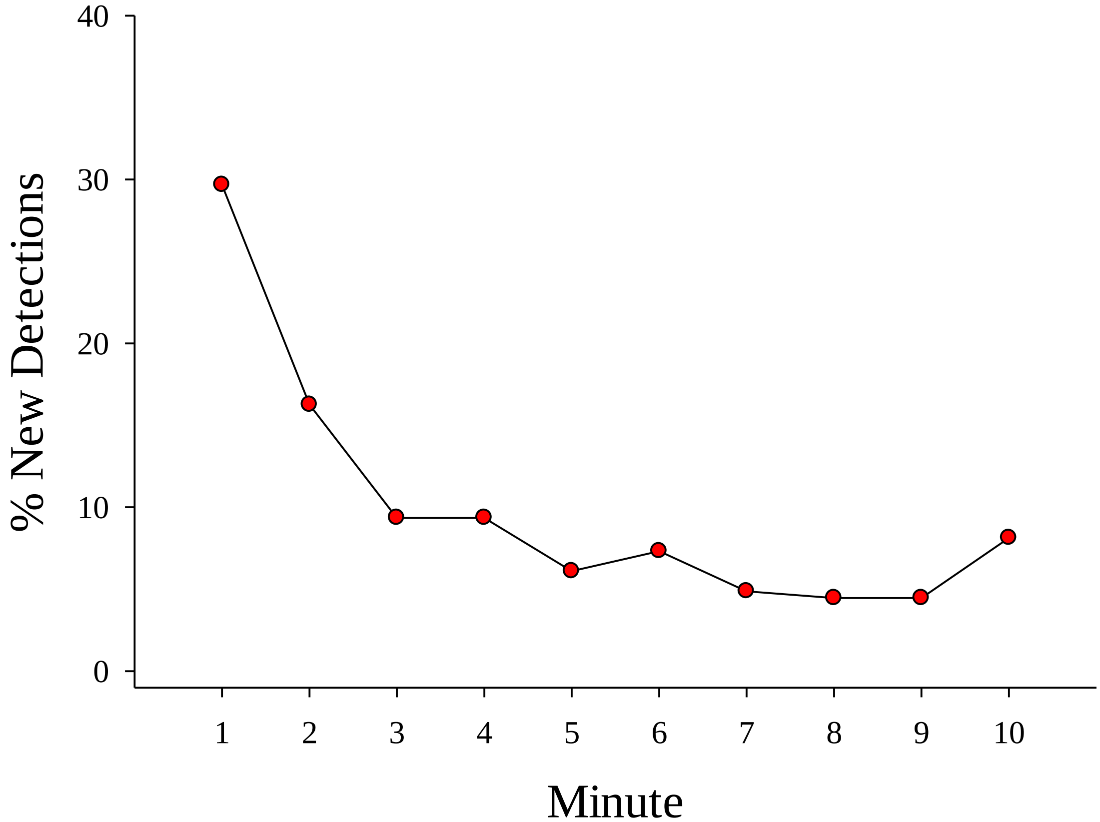

Figure 6. Percent of Pileated Woodpeckers within 188 m (Effective Detection Radius) of the surveyor that were initially detected within each 1-min interval during the 2013-14 survey effort at Craig Mountain Wildlife Management Area in northern Idaho.

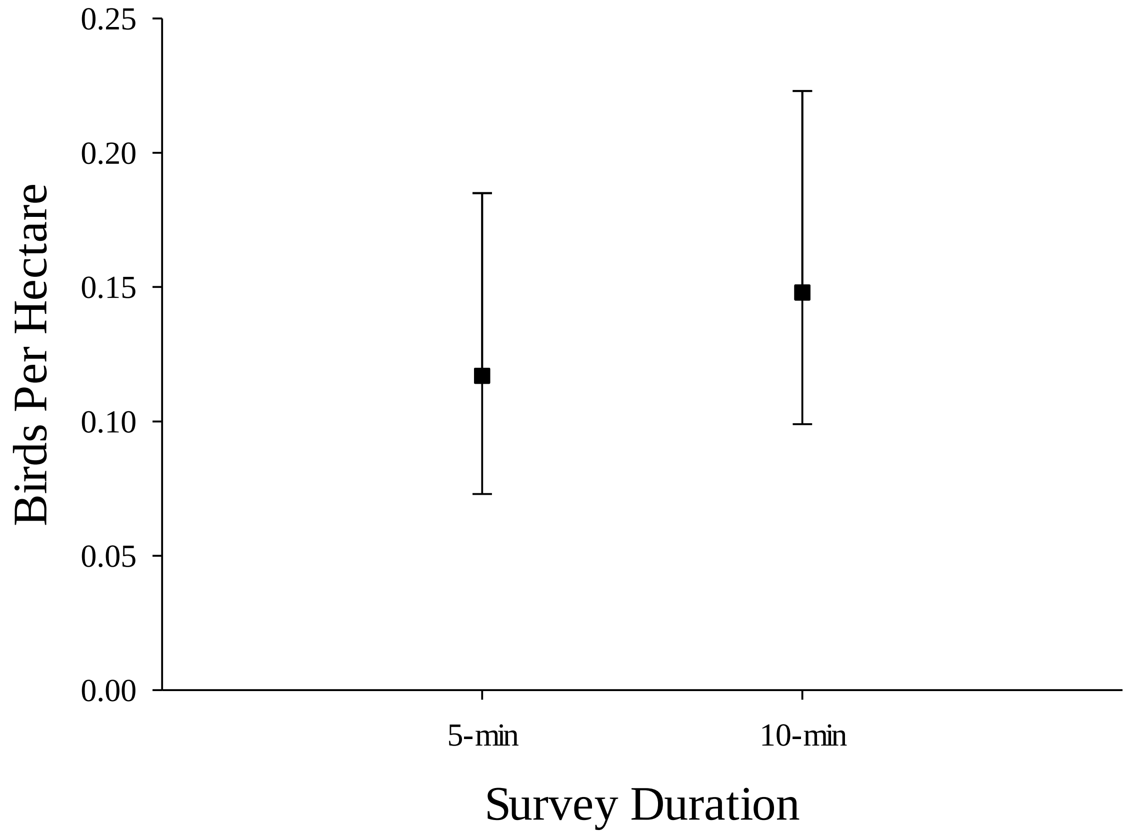

Figure 7. Density of Black-capped Chickadees in 2013-14 for 5-minute and 10-minute survey durations at Craig Mountain Wildlife Management Area in northern Idaho. Error bars represent a 95% confidence interval.

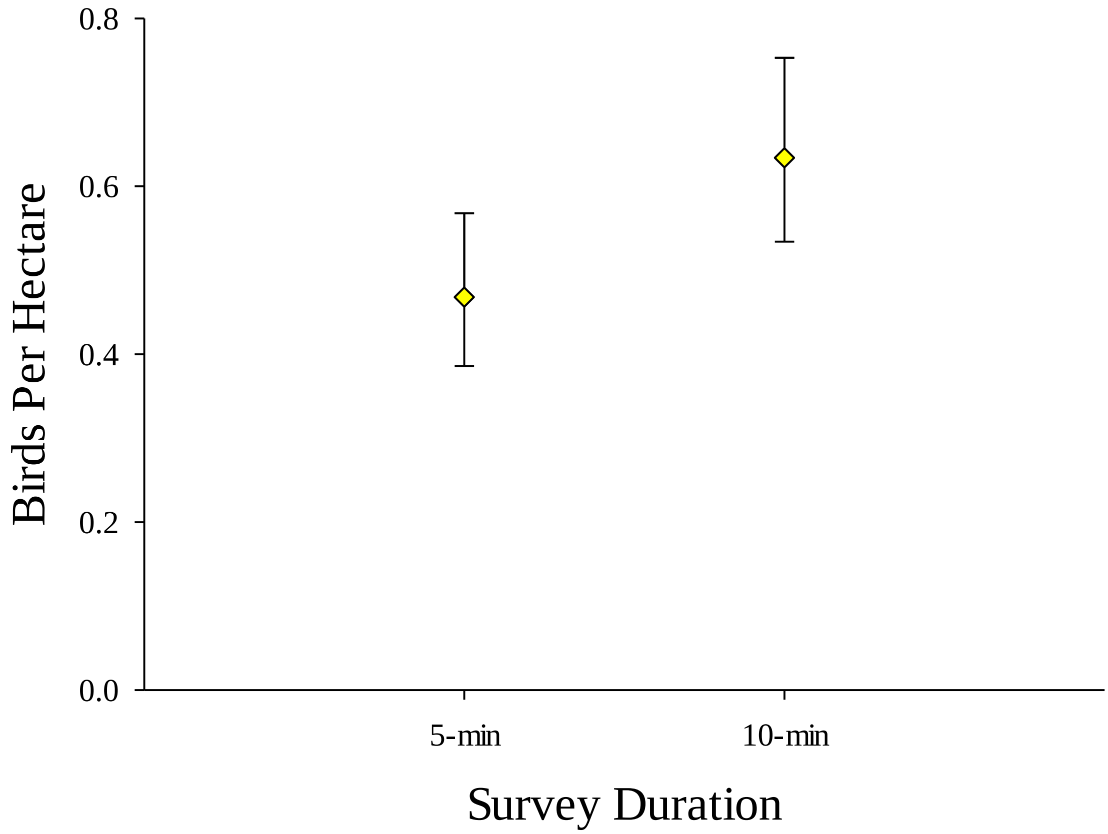

Figure 8. Density of Yellow Warblers in 2013-14 for 5-minute and 10-minute survey durations at Craig Mountain Wildlife Management Area in northern Idaho. Error bars represent a 95% confidence interval.

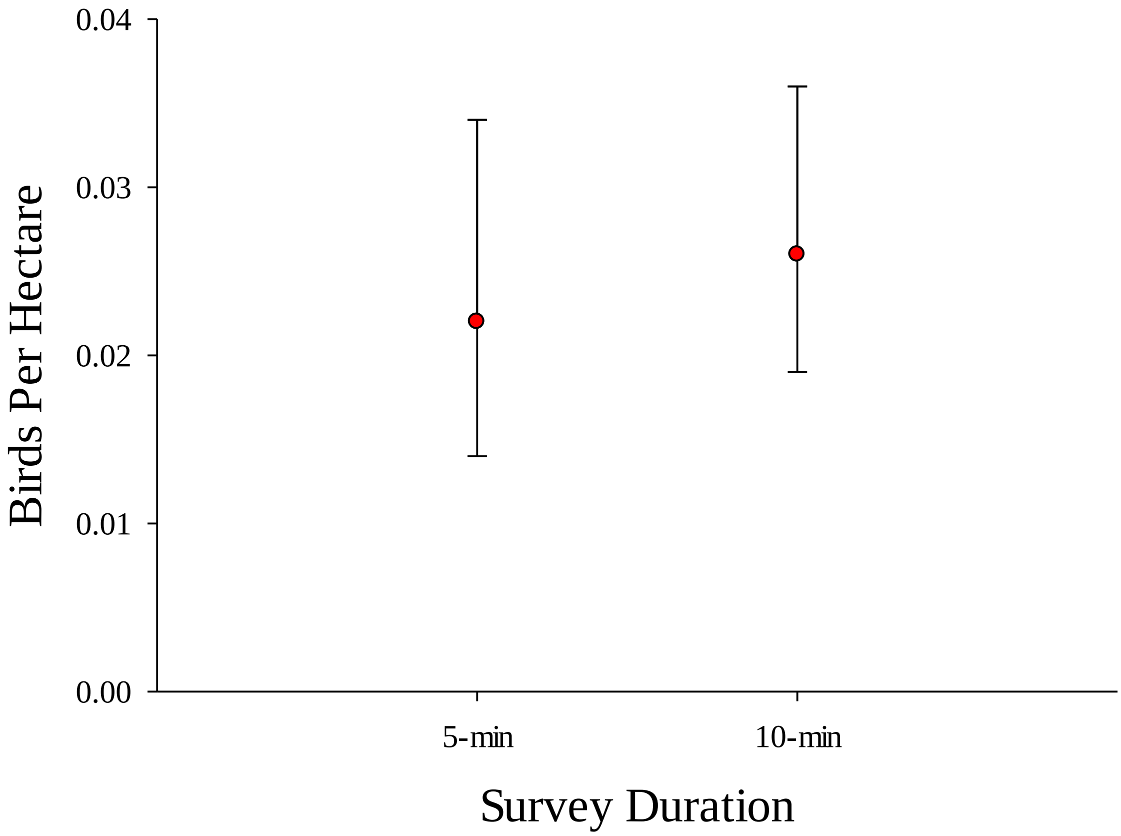

Figure 9. Density of Pileated Woodpeckers in 2013-14 for 5-minute and 10-minute survey durations at Craig Mountain Wildlife Management Area in northern Idaho. Error bars represent a 95% confidence interval.

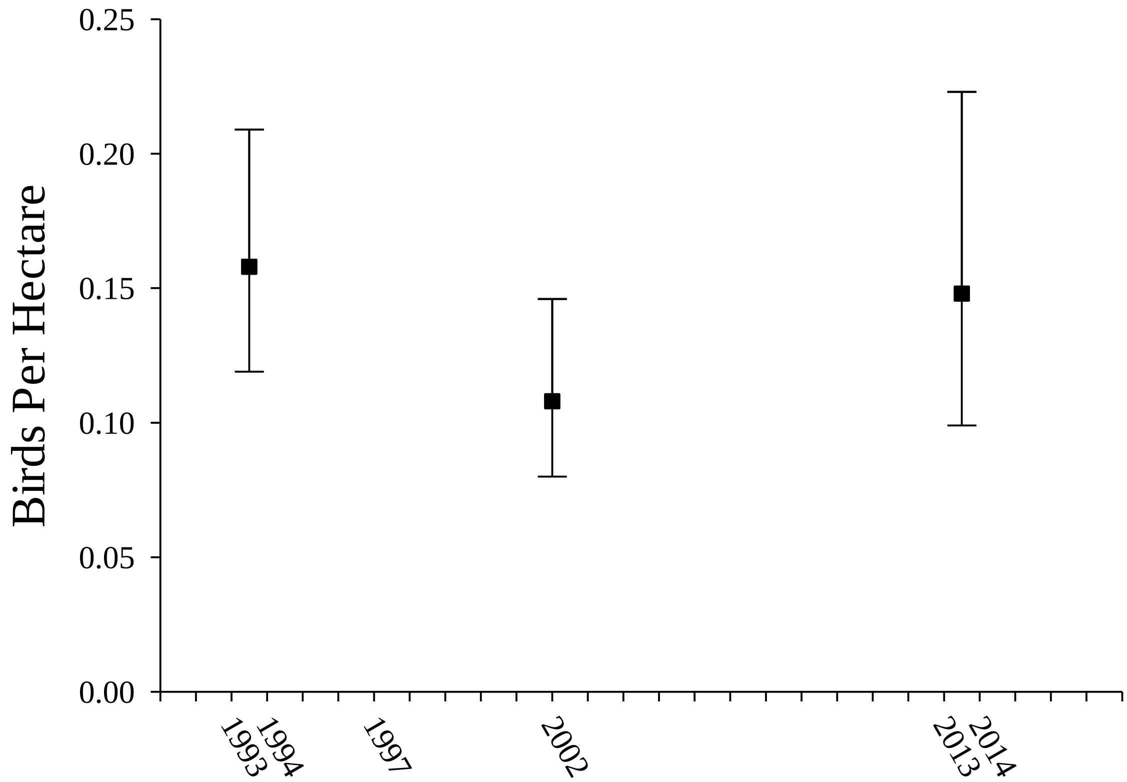

Figure 10. Density of Black-capped Chickadees on Craig Mountain Wildlife Management Area for 3 time periods (1993-94, 2002, 2013-14) for which point-count survey data were available. Estimates are from Program Distance after accounting for differences in detection probability among the 3 survey efforts. Error bars represent a 95% confidence interval.

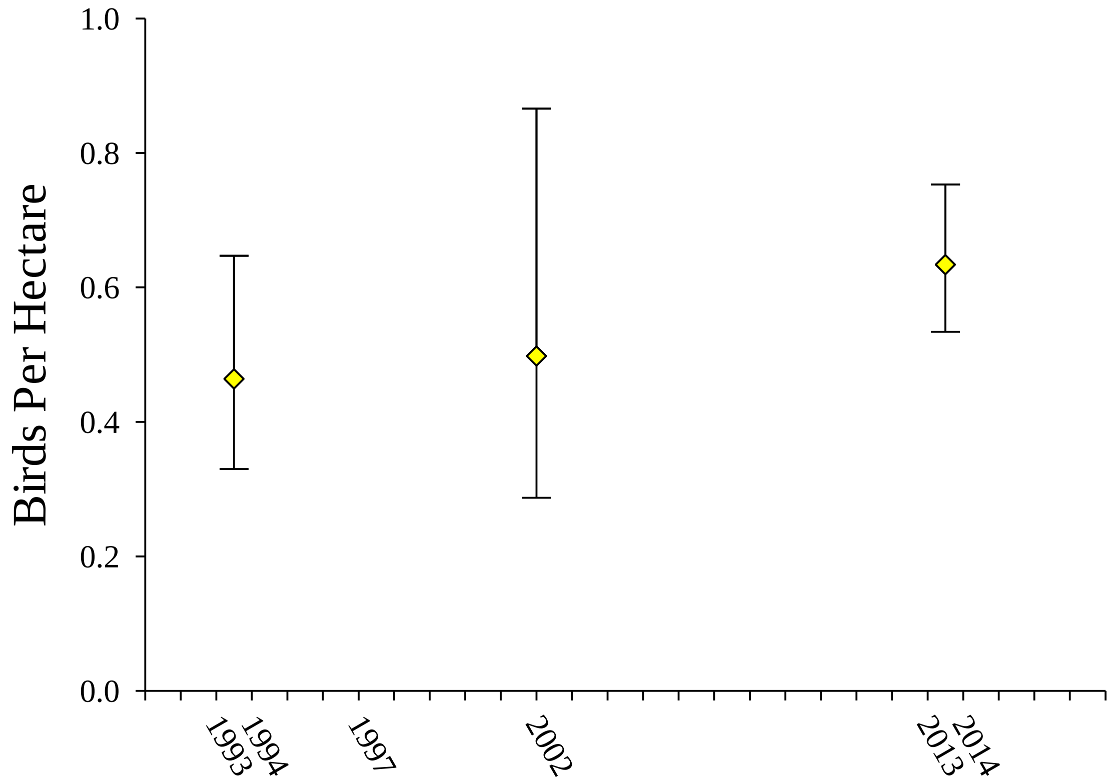

Figure 11. Density of Yellow Warblers on Craig Mountain Wildlife Management Area for 3 time periods (1993-94, 2002, 2013-14) for which point-count survey data were available. Estimates are from Program Distance after accounting for differences in detection probability among the 3 survey efforts. Error bars represent a 95% confidence interval.

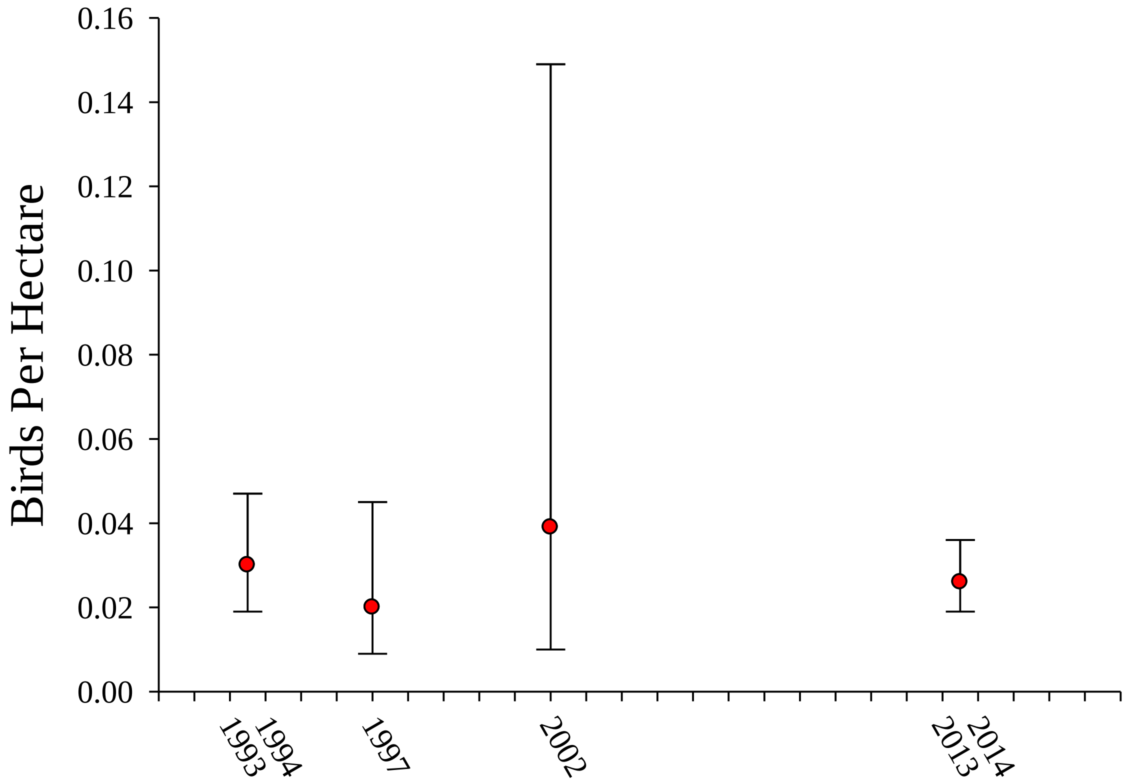

Figure 12. Density of Pileated Woodpeckers on Craig Mountain WMA for 4 time periods (1993-94, 1997, 2002, 2013-14) for which point-count survey data were available. Estimates are from Program Distance after accounting for differences in detection probability among the 4 survey efforts. Error bars represent a 95% confidence interval.

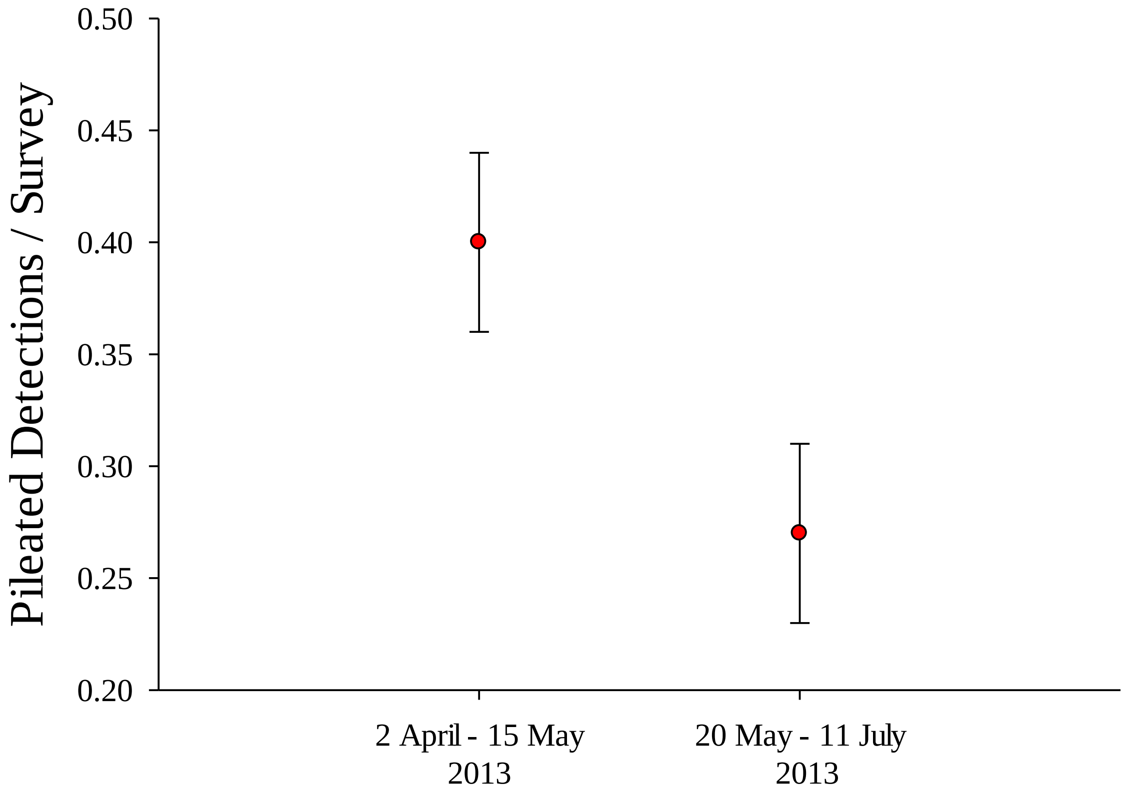

Figure 13. The average number of Pileated Woodpeckers detected per survey during early (2 April – 15 May) and late (20 May – 11 July) survey timeframes at the same set of 134 forested survey points in 2013 at Craig Mountain Wildlife Management Area in northern Idaho. Error bars represent standard error.

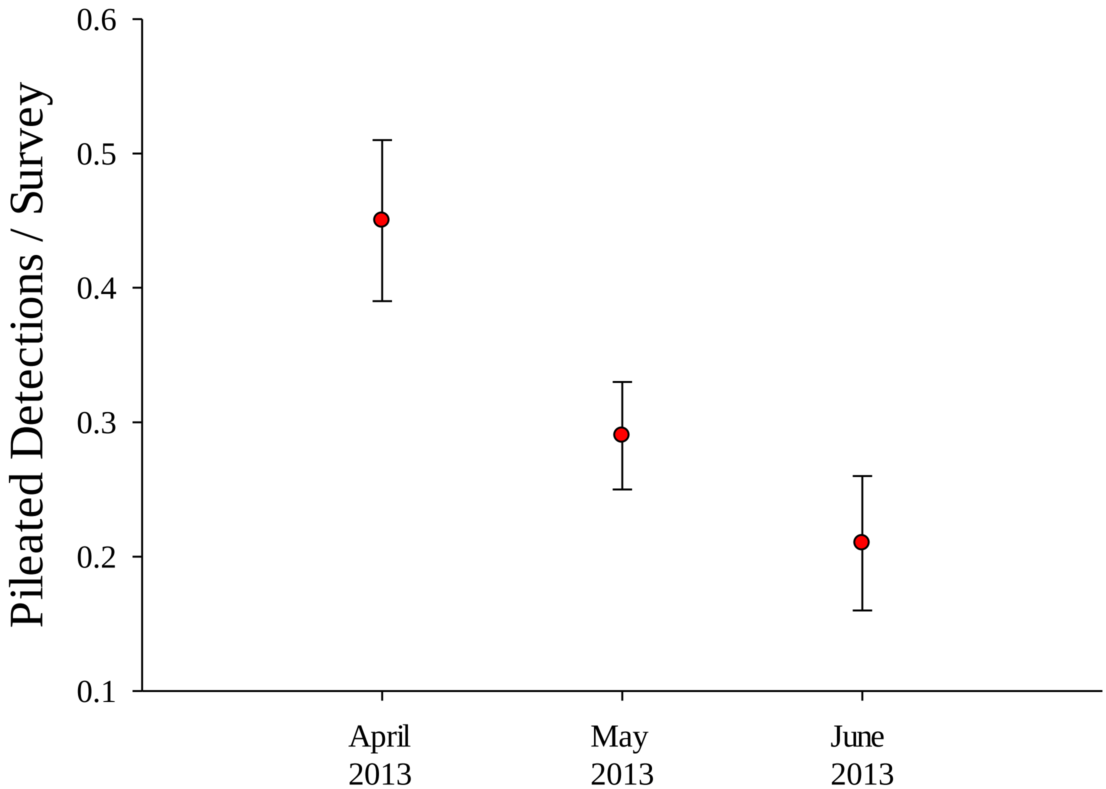

Figure 14. The average number of Pileated Woodpeckers detected per survey during April, May, and June at the same set of 134 forested survey points in 2013 at Craig Mountain Wildlife Management Area in northern Idaho. Error bars represent standard error.

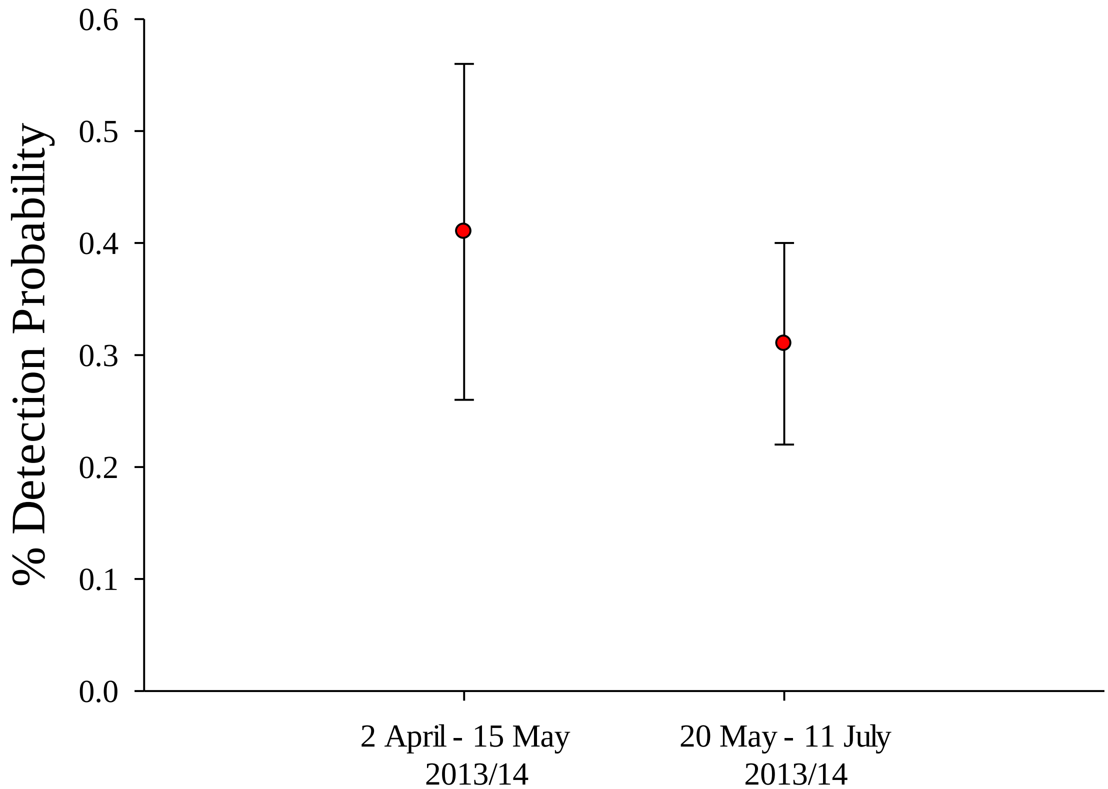

Figure 15. Percent detection probability of Pileated Woodpeckers for the early (2 April – 15 May) and late (20 May – 11 July) survey timeframes during the 2013-14 survey effort on Craig Mountain Wildlife Management Area in northern Idaho. Estimates are based on Program Distance. Error bars represent a 95% confidence interval.

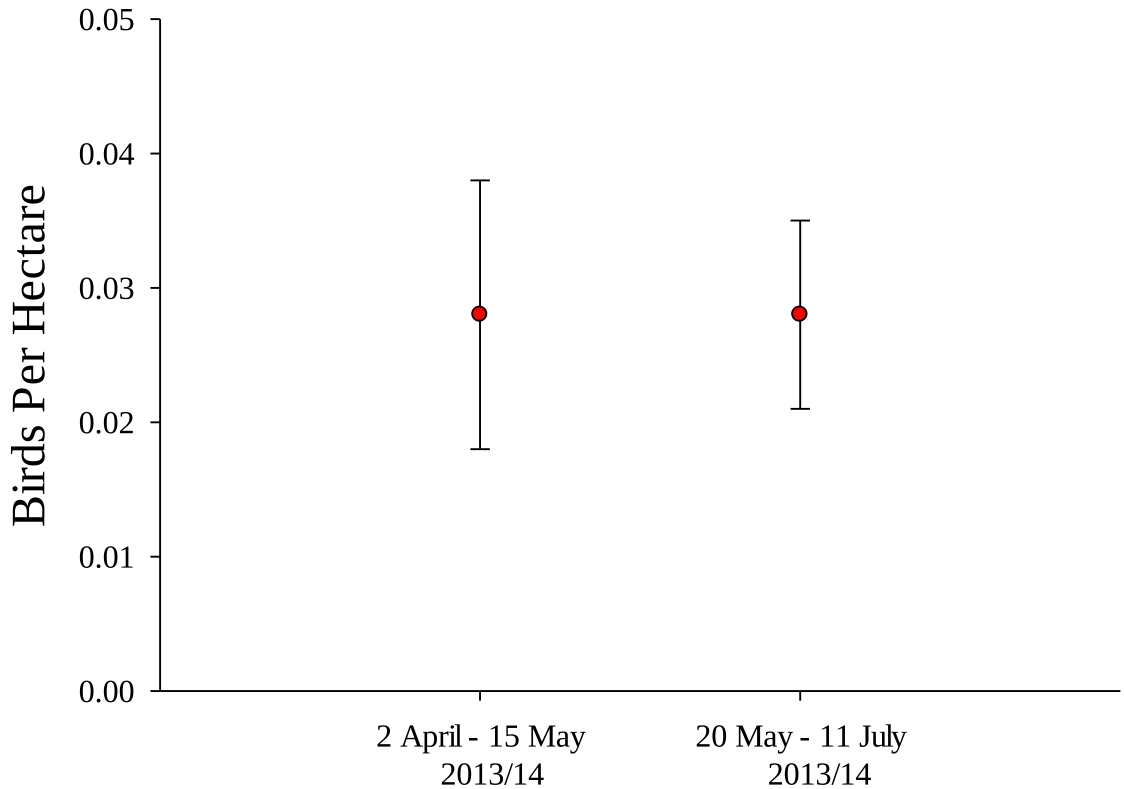

Figure 16. Pileated woodpecker density for the early (2 April – 15 May) and late (20 May – 11 July) survey timeframes during the 2013-14 survey effort at Craig Mountain Wildlife Management Area in northern Idaho. Estimates are from Program Distance after accounting for differences in detection probability. Error bars represent a 95% confidence interval.

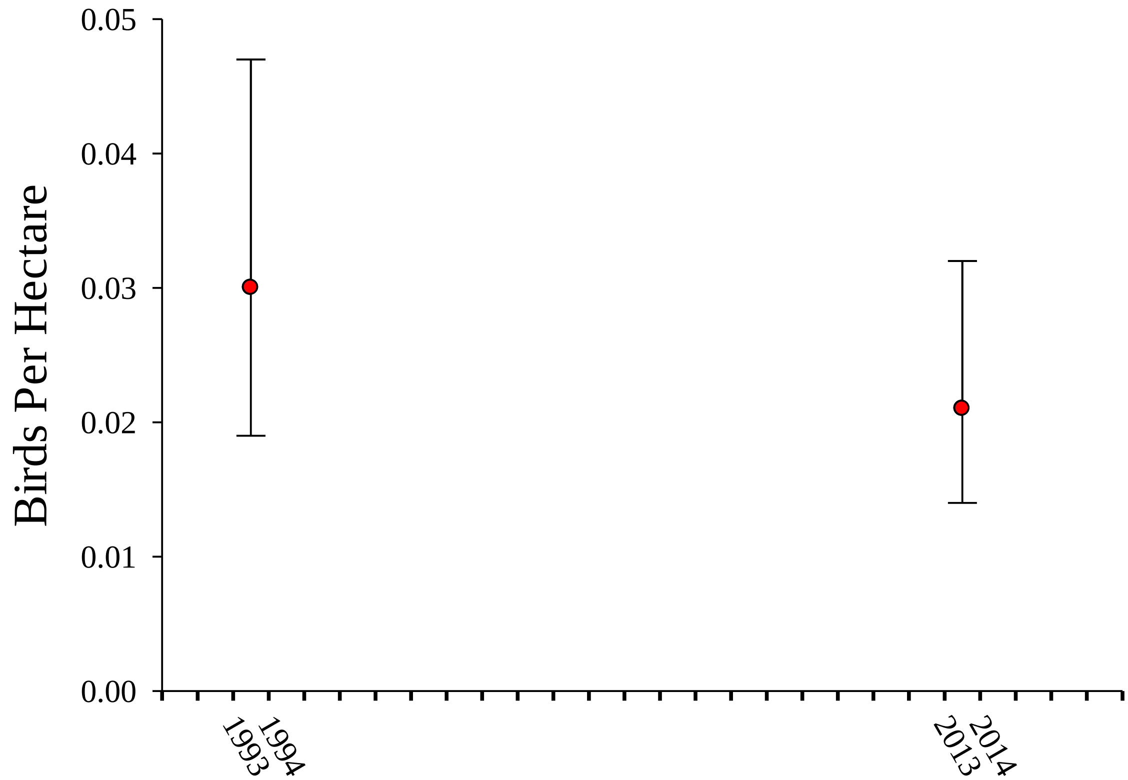

Figure 17. Density of Pileated Woodpeckers for 2 (1993-94 and 2013-14) time periods on Craig Mountain Wildlife Management Area in northern Idaho. Estimates are from Program Distance. Estimates for both survey periods are based on detections during 5-minute point-count surveys. Error bars represent a 95% confidence interval.

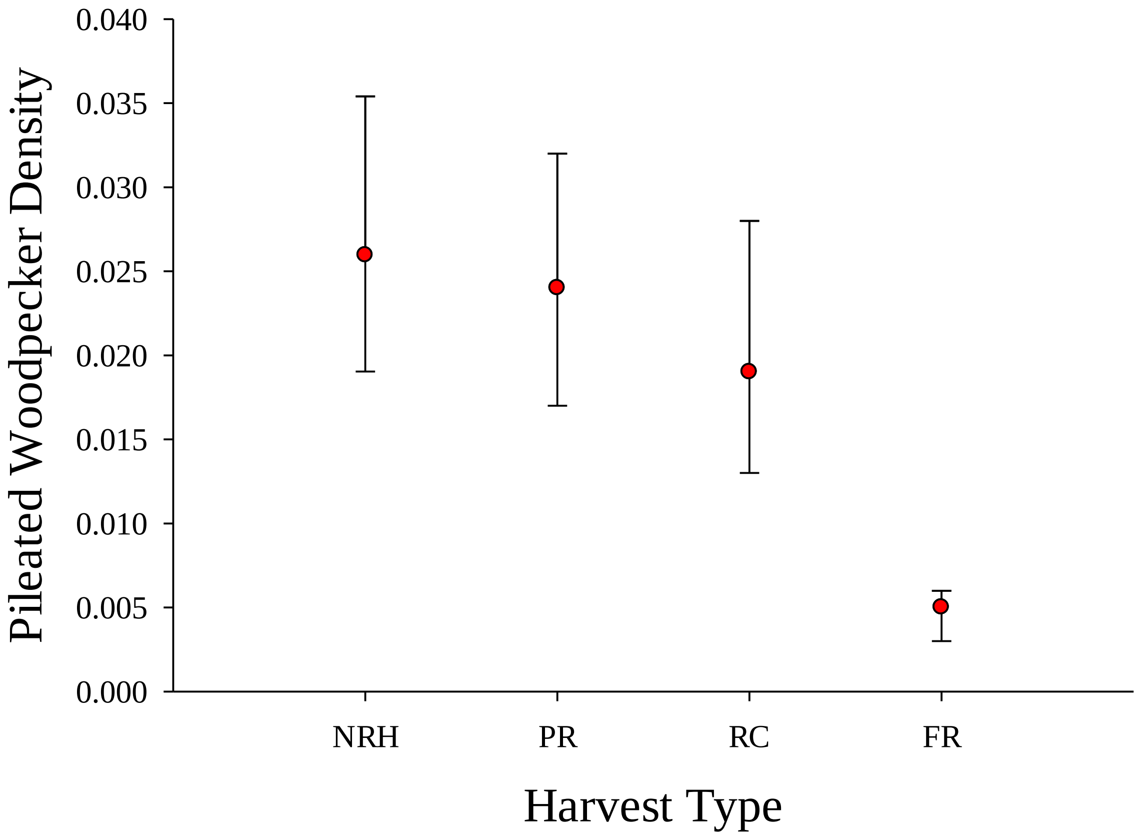

Figure 18. Density of Pileated Woodpeckers from the 2013-14 survey effort at survey points within 4 timber harvest categories on Craig Mountain Wildlife Management Area in northern Idaho. Estimates are from Program Distance. Estimates are based on detections during 10-minute point-count surveys in 2013-14 using the original 14 forested transects plus 2 transects established in 2014. NRH = Not Recently Harvested; PR = Partial Removal Cut; RC = Regeneration Cut; FR = Fuel Reduction Cut. Error bars represent a 95% confidence interval.

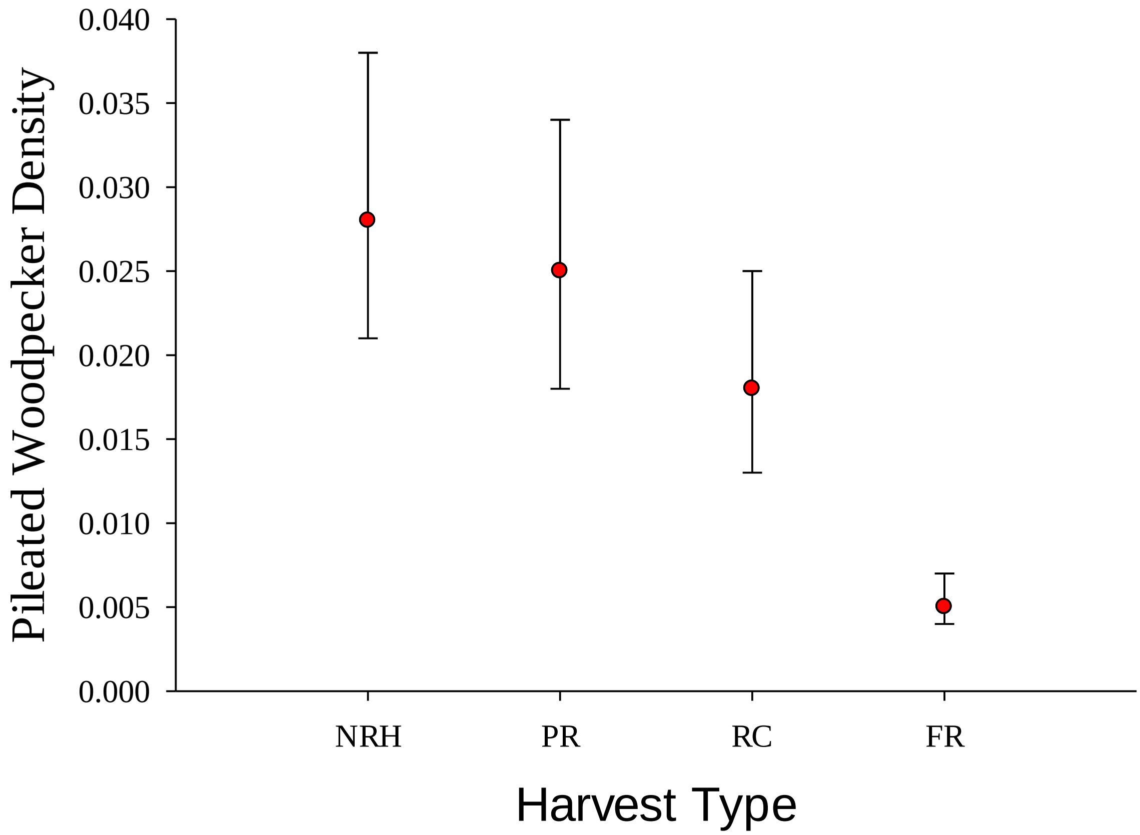

Figure 19. Density of Pileated Woodpeckers from the 2013-14 survey effort at survey points within 300 m (farthest truncation distance) of 4 timber harvest categories at Craig Mountain Wildlife Management Area in northern Idaho. Estimates are based on detections during 10-minute point-count surveys in 2013-14 using the original 14 forested transects plus 2 transects established in 2014. NRH = Not Recently Harvested; PR = Partial Removal Cut; RC = Regeneration Cut; FR = Fuel Reduction Cut. Error bars represent a 95% confidence interval.

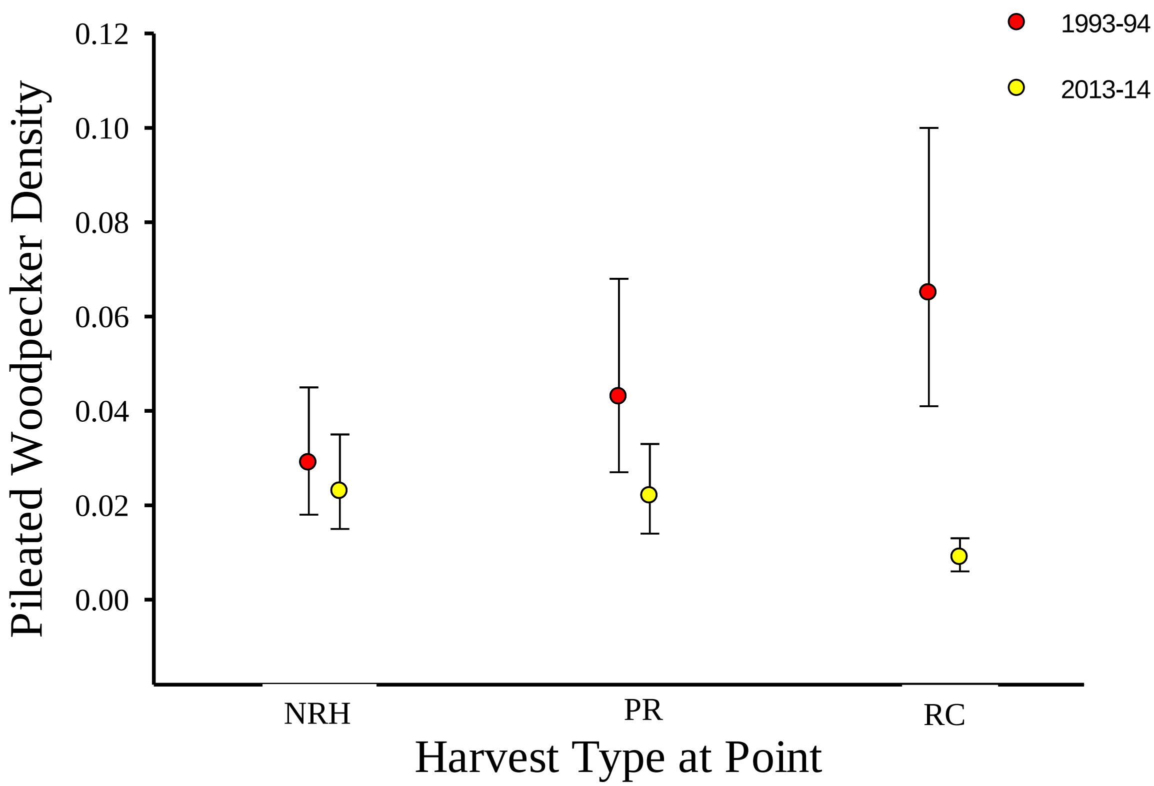

Figure 20. Density of Pileated Woodpeckers from 2 survey periods (1993-94 and 2013-14) among 3 timber harvest categories at forested survey points on Craig Mountain Wildlife Management Area in northern Idaho. Only survey points that were within the footprint (polygon) of a timber harvest were assigned to that harvest category. Estimates are from Program Distance. Estimates for both survey periods are based on detections during 5-minute point-count surveys using the original 134 forested points. The change in density between 1993-94 (red dots) and 2013-14 (yellow dots) reflect the effects of the 3 harvest categories on densities of Pileated Woodpeckers. We were unable to obtain a density estimate for Pileated Woodpeckers at points within fuel reduction cuts. Only 1 of the original 134 forested points fell within a fuel reduction cut. NRH = Not Recently Harvested; PR = Partial Removal Cut; RC = Regeneration Cut. Error bars represent a 95% confidence interval.

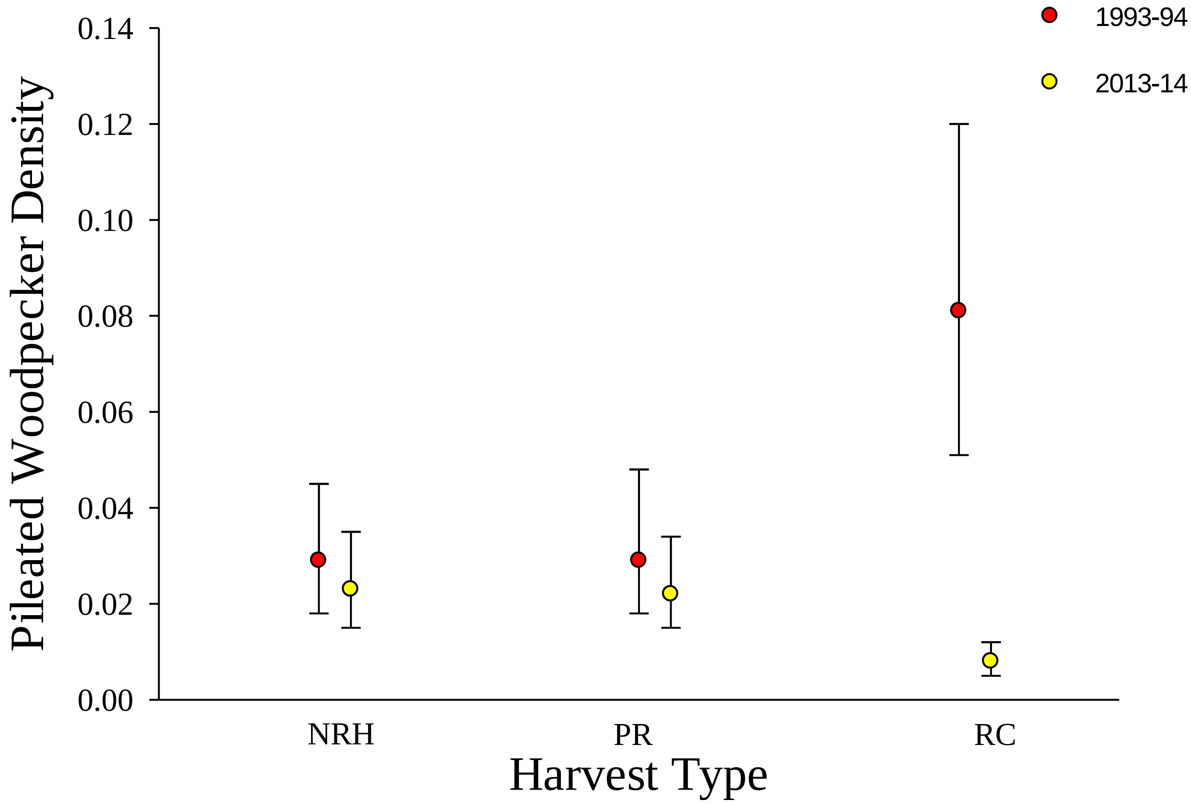

Figure 21. Density of Pileated Woodpeckers from 2 survey periods (1993-94 and 2013-14) among 3 timber harvest categories on Craig Mountain Wildlife Management Area in northern Idaho. Survey points within 300 m of a timber harvest were assigned to that harvest category. Estimates are from Program Distance. Estimates for both survey periods are based on detections during 5-minute point-count surveys using the original 14 forested transects. The change in density between 1993-94 (red dots) and 2013-14 (yellow dots) reflect the effects of the 3 harvest categories on densities of Pileated Woodpeckers. We were unable to obtain a density estimate for Pileated Woodpeckers at points within fuel reduction cuts. Only 1 of the original 134 forested points fell within 300 m of a fuel reduction cut. NRH = Not Recently Harvested; PR = Partial Removal Cut; RC = Regeneration Cut. Error bars represent a 95% confidence interval.

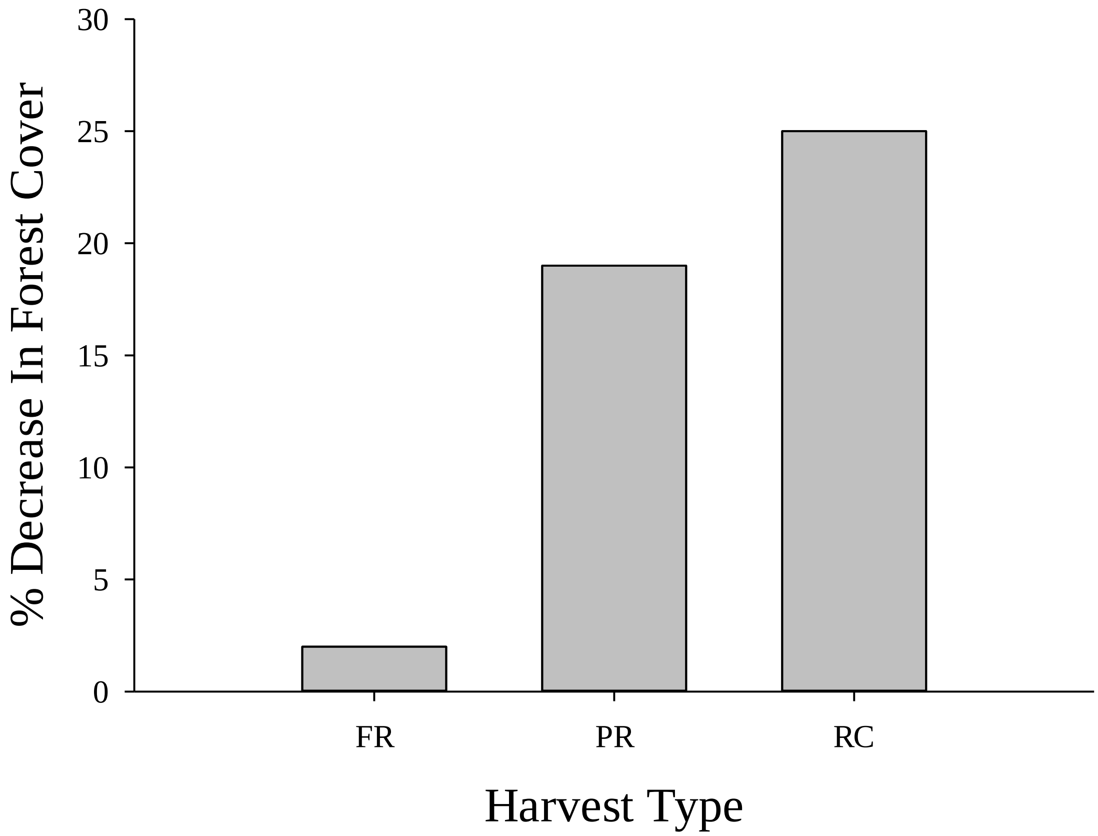

Figure 22. Percent decrease in forest cover between 2004 and 2013 at 23 timber harvests on Craig Mountain WMA in northern Idaho. Timber harvests were split into 3 harvest categories: FR = Fuel Reduction Cut (3 harvests); PR = Partial Removal Cut (18 harvests); RC = Regeneration Cut (2 harvests).

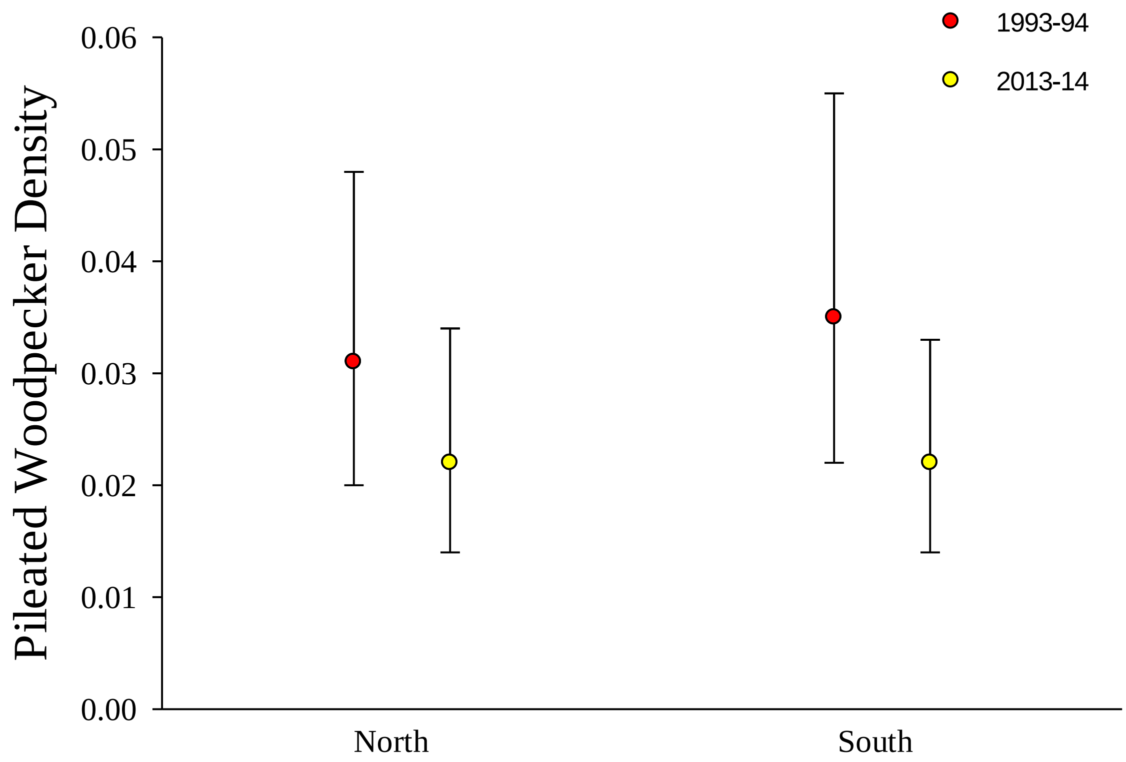

Figure 23. Density of Pileated Woodpeckers from 2 survey periods (1993-94 and 2013-14) at the North and South survey transects on Craig Mountain Wildlife Management Area in northern Idaho. Estimates are from Program Distance. Estimates for both survey periods are based on detections during 5-minute point-count surveys. Error bars represent a 95% confidence interval.

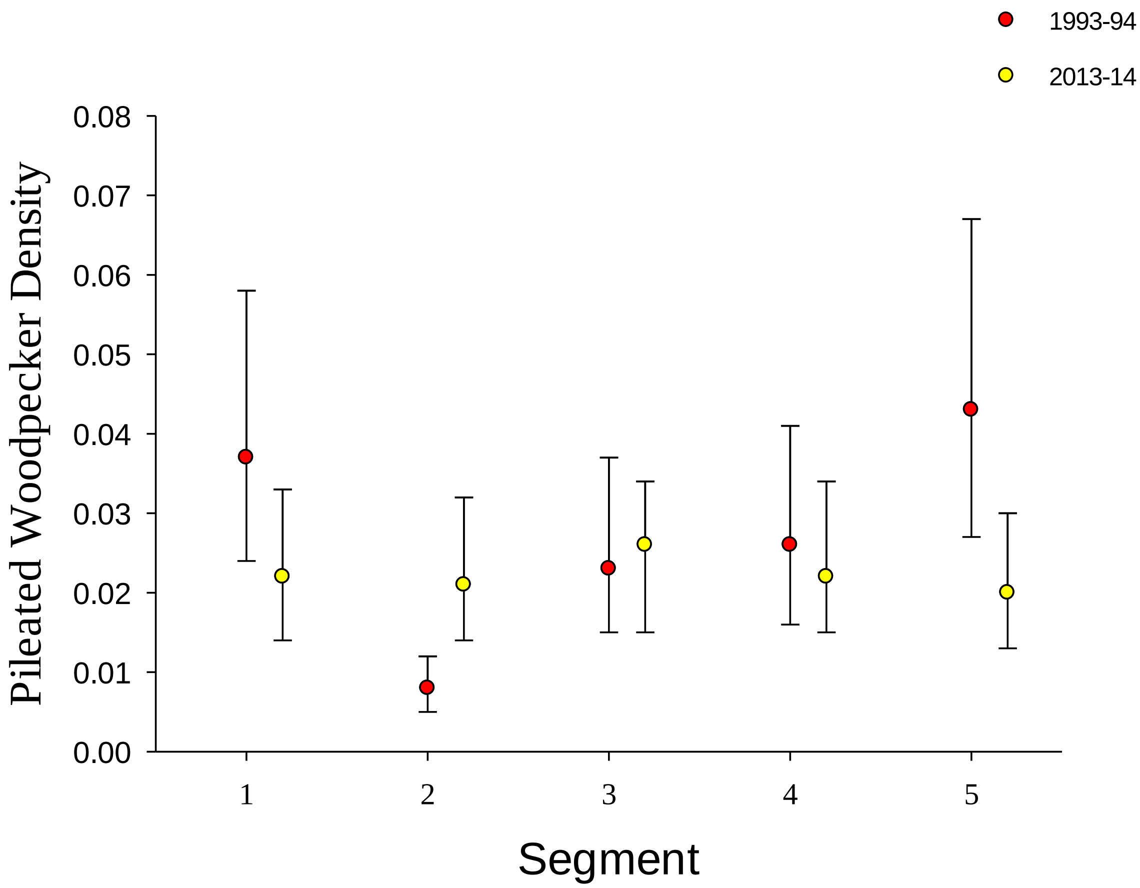

Figure 24. Density of Pileated Woodpeckers from 2 survey periods (1993-94 and 2013-14) at the 5 forested survey segments on Craig Mountain Wildlife Management Area in northern Idaho. Estimates are from Program Distance. Estimates for both survey periods are based on detections during 5-minute point-count surveys. Error bars represent a 95% confidence interval.

Tables

Table 1. Number of point-count surveys performed and number of bird detections for the 3 target bird species for each of 4 point-count survey efforts at Craig Mountain Wildlife Management Area in northern Idaho. Points were surveyed multiple times per year (range 1-10 visits) so number of detections does not reflect number of individuals.

Year	# of Surveys	# of Pileated Woodpeckers detected	# of Black-capped Chickadees detected	# of Yellow Warblers detected
1993-94	1,223	65	93	89
1997	492	11	31	60
2002	294	8	29	42
2013-14	3,275*	556*	154*	331*

*Includes double- and multiple-observer surveys.

Table 2. Percent of new Black-capped Chickadee detections during each 1-minute interval of 10-minute point-count surveys during the 2013-14 survey effort at Craig Mountain Wildlife Management Area in northern Idaho. Numbers include only those detections that were within 34 meters of the surveyor.

Survey minute	Number of new detections	% of detections
1	20	30.30
2	4	6.06
3	6	9.09
4	8	12.12
5	4	6.06
6	2	3.03
7	4	6.06
8	4	6.06
9	5	7.58
10	9	13.64
1-5	42	63.6
5-10	24	36.4

Table 3. Percent of new Yellow Warbler detections during each 1-minute interval of 10-minute point-count surveys during the 2013-14 survey effort at Craig Mountain Wildlife Management Area in northern Idaho. Numbers include only those detections that were within 35 meters of the surveyor.

Survey minute	Number of new detections	% of detections
1	45	28.30%
2	20	12.58%
3	18	11.32%
4	14	8.81%
5	17	10.69%
6	9	5.66%
7	14	8.81%
8	9	5.66%
9	6	3.77%
10	7	4.40%
1-5	114	71.70%
5-10	45	28.30%

Table 4. Percent of new Pileated Woodpeckers detections during each 1-minute interval of 10-minute point-count surveys during the 2013-14 survey effort at Craig Mountain Wildlife Management Area in northern Idaho. Numbers include only those detections that were within 188 meters of the surveyor.

Survey minute	Number of new detections	% of detections
1	73	29.7%
2	40	16.3%
3	23	9.3%
4	23	9.3%
5	15	6.1%
6	18	7.3%
7	12	4.9%
8	11	4.5%
9	11	4.5%
10	20	8.1%
1-5	174	70.7%
5-10	72	29.3%

Table 5. Comparison of 6 models intended to quantify the relationship between distance and number of Black-capped Chickadees detected (60 observations) during point-count surveys in 1993-94 at Craig Mountain Wildlife Management Area in northern Idaho. HnCo = half-normal key and cosine adjustment; HnHp = half-normal key and hermite polynomial adjustments; UnCo = uniform key and cosine adjustments; UnSp = uniform key and simple polynomial adjustments; HzSp = hazard-rate key and simple polynomial adjustments; HzCo = hazard-rate key and cosine adjustments; CV = coefficient of variation; D = density. We only used detections that were <80 m from the survey point (we truncated the data to remove the furthest 10% of the 60 detections; those furthest from the survey point).

Model	ΔAIC	χ^2 *p*-value	CV	D	95% confidence interval
HnCo	0.00	0.563	0.142	0.158	0.119, 0.209
HnHp	0.00	0.563	0.142	0.158	0.119, 0.209
UnCo	2.35	0.288	0.134	0.148	0.113, 0.193
UnSp	4.32	0.118	0.184	0.151	0.105, 0.218
HzSp	3.75	0.285	0.543	0.253	0.092, 0.701
HzCo	2.84	0.455	0.292	0.225	0.127, 0.398

Table 6. Comparison of 6 models intended to quantify the relationship between distance and number of Black-capped Chickadees detected (25 observations) during point-count surveys in 2002 at Craig Mountain Wildlife Management Area in northern Idaho. HnCo = half-normal key and cosine adjustment; HnHp = half-normal key and hermite polynomial adjustments; UnCo = uniform key and cosine adjustments; UnSp = uniform key and simple polynomial adjustments; HzSp = hazard-rate key and simple polynomial adjustments; HzCo = hazard-rate key and cosine adjustments; CV = coefficient of variation; D = density. We only used detections that were <70 m from the survey point (we truncated the data to remove the furthest 22% of the 25 detections; those furthest from the survey point).

Model	ΔAIC	χ^2 *p*-value	CV	D	95% confidence interval
HnCo	0.13	0.944	0.274	0.132	0.076, 0.222
HnHp	0.13	0.944	0.274	0.132	0.076, 0.222
UnCo	0.38	0.918	0.206	0.139	0.092, 0.211
UnSp	0.00	0.959	0.147	0.108	0.080, 0.146
HzSp	2.46	0.906	0.262	0.096	0.056, 0.163
HzCo	2.46	0.906	0.262	0.096	0.056, 0.163

Table 7. Comparison of 6 models intended to quantify the relationship between distance and number of Black-capped Chickadees detected (90 observations) during point-count surveys in 2013-14 at Craig Mountain Wildlife Management Area in northern Idaho. HnCo = half-normal key and cosine adjustment; HnHp = half-normal key and hermite polynomial adjustments; UnCo = uniform key and cosine adjustments; UnSp = uniform key and simple polynomial adjustments; HzSp = hazard-rate key and simple polynomial adjustments; HzCo = hazard-rate key and cosine adjustments; CV = coefficient of variation; D = density. We only used detections that were <8 m from the survey point (we truncated the data to remove the furthest 10% of the 90 detections; those furthest from the survey point).

Model	ΔAIC	χ^2 *p*-value	CV	D	95% confidence interval
HnCo	0.00	0.487	0.206	0.148	0.099, 0.223
HnHp	0.86	0.183	0.125	0.107	0.084, 0.137
UnCo	1.29	0.415	0.229	0.165	0.106, 0.259
UnSp	2.42	0.157	0.251	0.130	0.080, 0.212
HzSp	0.67	0.917	0.712	0.233	0.065, 0.832
HzCo	1.25	0.433	0.251	0.170	0.104, 0.278

Table 8. Comparison of 6 models intended to quantify the relationship between distance and number of Yellow Warblers detected (72 observations) during point-count surveys in 1993-94 at Craig Mountain Wildlife Management Area in northern Idaho. HnCo = half-normal key and cosine adjustment; HnHp = half-normal key and hermite polynomial adjustments; UnCo = uniform key and cosine adjustments; UnSp = uniform key and simple polynomial adjustments; HzSp = hazard-rate key and simple polynomial adjustments; HzCo = hazard-rate key and cosine adjustments; CV = coefficient of variation; D = density. We only used detections that were <40 m from the survey point (we truncated the data to remove the furthest 10% of the 72 detections; those furthest from the survey point).

Model	ΔAIC	χ^2 *p*-value	CV	D	95% confidence interval
HnCo	1.33	0.590	0.175	0.440	0.311, 0.622
HnHp	1.33	0.590	0.175	0.440	0.311, 0.622
UnCo	2.49	0.390	0.159	0.474	0.345, 0.649
UnSp	0.00	0.863	0.084	0.351	0.297, 0.415
HzSp	2.39	0.575	0.188	0.368	0.254, 0.535
HzCo	2.39	0.575	0.188	0.368	0.254, 0.535

Table 9. Comparison of 6 models intended to quantify the relationship between distance and number of Yellow Warblers detected (32 observations) during point-count surveys in 2002 at Craig Mountain Wildlife Management Area in northern Idaho. HnCo = half-normal key and cosine adjustment; HnHp = half-normal key and hermite polynomial adjustments; UnCo = uniform key and cosine adjustments; UnSp = uniform key and simple polynomial adjustments; HzSp = hazard-rate key and simple polynomial adjustments; HzCo = hazard-rate key and cosine adjustments; CV = coefficient of variation; D = density. We only used detections that were <48 m from the survey point (we truncated the data to remove the furthest 10% of the 32 detections; those furthest from the survey point).

Model	ΔAIC	χ^2 *p*-value	CV	D	95% confidence interval
HnCo	0.05	0.970	0.277	0.498	0.287, 0.866
HnHp	0.05	0.970	0.277	0.498	0.287, 0.866
UnCo	0.17	0.913	0.259	0.532	0.317, 0.893
UnSp	0.00	0.994	0.209	0.466	0.306, 0.709
HzSp	2.27	0.999	0.323	0.433	0.228, 0.823
HzCo	2.27	0.999	0.323	0.433	0.228, 0.823

Table 10. Comparison of 6 models intended to quantify the relationship between distance and number of Yellow Warblers detected (202 observations) during point-count surveys in 2013-14 at Craig Mountain Wildlife Management Area in northern Idaho. HnCo = half-normal key and cosine adjustment; HnHp = half-normal key and hermite polynomial adjustments; UnCo = uniform key and cosine adjustments; UnSp = uniform key and simple polynomial adjustments; HzSp = hazard-rate key and simple polynomial adjustments; HzCo = hazard-rate key and cosine adjustments; CV = coefficient of variation; D = density. We only used detections that were <75 m from the survey point (we truncated the data to remove the furthest 10% of the 202 detections; those furthest from the survey point).

Model	ΔAIC	χ^2 *p*-value	CV	D	95% confidence interval
HnCo	0.00	0.573	0.087	0.634	0.534, 0.753
HnHp	0.00	0.573	0.087	0.634	0.534, 0.753
UnCo	1.99	0.398	0.105	0.619	0.503, 0.761
UnSp	4.00	0.225	0.162	0.616	0.449, 0.846
HzSp	4.59	0.142	0.158	0.548	0.402, 0.747
HzCo	3.69	0.288	0.201	0.678	0.485, 1.005

Table 11. Comparison of 6 models intended to quantify the relationship between distance and number of Pileated Woodpeckers detected (58 observations) during point-count surveys in 1993-94 at Craig Mountain Wildlife Management Area in northern Idaho. HnCo = half-normal key and cosine adjustment; HnHp = half-normal key and hermite polynomial adjustments; UnCo = uniform key and cosine adjustments; UnSp = uniform key and simple polynomial adjustments; HzSp = hazard-rate key and simple polynomial adjustments; HzCo = hazard-rate key and cosine adjustments; CV = coefficient of variation; D = density. We only used detections that were <210 m from the survey point (we truncated the data to remove the furthest 10% of the 58 detections; those furthest from the survey point).

Model	ΔAIC	χ^2 *p*-value	CV	D	95% confidence interval
HnCo	0.00	0.532	0.155	0.033	0.024, 0.044
HnHp	0.00	0.532	0.155	0.033	0.024, 0.044
UnCo	1.33	0.289	0.081	0.027	0.023, 0.031
UnSp	3.33	0.233	0.233	0.029	0.019, 0.047
HzSp	1.00	0.577	0.228	0.030	0.019, 0.047
HzCo	1.00	0.577	0.228	0.030	0.019, 0.047

Table 12. Comparison of 6 models intended to quantify the relationship between distance and number of Pileated Woodpeckers detected (10 observations) during point-count surveys in 1997 at Craig Mountain Wildlife Management Area in northern Idaho. HnCo = half-normal key and cosine adjustment; HnHp = half-normal key and hermite polynomial adjustments; UnCo = uniform key and cosine adjustments; UnSp = uniform key and simple polynomial adjustments; HzSp = hazard-rate key and simple polynomial adjustments; HzCo = hazard-rate key and cosine adjustments; CV = coefficient of variation; D = density. We only used detections that were <200 m from the survey point (we truncated the data to remove the furthest 10% of the 10 detections; those furthest from the survey point). HzSp, HzCo and HnCo had to many parameters to estimate the χ^2 *p*-value.

Model	ΔAIC	χ^2 *p*-value	CV	D	95% confidence interval
HnCo	0.00	0.639	0.378	0.020	0.009, 0.045
HnHp	0.00	0.639	0.378	0.020	0.009, 0.045
UnCo	1.19	0.250	0.261	0.012	0.007, 0.021
UnSp	0.74	0.303	0.248	0.013	0.008, 0.023
HzSp	1.78	N/A	0.603	0.021	0.006, 0.077
HzCo	1.78	N/A	0.603	0.021	0.006, 0.077

Table 13. Comparison of 6 models intended to quantify the relationship between distance and number of Pileated Woodpeckers detected (8 observations) during point-count surveys in 2002 at Craig Mountain Wildlife Management Area in northern Idaho. HnCo = half-normal key and cosine adjustment; HnHp = half-normal key and hermite polynomial adjustments; UnCo = uniform key and cosine adjustments; UnSp = uniform key and simple polynomial adjustments; HzSp = hazard-rate key and simple polynomial adjustments; HzCo = hazard-rate key and cosine adjustments; CV = coefficient of variation; D = density. We only used detections that were <200 m from the survey point (we truncated the data to remove the furthest 10% of the 8 detections; those furthest from the survey point). HzSp, HzCo and HnCo had to many parameters to estimate the χ^2 *p*-value.

Model	ΔAIC	χ^2 *p*-value	CV	D	95% confidence interval
HnCo	3.82	N/A	2.142	0.041	0.002, 1.010
HnHp	1.82	0.970	0.620	0.039	0.010, 0.149
UnCo	0.00	0.688	0.042	0.029	0.027, 0.032
UnSp	0.00	0.688	0.042	0.029	0.027, 0.032
HzSp	3.82	N/A	2.142	0.041	0.002, 1.010
HzCo	3.82	N/A	2.142	0.041	0.002, 1.010

Table 14. Comparison of 6 models intended to quantify the relationship between distance and number of Pileated Woodpeckers detected (431 observations) during point-count surveys in 2013-14 (10-minute surveys) at Craig Mountain Wildlife Management Area in northern Idaho. HnCo = half-normal key and cosine adjustment; HnHp = half-normal key and hermite polynomial adjustments; UnCo = uniform key and cosine adjustments; UnSp = uniform key and simple polynomial adjustments; HzSp = hazard-rate key and simple polynomial adjustments; HzCo = hazard-rate key and cosine adjustments; CV = coefficient of variation; D = density. We only used detections that were <300 m from the survey point (we truncated the data to remove the furthest 10% of the 431 detections; those furthest from the survey point).

Model	ΔAIC	χ^2 *p*-value	CV	D	95% confidence interval
HnCo	0.44	0.772	0.136	0.028	0.022, 0.037
HnHp	2.16	0.664	0.153	0.027	0.020, 0.036
UnCo	0.35	0.794	0.106	0.026	0.021, 0.031
UnSp	2.41	0.589	0.124	0.026	0.020, 0.033
HzSp	0.00	0.874	0.169	0.026	0.019, 0.036
HzCo	0.00	0.874	0.169	0.026	0.019, 0.036

Table 15. Canopy cover, canopy height, number of medium size trees (10-40cm dbh), and number of large trees (>40cm dbh) within areas on CMWMA that received 1 of 4 types of timber harvest prescriptions during the past 20 years: fuel reduction cut, partial removal cut, regeneration cut, or no harvest. FR = Fuels Reduction Cut; PR = Partial Removal Cut; RC = Regeneration Cut; NRH = Not Recently Harvested. The sample size represents the number of point-count surveys within that harvest type where we sampled vegetation.

Harvest Type	Sample Size	% Canopy Cover (within 30m)				Canopy Height (within 30m)				# Medium Trees (10-40cm dbh) (within 15m)				# Large Trees (>40cm dbh) (within 15m)			
		$\bar{x}$	Min.	Max.	SE	$\bar{x}$	Min.	Max.	SE	$\bar{x}$	Min.	Max.	SE	$\bar{x}$	Min.	Max.	SE
FR	5	15.6	0	30	6.0	14.0	0	30	4.8	5.0	1	7	0.6	0.4	0	1	0.3
PR	25	26.7	2	85	4.8	22.0	15	35	1.3	8.2	0	25	0.1	0.8	0	4	0.3
RC	10	10.4	0	30	4.1	17.5	0	30	3.4	3.0	0	8	0.9	0.1	0	1	0.1
NRH	110	26.5	0	85	1.9	23.5	0	40	0.8	9.3	0	44	0.8	0.8	0	9	0.2

Table 16. Number of medium snags (21-50cm dbh), number of large snags (>50cm dbh), number of downed logs (>18cm dia.), and number of stumps (>30.5cm and >18 cm dbh) within 30m of points within areas on CMWMA that received 1 of 4 types of timber harvest prescriptions during the past 20 years: fuel reduction cut, partial removal cut, regeneration cut, or no harvest. FR = Fuels Reduction Cut; PR = Partial Removal Cut; RC = Regeneration Cut; NRH = Not Recently Harvested. The sample size represents the number of point-count surveys within that harvest type where we sampled vegetation.

Harvest Type	Sample Size	# Medium Snags (21 to 50cm dbh)				# Large Snags (>50cm dbh)				# Downed Logs (>18cm dia.)				# Stumps (>30.5cm height and > 18cm dbh)			
		$\bar{x}$	Min.	Max.	SE	$\bar{x}$	Min.	Max.	SE	$\bar{x}$	Min.	Max.	SE	$\bar{x}$	Min.	Max.	SE
FR	5	1.8	0	5	0.4	0	0	0	0	19.4	3	38	6.6	6.4	3	13	1.8
PR	25	1.6	0	25	1.0	0.1	0	2	0.9	17.0	0	120	4.7	10.8	0	30	1.8
RC	10	0.3	0	2	0.2	0	0	0	0	10.8	5	20	1.5	17.6	0	48	4.9
NRH	110	1.2	0	10	0.2	0.2	0	8	0.8	13.3	0	57	0.9	8.7	0	33	0.6

Table 17. Comparison of 6 models intended to quantify the relationship between distance and number of Pileated Woodpeckers detected (297 observations) during point-count surveys in 2013-14 (5-minute surveys) at Craig Mountain Wildlife Management Area in northern Idaho. HnCo = half-normal key and cosine adjustment; HnHp = half-normal key and hermite polynomial adjustments; UnCo = uniform key and cosine adjustments; UnSp = uniform key and simple polynomial adjustments; HzSp = hazard-rate key and simple polynomial adjustments; HzCo = hazard-rate key and cosine adjustments; CV = coefficient of variation; D = density. We only used detections that were <300 m from the survey point (we truncated the data to remove the furthest 10% of the 297 detections; those furthest from the survey point).

Model	ΔAIC	χ^2 *p*-value	CV	D	95% confidence interval
HnCo	0.04	0.860	0.146	0.024	0.018, 0.032
HnHp	2.02	0.693	0.168	0.024	0.017, 0.033
UnCo	1.56	0.517	0.113	0.020	0.016, 0.025
UnSp	2.47	0.554	0.127	0.022	0.017, 0.028
HzSp	0.00	0.870	0.217	0.022	0.014, 0.034
HzCo	0.00	0.870	0.217	0.022	0.014, 0.034

Table 18. Distribution of Pileated Woodpecker detection distances (meters) by harvest type at Craig Mountain Wildlife Management Area in northern Idaho. FR = fuel reduction cut; PR = partial removal cut; RC = regeneration cut; NRH = not recently harvested. Includes original forested transects (14) plus 2 transects established in 2014.

Harvest Type	# Points within Harvest Type	# Surveys within Harvest Type	Pileated Woodpecker Detections	Min. Distance	Max. Distance	Mean Distance
FR	5	19	1	120	120	120
PR	25	267	76	10	500	184
RC	10	75	22	70	600	251
NRH	110	1,188	381	15	800	185

Appendix 1

Craig Mountain Wildlife Management Area Bird Survey Form

Page	of

Craig Mountain Bird Survey Form

Observer	Date	Site	Visit #

Wind (0-5)	**Sky** (0-6)	**Stream Noise** (0-4)	**Temperature** (C)	**Start Time**

Species	**#** (when>5)	**Type** (A,V,B)	**Activity** (C,S,D,P,Y,Z,F,N)	**Distance** (flyover=999)	**Minute** (detected)

Comments (PIWO activities, before/after sighting, precipitation, etc…)

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Appendix 2

A list of surveyors (by initial), year surveyor conducted surveys, number of point-count surveys completed, and number of detections made by surveyors on Craig Mountain Wildlife Management Area in northern Idaho. Point-count surveys were completed on Craig Mountain Wildlife Management Area during 4 survey periods (1993-94, 1997, 2002, and 2013-14).

Surveyor	Year	# of point-count surveys	# of detections
C. Bradford	1993	129	513
S. Ritter	1993	479	2,254
D. Gomez	1994	205	1,047
K. Singer	1994	20	133
R. Olson	1994	60	157
F. Cassirer	1993-94	330	1,491
J. Karl	1997	271	2,352
M. Minik	1997	221	2,279
A. Duff	2002	294	2,278
A. Lankford	2013	199	2,533
L. Snoddy	2013	491	4,506
T. Schrempp	2013	7	75
Z. Swearingen	2013	169	2,000
A. Vincent	2014	220	2,416
A. Winkler	2014	193	2,162
M. Sluk	2014	616	6,158
J. Runco	2013-14	1050	12,422

Appendix 3

Number of detections for each bird species during point-count surveys on Craig Mountain Wildlife Management Area in northern Idaho during 2013 and 2014. Does not include multiple observer surveys.

Species	# of detections	Species	# of detections
American Robin	2337	Vesper Sparrow	244
Dark-eyed Junco	1705	Dusky Flycatcher	243
Mountain Chickadee	1545	Wild Turkey	241
Red-breasted Nuthatch	1431	Red-naped Sapsucker	223
Yellow-rumped Warbler	1316	Cedar Waxwing	188
Chipping Sparrow	1029	Canyon Wren	185
Northern Flicker	1013	House Wren	164
Lazuli Bunting	937	Mountain Bluebird	160
Western Tanager	897	Violet-green Swallow	155
Common Raven	814	Chestnut-backed Chickadee	154
Golden-crowned Kinglet	683	Gray Jay	154
Orange-Crowned Warbler	649	Black-capped Chickadee	135
Ruby-crowned kinglet	649	American Goldfinch	128
Spotted Towhee	581	Pacific Wren	127
Ruffed Grouse	546	Black-billed Magpie	125
MacGillivray's Warbler	539	Lesser Goldfinch	121
Pileated Woodpecker	513	Warbling Vireo	112
Song Sparrow	501	Pine Siskin	111
Swainson's Thrush	498	American Kestrel	104
Western Meadowlark	479	Brown-headed Cowbird	99
Townsend's Warbler	440	Western Kingbird	97
Yellow-breasted Chat	426	Nashville Warbler	89
Hermit Thrush	413	Black-headed Grosbeak	83
Hammond's Flycatcher	388	Western Bluebird	82
Chukar	357	Red-eyed Vireo	78
Cassin's Finch	350	Red-tailed Hawk	73
American Crow	343	Downy Woodpecker	70
Steller's Jay	307	Say's Phoebe	62
Western Wood-pewee	306	Red Crossbill	61
Yellow Warbler	300	Bewick's Wren	58
Cassin's Vireo	276	Bullock's Oriole	58
Rock Wren	262	Brown Creeper	55
Hairy Woodpecker	247	Vaux's Swift	48

Species	# of detections	Species	# of detections
Veery	46	Barred Owl	7
Townsend's Solitaire	45	Black-chinned Hummingbird	7
Canada Goose	43	Mountain Quail	6
Tree Swallow	41	Rock Pigeon	6
Mourning Dove	39	White-throated Swift	6
Cordilleran Flycatcher	38	Belted Kingfisher	5
Wilson's Snipe	36	Red-Winged Blackbird	5
Olive-sided Flycatcher	35	Lincoln's Sparrow	5
Lewis's Woodpecker	30	White-crowned Sparrow	5
Williamson's Sapsucker	28	Eurasian Collared-Dove	4
Varied Thrush	26	Golden Eagle	4
Common Nighthawk	24	Lark Sparrow	4
Northern Pygmy-Owl	23	Cliff Swallow	3
European Starling	18	Fox Sparrow	3
Spotted Sandpiper	18	Three-toed Woodpecker	3
Great Gray Owl	16	Western Flycatcher	3
California Quail	14	White-breasted Nuthatch	3
Clark's Nutcracker	14	Brewer's Blackbird	2
Dusky Grouse	14	Northern Rough-winged Swallow	2
House Finch	14	Ring-necked Pheasant	2
Mallard	13	Eastern Kingbird	2
Rufous Hummingbird	13	Flammulated Owl	2
Northern Goshawk	12	Gray Catbird	2
Willow Flycatcher	11	Horned Lark	2
Northern Harrier	10	Killdeer	2
Sharp-shinned Hawk	10	Barn Swallow	1
Evening Grosbeak	10	Clay-colored Sparrow	1
Gray Partridge	10	Common Poorwill	1
Great Horned Owl	10	Osprey	1
Wilson's Warbler	10	Pine Grosbeak	1
Calliope Hummingbird	9	Snow Goose	1
Cooper's Hawk	9	Long-eared Owl	1
Common Merganser	8	Turkey Vulture	1

Appendix 4

Craig Mountain Wildlife Management Area Vegetation Survey Sheets

Craig Mountain Vegetation Data

Observer ____________________ Date ____________
Site# ____________________ Craig Mt. Veg Type ____________

Cover Type [ ] Edge 1 [ ] Edge 2 [ ]

No. Saplings w/in 15m (5-10)cm.. [ ]

No. Medium trees w/in 15m (10-40 cm)... [ ]

No. Large trees w/in 15m (>40cm)... [ ]

Average canopy height (w/in 30m to nearest 5m)..(Everything Larger Than Sapling).... [ ]

Canopy coverage (w/in 30m, nearest 5%)......(Everything Larger Than Sapling)
Spp. &% ____________ [ ]
Seedling coverage (w/in 30m to nearest 5%)......(< 5 cm dbh)
Spp. & % ____________ [ ]
Sapling coverage (w/in 30m, to nearest 5%)........(5-10 cm dbh)
Spp. &% ____________ [ ]
Shrub coverage (w/in 30m to nearest 5%)........(> 1 m tall)
Spp. &% ____________ [ ]
Average shrub height (m) ____________ [ ]
Brush coverage (w/in 30m to nearest 5%).... (< 1 m tall)
Spp. &% ____________ [ ]
Forb coverage (w/in 30m, to nearest 5%)
Spp. &% ____________ [ ]
Grass coverage (w/in 30m, to nearest 5%)
Spp. &% ____________ [ ]
Grass and Forb coverage (w/in 30m to nearest 5%) ____________ [ ]
Noxious weed coverage (w/in 30m, to nearest 5%)
Spp. &% ____________ [ ]

No. snags (10-20 cm dbh) w/in 30M ____________ [ ]
No. snags (21-50 cm dbh) w/in 30M ____________ [ ]
No. snags (> 50 cm dbh) w/in 30M ____________ [ ]
Mean dbh of snags > 50 cm w/in 30m ____________ [ ]

No. downed logs > 18 cm (7 in.) dia. w/in 30m ____________ [ ]
No. stumps > 30.5 cm (1 ft.) high and > 18 cm (7 in.) dia. ____________ [ ]

Road w/in 100m? (0 = no, 1 = Yes) ____________ [ ]

Riparian w/in 100m? (0 = no, 1 = Yes) ____________ [ ]

Rock outcrop w/in 100m? (0 = no, 1 = Yes) [ ]

Photo Points

North	°Degrees	Photo #
East	°Degrees	Photo #
South	°Degrees	Photo #
West	°Degrees	Photo #

Craig Mountain Canopy/Woody Debris Survey

Observer ____________________ **Date** __________________________

Site# ________________________________

Densiometer Readings

North ____________________

East ____________________

South ____________________

West ____________________

Downed Logs (w/in 15m radius)

		% Bark			
Length	Diameter	0 - 25%	25 - 50%	50 - 75%	75 - 100%
< 4m	<25 cm				
< 4m	25-50 cm				
< 4m	>50 cm				
4-12m	<25 cm				
4-12m	25-50 cm				
4-12m	>50 cm				
>12m	<25 cm				
>12m	25-50 cm				
>12m	>50 cm				

Dominant Spp. Of Downed Logs (w/in 15m radius): __________________________

Stumps (lower than bh w/in 15m radius)

		% Bark			
Hieght	Diameter	0 - 25%	25 - 50%	50 - 75%	75 - 100%
< 30.5cm	<25 cm				
< 30.5cm	25-50 cm				
< 30.5cm	>50 cm				
30.5-80cm	<25 cm				
30.5-80cm	25-50 cm				
30.5-80cm	>50 cm				
>80cm	<25 cm				
>80cm	25-50 cm				
>80cm	>50 cm				

Dominant Spp. Of Stumps (lower than bh w/in 15m): __________________________

Fire Severity (w/in 15m radius): __________________________

Notes: ____

Fire Severity

0. No evidence of recent fire

1. Evidence of low-severity surface fire (e.g., fire-charring roughly 0–0.3m above ground on a few trees)

2. Evidence of moderate-severity surface fire (e.g., fire-charring roughly 0.3–1.5 m above ground on most trees; a few small pines or shrubs killed in understory)

3. Evidence of severe surface fire (e.g., fire-charring often. 1.5 m above ground on trees; almost all understory shrubs or pines killed [some shrubs re-sprouting]; a few large trees killed [burned snags or fallen trunks])

4. Evidence of severe crown fire (e.g., all above-ground vegetation killed with some re-growth from roots and/or seeds)