Density and Abundance of Black-Backed Woodpeckers in a Ponderosa Pine Ecosystem

SEAN R. MOHREN[1], MARK A. RUMBLE[2], AND STANLEY H. ANDERSON[3]

Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, Wyoming 82071, USA (SRM, SHA)
U.S. Forest Service, Rocky Mountain Research Station, 8221 S. Highway 16, Rapid City, South Dakota 57702, USA (MAR)

ABSTRACT Black-backed woodpeckers (*Picoides arcticus*) are usually associated with forest disturbance resulting in recently killed trees. While black-backed woodpeckers are attracted to areas affected by these disturbances, in the Black Hills they exist during interim disturbance periods in largely undisturbed forests. In 2012, a petition for listing black-backed woodpeckers in the Black Hills as a distinct population segment identified current population size and the population size necessary to minimize risk of extinction as key components of the decision process. Our objective was to estimate the population size of black-backed woodpeckers in the Black Hills National Forest of South Dakota and Wyoming during a period of relatively low disturbance (e.g., 2000–2001). The estimated population was 641 (95% CI = 405–990) and 456 (95% CI = 293–705) breeding pairs in 2000 and 2001, respectively. The average density of 0.12/km^2 (95% CI = 0.07–0.18) was similar to densities in other undisturbed forests. This population estimate provides a starting point for population viability analyses during periods of relatively low disturbance by fire or insects.

KEY WORDS Black-backed woodpeckers, Black Hills, density, *Picoides arcticus*, population, South Dakota

Black-backed woodpeckers (*Picoides arcticus*) are uncommon to rare across their range. Region 2 of the U.S. Forest Service lists the black-backed woodpecker as a sensitive species and it is a management indicator species for the Black Hills National Forest (BHNF). They are a species of greatest conservation concern in the Black Hills ecoregion (South Dakota Department of Game, Fish and Parks 2005) and have been petitioned for protection as a distinct population segment under the Endangered Species Act (Hanson et al. 2012).

Black-backed woodpecker populations are irruptive following forest disturbance and are dependent on fire or woodboring beetle outbreaks that provide increased foraging opportunities (Hutto 1995, Dixon and Saab 2000). Dramatic increases in densities and abundance for this species can occur following large wildfires or outbreaks of woodboring (Family: *Buprestidae* and *Cerambycidae*) or bark beetles (Family: *Curculionidae* and *Scolytinae*; Blackford 1955, Bock and Lynch 1970, Taylor and Barmore 1980, Apfelbaum and Haney 1981, Murphy and Lehnhausen 1998) which may result in movements from adjacent undisturbed forests (Murphy and Lehnhausen 1998). However, the benefits obtained from recently killed forests due to wildfires occur only for short periods of time (Bock and Lynch 1970, Harris 1982, Murphy and Lehnhausen 1998, Rota et al. 2014*a*). The relation between black-backed woodpeckers and disturbance events has led many researchers to examine this species in disturbed areas. In the Black Hills, extensive areas of recently disturbed forests are not continually available and the extensive gap between the Black Hills and other forested areas essentially serve as a barrier to this population of black-backed woodpeckers (Pierson et al. 2010). Consequently, black-backed woodpeckers must rely on forests that often are undisturbed and little information exits about this species in undisturbed forests. In undisturbed forests, black-backed woodpeckers are uncommon (Hutto 1995, Dykstra et al. 1997, Rumble et al. 1999) and are associated with old stands and dead wood in the early stages of decay (Setterington et al. 2000, Tremblay et al. 2009).

We initiated this study following identification of black-backed woodpeckers as a management indicator species in the revised BHNF plan (BHNF 1996). At that time, little was known regarding habitat and population size and the U.S. Forest Service needed information from which they could monitor the status of this management indicator species. More recently, the petition for protection of the Black Hills black-backed woodpecker population as a distinct population segment (Hanson et al. 2012) identified population size and the population threshold necessary for long term viability as key components of the listing decision. Although our study occurred before the proposed listing, it was designed to estimate the black-backed woodpecker population in the Black Hills during a time period when significant forest disturbance was absent. Our objective for this study was to provide a population estimate for black-backed woodpeckers in the Black Hills and associated Bear Lodge Mountains of South Dakota and Wyoming. We evaluated competing hypotheses regarding the shape of detectability function and intervals for grouped distance estimates for estimating the population size.

STUDY AREA

Our study area included 543,591 ha of the central and northern Black Hills and Bear Lodge Mountains in southwest South Dakota and northeast Wyoming (Fig. 1). The Black

[1] Current Address: Crater Lake National Park, PO Box 7, HWY 62 Sager Building, Crater Lake, OR 97604, USA
[2] Corresponding author email address: mrumble@fs.fed.us
[3] Deceased.

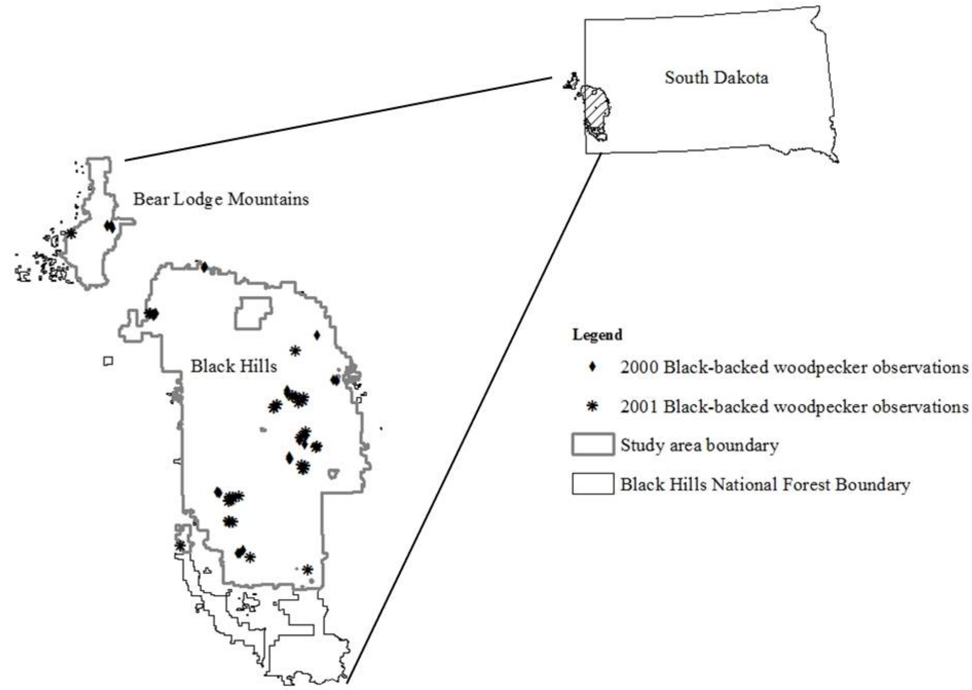

Figure 1. Map of study area and Black Hills National Forest in the Black Hills and Bear Lodge Mountains of South Dakota and Wyoming, USA, with locations of black-backed woodpeckers in 2000 (solid diamonds) and 2001 (asterisks).

Hills and Bear Lodge Mountains form an island of predominantly ponderosa pine (*Pinus ponderosa*) forest surrounded by prairies with elevation ranges from approximately 1,065 m to 2,207 m (Hoffman and Alexander 1987). Frequent low intensity fires with large scale disturbance from fire and mountain pine beetle (*Dendroctonus ponderosae*) infestations, primarily in the northern latitudes and higher elevations, created the distinctive vegetation patterns in the BHNF (Brown and Sieg 1996, Parrish et al. 1996, Shinneman and Baker 1997, Brown and Sieg 1999).

METHODS

Most of the Black Hills are managed by the BHNF. Land management units are divided into 432 ha stands of similar vegetation that are classified using a surrogate hierarchal seral stage classification based on the dominant vegetation type, stand age/diameter-at-breast height (DBH), and overstory canopy cover (Buttery and Gillam 1983). Approximately 13% of the area was unclassified, most of which was under private ownership. In late August-September 2000, a 33,809-ha wildfire occurred and we edited the GIS coverage to include an additional stage representing the intensive burn.

Field Surveys

We used a stratified random sampling approach to distribute 1-km transects throughout the BHNF. Stratifications included U.S. Forest Service ranger districts and vegetation structure stage from the classification described above. We randomly selected five stands of each of the dominant vegetation structural stages, within each of four Forest Service ranger districts, in the BHNF (Table 1) from the GIS coverage of the study area. Some districts did not have five stands of each vegetation structural stage, so we selected additional stands for this vegetation structural stand on another district.

After selecting the stand from which each transect originated, we located a random point in the stand and initiated a transect of approximately 1.0 km in a random direction with the constraint that transect length was maximized and passed through the selected (random) point. However, our implementation resulted in some transects being longer and some being shorter (range of 343–1,192 m).

We surveyed transects from April 29 to June 25 during 2000 and 2001 between 0600–1300 hrs. We did not conduct surveys on days with rain, or days with winds >15 mph. We sampled each transect one time for approximately one hour. We used a handheld global positioning system (GPS; Garmin International, Inc., Olathe, KS) unit to navigate along each transect. The probability of detection for black-backed woodpeckers is increased three times when calls are used on surveys (Siegel et al. 2010). At the start, end, and at 200 m intervals along each transect, we broadcast a recorded black-backed woodpecker drum recording three times to elicit a response and improve detection of individuals We only broadcasted the black-backed woodpecker drum which is not

Table 1. Description for the vegetation structural stages used for the initial stratified random assignments for locating transect to survey.

Vegetation Type	Stand age[1]	Canopy Cover Category
Ponderosa pine	Sapling/pole	0–40%
Ponderosa pine	Sapling/pole	41–70%
Ponderosa pine	Sapling/pole	>71%
Ponderosa pine	Mature	0–40%
Ponderosa pine	Mature	41–70%
Ponderosa pine	Mature	>71%
Ponderosa pine	Old growth	
White spruce	Sapling/pole	0–40%
White spruce	Sapling/pole	41–70%
White spruce	Sapling/pole	>71%
White spruce	Mature	0–40%
White spruce	Mature	41–70%
White spruce	Mature	>71%
White spruce	Oldgrowth	
Aspen	Sapling/pole	0–40%
Aspen	Sapling/pole	>41–70%
Aspen	Sapling/pole	>71%
Aspen	Mature	0–40%
Aspen	Mature	>41–70%
Aspen	Mature	>71%
Aspen	Oldgrowth	

[1] Sapling-pole age class = 2.55–22.8 cm DBH, Mature age class = >22.8 cm dbh, and old-growth classification = >35.6 cm DBH

an aggressive social behavior. Black-backed woodpeckers drum year round, but more from April to June to advertise presence; vocalizations, on the other hand, are associated with social interactions or aggression (Dixon and Saab 2000) and thus would more likely draw individuals to observers. When a response to the drum was heard, we approached the estimated location of the response and searched until we found the bird. All locations of black-backed woodpeckers were visually confirmed and recorded in the GPS unit. After obtaining visual confirmation, we returned to the transect and resumed our survey.

We implemented an adaptive cluster sampling strategy, which improves precision of estimates, efficiency of sampling, and encounters of uncommon species that are not randomly distributed (Thompson and Seber 1996). If a black-backed woodpecker was recorded on a survey, we surveyed additional 1-km transects 800 m away using the same protocol. If a black-backed woodpecker was encountered on these surveys, additional transects were added in pairs until birds were not encountered. Most of the additional transects were parallel to the original transect; but if >2 additional transects were added (e.g., birds were encountered on the cluster transect), additional transects were added and oriented perpendicular to the original transects.

To examine the potential that use of a call attracted birds to the observers and biased our data, we initiated a study for which we identified four areas that black-backed woodpeckers were observed: one recent burn, one 3-year-old burn, and two sites in a recent mountain pine beetle infestation. We surveyed each of these areas on calm days during the third week of March, April, and May of 2014. Each survey included locating individuals by listening for pecking, calls or drums, although occasionally in mountain pine beetle areas, we broadcast a black-backed woodpecker drum to improve our ability to locate individuals. Once individuals were located, one person maintained observation of the bird while another person broadcast a black-backed woodpecker drum at approximate 100 m and 200 m. We noted the sex and the bird's response after the broadcast.

Analyses

We delineated transects using the starting and ending coordinates and calculated the distance from each observation to the associated transect in ArcMap 10.1 (Environmental Systems Research Institute, Redlands, CA, USA). We used the conventional distance sampling analysis in program DISTANCE (Thomas et al. 2009) and truncated observations beyond 350 m to estimate the detection function and black-backed woodpecker density and abundance. Although additional transects surveyed were intended to be spaced 800 m apart, implementation in the field required us to truncate distances to birds along transects at 350 m to minimize overlap of survey effort. To ensure we did not include multiple observations of the same individual while surveying additional transects, we censored observations of the same sex ≤1,500 m apart on different transects on different days, keeping the first recorded location. We selected 1,500 m because it was the approximate radius of the largest black-backed woodpecker range in the Black Hills for birds using green forest and interspersed mountain pine beetle infestations (Rota et al. 2014*b*) and the approximate spacing between pairs in Vermont (Lisi 1988). Survey effort combined lengths of original and associated transects from cluster samples which were then treated as single long transects to avoid artificially inflating sample size (DISTANCE 6.0, Online Manual: 15). We assumed that detectability of black-backed woodpeckers at various distances from transects was similar between years, so the population estimate was made using a posterior stratification of the same detection model for each year. We considered 4 detection model functions: 1) half-normal with cosine adjustment, 2) hazard rate with cosine adjustment, 3) uniform with cosine adjustment, and 4) negative exponential with cosine adjustment. We adopted the Information-theoretic approach (Burnham and Anderson 2002) for evaluating models based on Akaike's information criterion for small samples (AIC_c) and selected the detection function shape that had the lowest AIC_c. We then evaluated the modeled detection function shape using various distance intervals, again accepting the model with the lowest AIC_c to estimate density.

We used ArcMap 10.1 to calculate the composition of vegetation structural stages within 350 m of transects by creating rectangular buffers 350 m on either side of the transect. We intersected transect buffers with the vegetation structural stage GIS coverages for the BHNF for each year (the 2001 coverage was edited to reflect vegetation changes from the large wildfire). We corrected population estimates from DISTANCE for the entire study area based on the ratio of the vegetation structural stage composition for the surveyed area (350-m buffers) to the vegetation structural stage composition of the study area; this adjustment was applied to better estimate the population abundance. For these analyses, we aggregated vegetation structural stage categories into grasslands, deciduous, white spruce, grass/forb stage of ponderosa pine, seedling/sapling stage of ponderosa pine, and ponderosa pine <40% overstory cover, 41–70% overstory cover, and >70% overstory cover.

Because observations were recorded as individuals, we corrected the population estimate to represent pairs of black-backed woodpeckers. For this calculation, we assumed that all individuals were paired. Yuncik (1985) noted a slight (0.17) male bias during irruptions of black-backed woodpecker populations. However, this population was not irruptive and research in the Black Hills area noted that of 232 radiomarked black-backed woodpeckers alive in April, all had mates in the spring (C. Rota, personal communication). Thus, we considered observations of a male and a female <1500 m apart to be mates (e.g., Lisi 1988, Rota et al. 2014*b*). We calculated the estimated number of breeding pairs as:

$$\left(\frac{N_{pop} + \frac{N_{single}}{N_{obs}} \text{ X } N_{pop}}{2}\right),$$

where N_{pop} was the estimate from DISTANCE, N_{single} was number of single (unpaired) individuals observed and N_{obs} was the total number of black-backed woodpeckers we observed during our counts.

RESULTS

Our study area included the northern 76% of the area encompassed by the Black Hills Forest boundaries excluding small fragmented patches and privately owned land (Fig. 1). Transects were well dispersed throughout the study area but observations of black-backed woodpeckers were not randomly distributed. Rather, black-backed woodpeckers exhibited a clustered distribution across the study area and between years. In 2000, we found two black-backed woodpeckers on four original and seven cluster-sample transects within the burn perimeter. In 2001, we found five black-backed woodpeckers on 12 original transects and 20 clustersample transects within the burn perimeter and they were in the same general area as in 2000.

We surveyed 177 original and 67 additional "cluster" transects for a cumulative effort of 241,849 m in 2000. In 2001, we surveyed 197 original and 72 additional "cluster" transects for a cumulative effort of 265,072 m. We observed 27 and 29 individuals ≤350 m from survey transects in 2000 and 2001, respectively. All of the black-backed woodpeckers we observed were in ponderosa pine, although some observations occurred in stands where the dominant vegetation of the land unit was deciduous (Table 2).

Although the negative exponential detection model had a slightly lower AIC_c (AIC_c = 593.1), we disregarded it because the negative exponential model is not recommended (DISTANCE 6.0, Online Manual: 90) and appeared to overestimate the density, and accepted the half-normal model with

Table 2. Number of black-backed woodpeckers and vegetation structural stage where they occurred along with estimated population and density of breeding pairs in the Black Hills and Bear Lodge Mountains of South Dakota and Wyoming, USA, 2000–2001.

Vegetation structural stage	2000	2001
Deciduous	3	2
Ponderosa pine <40% overstory canopy cover	15	9
Ponderosa pine 41 – 70% overstory canopy cover	6	12
Ponderosa pine >70% overstory canopy cover	3	1
Recently burned forest		5
Estimated number of black-backed woodpecker pairs[a]	641 (95% CI = 404.9–989.9)	456 (95% CI = 293.3–704.6)
Estimated density/km^2 of black-backed woodpecker pairs	0.14 (95% CI = 0.09–0.21)	0.10 (95% CI = 0.06–0.15)

[a] Population and density estimates made using half-normal model of four equal distance intervals in Program DISTANCE 6.0.

cosine adjustment (AIC$_c$ = 588.3) for estimating density. We evaluated the half-normal detection function for 4 equal intervals (87.5 m wide) and 5 intervals (70 m wide) and selected the 4-interval model because it had the lowest AIC$_c$ (120.7 versus 148.4 for the 5-interval model). Models with more than 5 intervals suggested some short movements toward the observers. Interval widths of the 4-interval model were sufficiently wide to mask small movements of birds toward the observer (Fig. 2).

We estimated there were 641 (95% CI = 405–990) and 456 (95% CI = 293–705) pairs of black-blacked woodpeckers in 2000 and 2001, respectively. The estimated density of pairs in the study area was 0.13/km^2 in 2000 and 0.11/km^2 in 2001.

We broadcast the black-backed woodpecker drum from 67 locations, there were 28 vocal or movement responses and on 14 occasions birds moved closer ($\bar{x}$ = 29 m, range 10–90 m). Three birds made 8 movements toward the call ($\bar{x}$ = 33.1 m, SD = 23.9 m) following repeated broadcasts of the drum call. On four occasions, the response to the broadcast drum was movement toward the mate of the bird. Male and female black-backed woodpeckers did not respond similarly to the broadcast in our study; 24 of the responses were from females and four from males. There were four responses in March, 14 in April, and 10 in May.

DISCUSSION

Black-backed woodpeckers were uncommon in the relatively undisturbed forest conditions in our study. Although black-backed woodpeckers were uncommon, the population can be estimated using distance sampling methods with sample sizes similar to ours (e.g., Buckland et al. 1993, Reidy et al. 2014). We believe the population and density estimates we made were conservative for several reasons. First, application of a 1,500 m buffer (the radius of the largest home range reported by Rota et al. [2014*b*]) resulted in censoring a number of individuals that occurred along cluster sample transects. The 1,500-m buffer was derived from home range estimates in the Black Hills and was three times larger than occurred in a managed unburned, but different vegetation type, forest in Canada (Tremblay et al. 2009). However, it also was consistent with spacing of breeding black-backed woodpecker pairs in Vermont (Lisi 1988). Second, although we censored individuals, we retained the sampling effort associated with the cluster samples. Some censored observations were probably repeat observations, but it is unlikely that all were. Finally, previous studies suggest that the probability of detection of black-backed woodpeckers increased from 0.23 to about 0.7 when broadcasted calls and drums were used (Siegel et al. 2010), while we only used the drum. Setterington et al. (2000) reported similar numbers of black-backed woodpeckers on surveys that relied on auditory cues and surveys the following year that used broadcast calls and drums of black-backed woodpeckers. Nonetheless, we believe a conservative approach was warranted because it provided a baseline for future population viability analyses (e.g., Hanson et al. 2012) and the cluster sampling analysis because it was our a priori design. The density estimates were within the range reported by previous researchers (Salt 1957, Bock and Lynch 1970, Apfelbaum and Haney 1981, Murphy and Lehnhausen 1998), and were similar to initial analyses reported by Mohren (2002) that did not include the adaptive cluster samples.

The grouped nature of black-backed woodpeckers suggested they sought out habitat patches that persisted between the years of our study. In undisturbed forests, snags in the early stages of decay (Tremblay et al. 2009) and small patches of trees infested by mountain pine beetles (Mohren 2002) were associated with black-backed woodpeckers. Although black-backed woodpeckers are attracted to large scale wildfires (Yunick 1985, Villard and Schieck 1997, Murphy

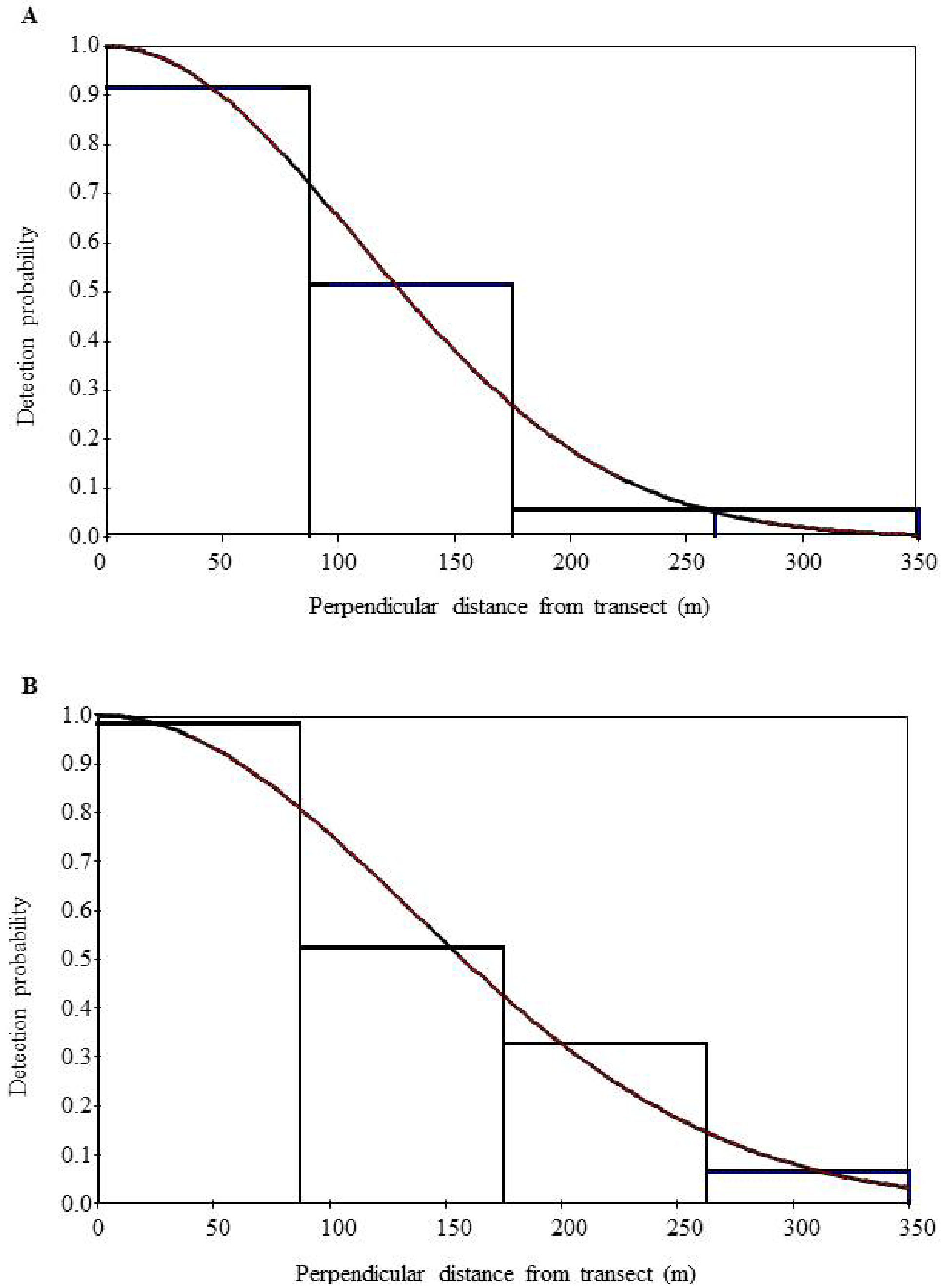

Figure 2. Half-normal detection function from DISTANCE for estimating the population of black-backed woodpeckers for (A) 2000 and (B) 2001 from surveys in the Black Hills, South Dakota, USA.

and Lehnhausen 1998), it is unlikely the large wildfire in late August/early September of 2000 attracted birds in 2001. Observations within the perimeter of the fire were in close proximity and number to those before the burn. Woodborers are a primary food of black-backed woodpeckers (Dixon and Saab 2000) and probably did not colonize the fall wildfire until June 2001. Estimated numbers of nesting black-backed woodpeckers in this burn suggest they were not attracted to the area until 2002 (Vierling 2004).

MANAGEMENT IMPLICATIONS

Black-backed woodpeckers occur in low density and a nonrandom distribution in undisturbed forests of the Black

Hills. The recent petition for listing this uncommon species and low population/density suggest that some management to increase populations may be warranted. Intentional decisions allowing some forest disturbances that result in recently killed trees and management that sustains some of these areas is recommended if black-backed woodpecker populations are a priority. We recommend that if a cluster sampling design is desirable, that transects be spaced >1,500 m apart to minimize chances of multiple observations of the same individual.

ACKNOWLEDGMENTS

This research was supported by the BHNF, Wyoming Cooperative Fish and Wildlife Research Unit, U.S. Forest Service Rocky Mountain Research Station, and the Maurie Audubon Society. Field assistance was provided by C. Quitmeyer and N. Stephens. K. Burns, T. Mills, and J. Reeke provided equipment, logistical support, and technical assistance.

LITERATURE CITED

Apfelbaum, S., and A. Haney. 1981. Bird populations before and after wildfire in a Great Lakes pine forest. Condor 83:347–354.

Blackford, J. L. 1955. Woodpecker concentration in burned forest. Condor 57:28–30.

BHNF. 1996. Final environmental impact statement. U.S. Forest Service, Land Resource and Management Plan for the Black Hills National Forest, Custer, South Dakota, USA.

Bock, C. E., and J. F. Lynch. 1970. Breeding bird populations of burned and unburned conifer forest in the Sierra Nevada. Condor 72:182–189.

Brown, P. M., and C. H. Sieg. 1996. Fire history in interior ponderosa pine forests of the Black Hills, South Dakota, USA. International Journal of Wildland Fire 6:97–105.

Brown, P. M., and C. H., Sieg. 1999. Historical variability in fire at the ponderosa pine-Northern Great Plains prairie ecotone, southeastern Black Hills, South Dakota. Ecoscience 6:539–547.

Buckland, S. T., D. R. Anderson, K. P. Burnham, and J. L Laake. 1993. Distance sampling: estimating abundance of biological populations. Chapman and Hall, London, UK. <http://www.colostate.edu/Dept/coopunit/download.html>. Accessed 29 May 2014.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Second edition. Springer-Verlag, New York, New York, USA.

Buttery, R. F., and B. C. Gillam. 1983. Ecosystem descriptions. Pages 42–71 *in* R. L. Hoover and D. L. Willis, editors. Managing forested lands for wildlife. Colorado Division of Wildlife in cooperation with the U.S. Forest Service, Rocky Mountain Region, Denver, USA.

Dixon, R. D., and V. A. Saab. 2000. Black-backed woodpecker (*Picoides arcticus*). Page 119 *in* F. B. Gill and A. Poole, editors. The birds of North America 509. The birds of North America Inc., Philadelphia, Pennsylvania, USA.

Dykstra, B. L., M. A. Rumble, and L. D. Flake. 1997. Effects of timber harvesting on birds in the Black Hills of South Dakota and Wyoming, USA. Pages 16–26 *in* J. E. Cook and B. P. Oswalk, compilers. First biennial North American forest ecology workshop. Society of American Foresters, Raliegh, North Carolina, USA.

Hanson, C. K., Coulter, J. Augustine, and D. Short. 2012. Petition to list the black-backed woodpecker (*Picoides arcticus*) as Threatened or Endangered under the federal Endangered Species Act. <http://www.biologicaldiversity.org/species/birds /black-backed_ woodpecker/pdfs/BBWO_FESA_Petition.pdf/>. Accessed 10 May 2012.

Harris, M. A. 1982. Habitat use among woodpeckers in forest burns. Thesis. University of Montana, Missoula, USA.

Hoffman, G. R., and R. R. Alexander. 1987. Forest vegetation of the Black Hills National Forest of South Dakota and Wyoming: a habitat classification. Research Paper RM276. U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

Hutto, R. L. 1995. Composition of bird communities following stand replacement fires in northern Rocky Mountain (U.S.A.) conifer forests. Conservation Biology 9:1041–1058.

Lisi, G. 1988. A field study of black-backed woodpeckers in Vermont. Technical Report 3. Vermont Fish and Wildlife Department, Nongame and Endangered Species Program, Burlington, USA.

Mohren, S. R. 2002. Habitat evaluation and density estimates for the black-backed woodpecker (*Picoides arcticus*) and three-toed woodpecker (*Picoides tridactylus*) in the Black Hills National Forest. Thesis. University of Wyoming, Laramie, USA.

Murphy, E. C., and W. A. Lehnhausen. 1998. Density and foraging ecology of woodpeckers following a standreplacement fire. Journal of Wildlife Management 62:1359–1372.

Parrish, J. B., D. J. Herman, and D. J. Reyher. 1996. A century of change in Black Hills forest and riparian ecosystems. B 722. South Dakota State University Agriculture Experiment Station, Brookings, USA.

Pierson, J. C., F. W. Allendorf, V. Saab, P. Drapeau, and M. K. Swartz. 2010. Do male and female black-backed woodpeckers respond differently to gaps in habitat? Evolutionary Applications 3:263–278.

Reidy, J. L., F. R. Thompson III, and S. W. Kendrick. 2014. Breeding bird response to habitat and landscape factors across a gradient of savanna, woodland, and forest in the Missouri Ozarks. Forest Ecology and Management 313:34–46.

Rota, C. T., J. J. Millspaugh, M. A. Rumble, C. P. Lehman, and D. C. Kesler. 2014*a*. The role of wildfire, prescribed fire, and mountain pine beetle infestations on the population dynamics of a disturbance-dependent species. PLoS ONE 9(4):e94700.

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

Rumble, M. A., T. R., Mills, and L. D. Flake. 1999. Habitat capability model for birds wintering in the Black Hills, South Dakota. Research Paper RMRP-19. U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

Salt, G. W. 1957. An analysis of avifaunas in the Teton Mountains and Jackson Hole, Wyoming. Condor 59:373–393.

Setterington, M. A., I. D. Thompson, and W. A. Montevecchi. 2000. Woodpecker abundance and habitat use in mature balsam fir forests in Newfoundland. Journal of Wildlife Management 64:335–345.

Shinneman, D., J., and W. L. Baker. 1997. Nonequilibrium dynamics between catastrophic disturbances and old-growth forests in ponderosa pine landscapes of the Black Hills. Conservation Biology 11:1276–1288.

Siegel, R. B., J. F. Saracco, and R. L. Wilkerson. 2010. Management Indicator Species (MIS) surveys on Sierra Nevada National Forests: Black-backed woodpecker. 2009 Annual report to U.S. Forest Service. The Institute for Bird Populations, Point Reyes Station, California, USA.

South Dakota Department of Game, Fish and Parks. 2005. South Dakota Comprehensive Wildlife Conservation Plan. Wildlife Division Report 2005-07. South Dakota Department of Game, Fish and Parks, Pierre, USA.

Taylor, B. C., and W. J. Barmore, Jr. 1980. Postfire succession of avifauna in coniferous forest of Yellowstone and Grand Teton National Park Wyoming. Pages 130–145 *in* R. M. DeGraff, technical coordinator. Management of western forests and grasslands for birds. General Technical Report INT86. U.S. Forest Service, Intermountain Research Station, Ogden, Utah, USA.

Thomas, L., Laake, J. L., E. Rexstad, S. Strindberg, F. F. C. Marques, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, M. L. Burt, S. L. Hedley, J. H. Pollard, J. R. B. Bishop, and T. A. Marques, T.A. 2009. Distance 6.0. Release 2. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. <http://www.ruwpa.st-and.ac.uk/distance/>. Accessed 4 July 2013.

Tremblay, J. A., J. Ibarzabal, C. Dussalt, and J-P. L. Savard. 2009. Habitat requirements of breeding black-backed woodpeckers, (*Picoides arcticus*) in managed, unburned boreal forest. Avian Conservation and Ecology 14:2. <http://www.aceeco.org/vol14/iss1/art2/>. Accessed 7 November 2013.

Thompson, S. K. and G. A. F. Seber. 1996. Adaptive sampling. John Wiley and Sons, Inc., New York, New York, USA.

Vierling, K. T. 2004. Report on woodpecker breeding in the Jasper fire. Black Hills National Forest, Custer, South Dakota, USA.

Villard, M., and J. Schieck. 1997. Immediate postfire nesting by black-backed woodpeckers, *Picoides arcticus*, in northern Alberta. Canadian Field Naturalist 111:478–479.

Yunick, R. P. 1985. A review of recent irruptions of the black-backed woodpecker and the three-toed woodpecker in eastern North America. Journal of Field Ornithology 56:138152.

Submitted 6 January 2014. Accepted 29 August 2014. Associate Editor was Mark Vrtiska.