Forest Ecology and Management 259 (2009) 220–228

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Multi-scale nest-site selection by black-backed woodpeckers in outbreaks of mountain pine beetles

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ARTICLE INFO

Article history:
Received 11 August 2009
Received in revised form 14 October 2009
Accepted 16 October 2009

Keywords:
Discrete choice
Wood borer
Picoides arcticus
Post-fire
Habitat

ABSTRACT

Areas of mountain pine beetle (*Dendroctonus ponderosae* Hopkins) outbreaks in the Black Hills can provide habitat for black-backed woodpeckers (*Picoides arcticus*), a U.S. Forest Service, Region 2 Sensitive Species. These outbreaks are managed through removal of trees infested with mountain pine beetles to control mountain pine beetle populations and salvage timber resources. To minimize impacts to black-backed woodpeckers while meeting management objectives, there is a need to identify characteristics of these areas that support black-backed woodpeckers. We examined the habitat associations of this species nesting in areas of beetle outbreaks in the Black Hills, South Dakota in 2004 and 2005. We used an information theoretic approach and discrete choice models to evaluate nest-site selection of 42 woodpecker nests at 3 spatial scales—territory, nest area, and nest tree. At the territory scale (250 m around nest), availability and distribution of food best explained black-backed woodpecker selection of beetle outbreaks versus the surrounding forest. Selection at the territory scale was positively associated with densities of trees currently infested by mountain pine beetles and indices of wood borer (Cerambycidae and Buprestidae) abundance, and was greatest at distances of 50–100 m from the nearest patch of infestation. At the nest-area scale (12.5 m radius around the nest), densities of snags positively influenced nest-area selection. Finally, at the nest-tree scale, aspen (*Populus tremuloides*) and 3–5-year-old ponderosa pine (*Pinus ponderosa*) snags were important resources. The association between abundant wood-boring insects and black-backed woodpeckers creates a difficult challenge for forest managers. In the absence of fire, areas of beetle outbreak might serve as the only substantial source of habitat in the Black Hills. Regulating insect populations via salvage logging will reduce key food resources to black-backed woodpeckers during nesting. Therefore, given the relatively infrequent occurrence of large-scale fire in the Black Hills, management should recognize the importance of beetle-killed forests to the long-term viability of the black-backed woodpecker population in the Black Hills.

1. Introduction

Although, black-backed woodpeckers (*Picoides arcticus*) are widely distributed geographically (Bock and Bock, 1974) and use a variety of forest types, they are closely associated with standing dead forests containing an abundance of snags (see Dixon and Saab, 2000). In the western United States, black-backed woodpeckers appear to be nearly restricted to post-fire forests created by stand-replacing fires (Hutto, 1995; Raphael and White, 1984; Smucker et al., 2005). When considering the suppression of historical fire regimes throughout the range of black-backed woodpeckers (Saab and Powell, 2005), this association with post-fire forest has prompted conservation concern by state and federal agencies. They are listed as locally rare and vulnerable to extinction and consequently are one of the Species of Greatest Concern in the Black Hills ecoregion (South Dakota Department of Game, Fish and Parks, 2006). Black-backed woodpeckers are also a "Sensitive Species" in Region 2 of the U.S. Forest Service and their habitat is given special consideration in the management of the Black Hills National Forest (USDA, 1996).

In addition to fire, areas of mountain pine beetle (*Dendroctonus ponderosae* Hopkins) outbreaks, which are historically and currently a source of large scale disturbance in the Black Hills (Shinneman and Baker, 1997), also provide habitat for black-backed woodpeckers in the region (Bonnot et al., 2008). Black-backed woodpeckers have been reported nesting in beetle killed forests in other regions (e.g., the Pacific Northwest (Bull et al.,

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doi:10.1016/j.foreco.2009.10.021

1986; Goggans et al., 1989) and Newfoundland (Setterington et al., 2000)). Forests with beetle outbreaks contain abundant snags that can provide food and nesting resources similar to recently burned forests. However, unlike recently burned forests, little is known about the specific resources within beetle-killed forests that support black-backed woodpeckers. For example, the role of food and nest-site availability in black-backed woodpecker nesting use of beetle killed forests remains unclear.

Forest managers have an interest in information that could help guide compromises between management of mountain pine beetle outbreaks and black-backed woodpecker conservation. Recent changes in management of the Black Hills National Forest place more emphasis on timber management for reducing fire and insect hazards (USDA, 2005). Current applications of salvage logging involve the removal of current and previously infested trees in an attempt to prevent insect dispersal and reduction in wood value. As with post-fire habitat, these activities could adversely affect conservation efforts for this Sensitive Species (Hutto and Gallo, 2006; Saab and Dudley, 1998; Saab et al., 2007). Thus, a better understanding of the important resources within outbreak areas is needed so managers can minimize impacts to black-backed woodpeckers when addressing threats to timber. For example, use of these areas by black-backed woodpeckers could be impacted if salvage logging reduced trees containing mountain pine beetle- or wood borer (Cerambycidae and Buprestidae) larvae, the primary foods of this species (Beal, 1911; Murphy and Lenhausen, 1998; Powell, 2000). Also, knowledge of the types of snags selected as nest sites or any characteristics of the forest around those nest sites could be considered when prescribing logging activities. Given the conservation status of black-backed woodpeckers and the need to manage threats to timber, it is critical that habitat associations of black-backed woodpeckers nesting in beetle killed forests be investigated to balance resource management.

With the objective of identifying resources important to black-backed woodpeckers in areas of mountain pine beetle outbreaks in the Black Hills, we evaluated nest-site selection by black-backed woodpeckers in these areas at three scales of selection. At a territory scale we compared resources within a 250 m radius around the nest to resources of similar scale from adjacent forests, allowing us to examine whether factors related to nest-site or food availability influence woodpecker use of beetle killed forests to other available forested areas. We evaluated selection of areas immediately surrounding the nest (nest-area scale) to help managers understand the importance of smaller scale features to nesting ecology of black-backed woodpeckers. Finally, we evaluated selection of the nest tree (nest-tree scale) to determine whether black-backed woodpeckers select a particular tree species, condition, or size of tree for nesting.

2. Materials and methods

2.1. Study site

The geographic scale of our study was the northern and central portions of the Black Hills National Forest in the Black Hills region of southwestern South Dakota (43°10' to 44°50' N and 103°20' to 104°50' W; Froiland, 1978). Elevation in the Black Hills ranges from 1066 m to 2207 m. The dominant forest type in the Black Hills is ponderosa pine (*Pinus ponderosa*), but stands of white spruce (*Picea glauca*), aspen (*Populus tremuloides*), and paper birch (*Betula papyrifera*) also occur (Hoffman and Alexander, 1987).

Mountain pine beetles caused extensive ponderosa pine mortality throughout the Black Hills in the six years leading up to our study (Harris, 2004). By 2004, beetle populations were elevated across the entire Black Hills, with tree mortality in the northern and central portions occurring at epidemic levels from coalescing areas of outbreak (Harris, 2004). Aerial surveys indicated that over 27 000 ha of forest were affected by outbreaks in 2004 (USFS, unpubl. data). Thirty-two percent of outbreaks occurred in patches greater than 100 ha in size. For comparison, during the three years from 2002 to 2004, the Black Hills had six fires that burned a total of 19 746 ha (USDA Forest Service, 2008).

We conducted our study in 2004 and 2005. For the 2004 field season, we identified 58 potential study sites using aerial surveys from a fixed-wing aircraft flown over the central and northern regions of the Black Hills in March 2004. We located areas of bark beetle infestation by the discoloration of foliage on dead ponderosa pines resulting from tree mortality two years prior. However, aerial surveys only provided the location of outbreaks in 2004, without information about their size or extent. For the 2005 field season we identified 54 study sites from remotely sensed imagery (USDA-Farm Service Agency, Aerial Photography Field Office, Salt Lake City, UT, USA) taken in the fall of the previous year. Sites identified for the 2005 field season averaged 195 ± 37 ha (SE).

2.2. Nest searches

We conducted area searches for black-backed woodpecker nests from 22 April to 1 July (the breeding season) in ≥90% of the identified potential study sites of 2004 and 2005. Our methods were adapted from Saab and Dudley (1998) and we searched areas using crews of 2–4 members that walked transects spaced between 100 m and 200 m apart, which ensured we were within 100 m of all areas in the site. We used call playbacks at intervals of 100–200 m to locate birds. Call playbacks consisted of a recorded sequence of 3 black-backed woodpecker vocalizations: a series of chirps, a series of 3 drums, and a series of 3 rattles. We paused recordings for 10–20 s between separate vocalizations to listen for responses. Once observed, we used behavioral cues to follow individuals until we located a nest or determined they were not nesting. We recorded UTM coordinates for all nests using handheld GPS units with accuracy ≤10 m. We marked nests by flagging a nearby bearing tree at least 5 m from the nest tree and labeled it with the azimuth and height to the cavity.

2.3. Resource sampling

Following the nesting period, we used a matched case control design to estimate used and available resources for black-backed woodpeckers at 3 spatial scales—territory, nest area, and nest tree (Fig. 1).

2.3.1. Territory scale

At the territory scale, we compared resource attributes of used territories to available territories in the adjacent forest. We established available territories by selecting a tree, 750 m away in a random direction obtained using a random number generator (Fig. 1). Because, we were interested in black-backed woodpecker use of forest structure or characteristics, as related to nest-site availability and food availability, not physiographic or topographic differences (i.e., elevation, slope and aspect), we incorporated the concept of alternative availability, where criteria (e.g., physiographic and topographic variables) are used to limit choice sets to specific alternatives (Ben-Akiva and Bierlaire, 1999). Therefore, we only identified available territories with approximately the same elevation (within 30 m), aspect, and position on slope as the used territories to avoid differences in forest structure and composition resulting from these factors. Application of these criteria did not strongly limit our selection of available territories, rather this constraint was used to avoid extreme differences, such as comparing river bottoms to ridges, where forest structure would obviously be different. We assumed a 250 m radius (19.6 ha) was