Forest Ecology and Management 363 (2016) 110–119

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Foraging plasticity by a keystone excavator, the white-headed woodpecker, in managed forests: Are there consequences for productivity?

Teresa J. Lorenz[a,*], Kerri T. Vierling[a], Jeffrey M. Kozma[b], Janet E. Millard[c]

[a] Department of Fish and Wildlife Sciences, University of Idaho, P.O. Box 441136, Moscow, ID 83844, USA
[b] Yakama Nation, Timber, Fish, and Wildlife/Fisheries Resource Management, P.O. Box 151, Toppenish, WA 98942, USA
[c] U.S. Department of Agriculture, Forest Service, Wenatchee River Ranger District, 600 Sherbourne Street, Leavenworth, WA 98826, USA

ARTICLE INFO

Article history:
Received 8 September 2015
Received in revised form 15 December 2015
Accepted 17 December 2015
Available online 29 December 2015

Keywords:
Forage site selection
Nest productivity
Picoides albolarvatus
Pinus ponderosa
Ponderosa pine

ABSTRACT

Information on the foraging ecology of animals is important for conservation and management, particularly for keystone species whose presence affects ecosystem health. We examined foraging by an at-risk cavity excavator, the white-headed woodpecker (*Picoides albolarvatus*). The foraging needs of this species are used to inform management of ponderosa pine (*Pinus ponderosa*) forests in some areas of western North America. Past observational studies indicated that white-headed woodpeckers forage predominately on cones and trunks of large-diameter (>68 cm) pines in old-growth stands, although habitat selection while foraging has not been formally examined. We used radio telemetry to track forage substrate use among 37 adult, breeding woodpeckers for 176 h (10,576 min) in forest stands that had been recently thinned and/or burned with prescribed fire. We used discrete choice models to examine forage site selection and multinomial regression to examine consequences of foraging on nest productivity. Woodpeckers foraged on more than ten individual substrates and switched substrates seasonally, presumably to take advantage of prey availability. Dead wood and fir foliage were used commonly in the nesting period (86% and 68% of foraging, respectively), whereas pine foliage and trunk foraging dominated in the fledgling (66% of foraging) and post-fledgling periods (73% of foraging). Average size of used trees was 49 cm (±20 cm) and pine cones were rarely used (4% of foraging). During the nesting period, substrate use (χ^2 = 1.49, df = 4, P = 0.83) and distances traveled from nests for foraging did not affect productivity ($F_{(3,16)}$ = 0.61, P = 0.62), which was high even for birds with the longest (2.1 km) and shortest (0.39 km) maximum forage distances. Habitats selected for foraging matched substrate use, and woodpeckers selected areas with low basal areas of live trees in the nesting period, but high basal areas in the post-nesting period. The variable foraging that we observed suggests that white-headed woodpeckers are plastic in their foraging in managed forests, and this plasticity has no negative consequences for productivity.

Published by Elsevier B.V.

1. Introduction

White-headed woodpeckers (*Picoides albolarvatus*) are important ecosystem engineers that act as keystone species in dry pine forests of western North American. They are one of the closest living relatives of the more widespread Hairy Woodpecker (*Picoides villosus*) (Fuchs and Pons, 2015; Weibel and Moore, 2002a, 2002b) and excavate nest cavities that are important nest and shelter sites for a wide variety of small-bodied animals (Tarbill et al., 2015). Throughout their range they are considered a sensitive or endangered species that has declined in the last century owing to intensive forest management practices (Garrett et al., 1996; Mellen-McLean et al., 2013). Old pine forests were thought to be important for providing snags for nesting and reliable cone crops for foraging (Dixon, 1995a; Mellen-McLean et al., 2013; Raphael and White, 1984). Because of white-headed woodpecker's association with old-growth ponderosa pine, they have also been considered management indicator species for ponderosa pine (*Pinus ponderosa*) restoration in the northwestern U.S.A. (Altman, 2000; Gaines et al., 2007, 2010). Their presence is thought to reflect ecosystem health and habitat quality for other pine-associated species and the management of ponderosa pine in some areas is

* Corresponding author at: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, 3625 93rd Avenue SW, Olympia, WA 98512, USA.
E-mail address: tlorenz@fs.fed.us (T.J. Lorenz).

http://dx.doi.org/10.1016/j.foreco.2015.12.021
0378-1127/Published by Elsevier B.V.

based at least partially on the nesting and foraging needs of the white-headed woodpecker.

While their nesting ecology has been well-studied range-wide (Hollenbeck et al., 2011; Milne and Hejl, 1989; Raphael and White, 1984; Wightman et al., 2010), studies of white-headed woodpecker foraging have mostly focused on southern populations (Hanson and North, 2008; Morrison et al., 1987; Morrison and With, 1987; Raphael and White, 1984). Four foraging studies have been conducted in the northwestern states of Oregon, Washington, and Idaho. These studies have helped advance our understanding of white-headed woodpecker foraging in this region, but were limited to relatively small sample sizes (three observations; Ligon, 1973) or single events within the breeding cycle (e.g., nestling period, Kozma and Kroll, 2013; or post-nesting autumn, Dixon, 1995a, 1995b). Management for the white-headed woodpecker in northern parts of their range is therefore guided by a combination of southern studies, and northern studies of limited scope and duration. This is potentially problematic because others have noted spatial and temporal variation in white-headed woodpecker foraging. For example, Morrison and With (1987) observed significant seasonal differences in populations in California. They also noted that populations in the central Sierra Nevada foraged on different tree species than southern populations, and both these sites differed from observations of foraging in Idaho (Ligon, 1973). In fact, in much of their southern range, white-headed woodpeckers forage on trees that do not even occur in the northern parts of their range, such as sugar pine (*P. lambertiana*), Coulter pine (*P. coulteri*), and incense cedar (*Calocedrus decurrens*; Hilkevitch, 1974; Morrison et al., 1987). Thus, although accurate information on foraging is important for management, there is a lack of regionally appropriate data on white-headed woodpecker foraging with which to guide management plans in the northwestern U.S.A. In addition to this region-specific need, no past studies have examined habitat selection by foraging white-headed woodpeckers; past studies have only measured use or selection relative to tree-level characteristics (e.g., Raphael and White, 1984). Information on use alone can lead to biased conclusions on resources that are important for animals (Johnson, 1980). We also could find no past studies that examined demographic consequences of foraging decisions. Thus it is not known whether observed differences in foraging by white-headed woodpeckers may contribute to local population declines, which have been suspected in some areas (Garrett et al., 1996).

Given these information gaps, we designed a study to examine white-headed woodpecker foraging ecology in the northwestern U.S.A. We studied foraging behavior in areas used for concurrent research on woodpecker nest site selection and space use. These areas were subject to both historic timber harvest (∼10–80 years) and recent (<10 year) thinning and prescribed fire and contained little or no old growth forest. We had three objectives. First, we measured substrate use by white-headed woodpeckers in these managed forests during a six-month period that encompassed the incubation, nestling, fledgling, and post-fledgling periods in their annual cycle. Our goal was to characterize both substrate use and size of trees used for foraging in areas that had been harvested and/or burned, and which generally lacked the large trees (e.g., 68 cm diameter; Dixon, 1995a) considered important for foraging in other studies. Second, we modeled habitat selection by foraging white-headed woodpeckers during two time periods, the nesting period (combining the incubation and nestling periods) and post-nesting period (combining the fledgling and post-breeding autumn periods). Third, we examined whether differences in foraging behavior affected one important measure of population growth, number of young fledged from nests.

2. Materials and methods

2.1. Study area

We conducted this study from 2011 to 2013 in six study sites on the east slopes of the Cascade Range in central Washington State (approximately 46°45′N, 120°58′W and 47°30′N, 120°33′W). We selected sites in which white-headed woodpeckers were known to occur from past research, or in which reconnaissance surveys revealed breeding woodpeckers. Five of these sites were on U.S. Department of Agriculture, Forest Service land, and one site encompassed both state (Washington Department of Natural Resources, and Washington Department of Fish and Wildlife) and private lands.

Within each of our 6 study sites, forest composition varied based on aspect, slope, elevation, and longitudinal distance from the Cascade Crest. On most sites ponderosa pine was dominant or co-dominant with Douglas-fir (*Pseudotsuga menziesii*) or grand fir (*Abies grandis*). Other tree species included western larch (*Larix occidentalis*), quaking aspen (*Populus tremuloides*), and black cottonwood (*Populus trichocarpa*). We estimated that ⩾92% of the area within study sites had been harvested for timber at least once since 1950 based on United States Forest Service Timber Harvest activity reports and Washington State Department of Natural Resources forest practice applications (FPAs). Most harvests were described as overstory removal cuts (removal of entire mature overstory) or partial removal cuts (removal of part of the overstory). Age of the dominant forest layer in each sites was estimated at <100 years (Lorenz et al., 2015a). Approximately 10% of the area within each study site had been burned with mixed severity prescribed fire and/or thinned by harvest within 10 years of the start of this study. Two sites each were actively grazed by domestic cattle or sheep during summer.

2.2. Field methods

We used radio telemetry to collect foraging observations on white-headed woodpeckers. From March through May we searched for territorial, adult white-headed woodpeckers in our study sites by broadcasting playback calls and drumming. We randomly selected, without replacement, a subsample of woodpecker nest territories for radio tracking from those within the study sites used in each year. At these territories we captured male white-headed woodpeckers with playbacks using noose traps on taxidermy mounts, and captured male and female woodpeckers at nest sites using mist-nests, noose traps, and hoop nets. We fit one adult from each territory with a 1.2 g VHF transmitter (∼2% of body weight; Advanced Telemetry Systems, Islanti, MN) using an elastic leg-loop harness (Rappole and Tipton, 1991) or by gluing transmitters to a central tail feather. We alternated the sex that was radio tagged between territories to ensure equal representation by both sexes in our sample, and we radio tagged only one individual from each territory for independence among individuals. All activities were performed under University of Idaho Animal Use and Care protocol #2011-30.

We began tracking white-headed woodpeckers either with the onset of nest incubation or capture of an adult, whichever came first. We ended tracking either when adults shed their transmitters or with the first frost. During this period we monitored breeding status every 1–5 days by observing behavior of the adults and young (Jackson, 1977), inspecting nests with video inspection probes, and opening nests with a hole-saw (Ibarzabal and Tremblay, 2006). To estimate productivity, we checked nest contents using a hole saw or video inspection probe within 5 days of fledging and counted the number of nestlings. At a subsample of