The Wilson Journal of Ornithology 123(2):381–386, 2011

High Density Nesting of Black-backed Woodpeckers (*Picoides arcticus*) in a Post-fire Great Lakes Jack Pine Forest

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ABSTRACT.—A stand-replacing fire in 404 ha of jack pine (*Pinus banksiana*) and mixed pine forest in Michigan's Upper Peninsula in 2007 resulted in Black-backed Woodpeckers (*Picoides arcticus*) nesting at high density in 2008, the second possible nesting season post-fire. Nests were found within a 93-ha study area and a 19-ha stand (a subset of the 93-ha study area) in 199.5 survey hours concentrated in March–July. The 19-ha stand had six nests, a density of 0.31 nests/ha or 0.63 individuals/ha, while the 93-ha study area had 20 nests yielding 0.21 nests/ha or 0.42 individuals/ha. These nest densities are higher than previously reported in the literature for comparable stands, indicating a large influx of nesting woodpeckers post-fire. High nesting densities in this study may have resulted from: (1) optimal timing of the fire for wood-boring beetle exploitation of burned trees, (2) the discrete nature of burned habitat in the study due to impacts of salvage logging, or (3) our focus on regions of the burn where high nesting densities occurred, as the entire burned area (404 ha) was not included in nest density calculations. *Received 23 April 2010. Accepted 28 December 2010.*

The distribution of Black-backed Woodpeckers (*Picoides arcticus*) in the Upper Peninsula of Michigan is limited to relict glacial depression bogs, and boreal outwash plains occupying 7.3% of Michigan's total forest area, widely interspersed within the ubiquitous deciduous forest matrix (Dickman and Leefers 2003). Black-backed Woodpeckers occur at low densities in these habitats and are irregularly detected; there were only 10 confirmed breeding records in seven Upper Peninsula counties during Michigan's Breeding Bird Atlas of 1983–1988 (Evers 1991). However, Black-backed Woodpeckers have been shown to increase seven-fold in density and abundance following sporadic occurrence of wildfire (Dixon and Saab 2000). This led Hutto (1995) to propose burns may be source habitats and unburned forests may be sinks. This implies: (1) burns favor maximum reproductive performance, (2) newly augmented populations disperse from a burn following depletion of burn resources, and (3) populations wait out a ''stasis-period'' at low densities in sub-optimal, unburned forests, until a new fire prompts immigration to new high-quality habitat. Nappi and Drapeau (2009) found that nesting densities and abundance peak in the second year post-fire and rapidly decline after the third year because saproxylic insects used as prey require recently dead trees. This suggests an ephemeral relationship where fire, wood-boring insects, and woodpeckers peak and wane in accord.

On 29 April 2007, a controlled burn set 2 days previously in the Ottawa National Forest of Upper Michigan escaped control and heavily burned ~404 ha of mature jack pine (*Pinus banksiana*), mixed jack-red (*P. resinosa*)-white pine (*P. strobus*), and deciduous–coniferous forest on the Baraga Plains, ~22 km southwest of L'Anse, Baraga County, Michigan (centered at 46° 35′ 20″ N and 88° 36′ 56″ W). We made minor explorations of a selected area within the entire burn in June 2007 and increased the frequency of visits through fall and winter 2007–2008. We decided in March 2008

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to investigate densities of nesting Black-backed Woodpeckers using a 93-ha subset of the 404-ha burn during the 2008 breeding season, the second opportunity for nesting (second year) after the fire. Our objectives in this paper are to report: (1) very high nest densities, and (2) a summation of general nesting phenology and site characteristics.

METHODS

We located three Black-backed Woodpecker nests within the burn in 2007 during limited surveys immediately following the fire. The 93-ha study area was delineated in early 2008 and two and three times weekly, 2 to 7-hr surveys were made on foot to locate as many Black-backed Woodpeckers and nests as possible. We slowly searched the study area for nests during each survey, bisecting the habitat in a series of transects spaced at 20 to 40-m intervals. When a Black-backed Woodpecker was located, we attempted to infer from its behavior whether it was (1) paired and (2) near an active nest. We recorded the following data when nests were located: tree species, tree diameter at breast height (DBH), nest height, nest orientation, tree status (killed by fire, snag, etc.), and latitude and longitude. We revisited previously located nests during successive surveys recording data on nest phenology for: start of nest excavation, first young heard, last young in nest, and first date of no nest activity. The entire 93-ha study area was not completely covered during each day's survey, but cumulative visits over the entire area ensured systematic sampling. The nature of the habitat with relatively small, discrete blocks of burned pines with little understory vegetation, set within a matrix of burned clear-cuts, made it relatively easy to keep track of our location in relation to woodpeckers. The desire to find all Black-backed Woodpecker nests in the study area and limited hours available prevented following any one pair or nest intensively. We conducted surveys from 7 January 2008 through 7 December 2009 with 40 surveys totaling 160 hrs concentrated in March through July; 199.5 survey hrs were accumulated in the total survey period of January–December. A period from 28 May through 3 June had no surveys at all.

We used circular statistics (Rao's spacing test, U; mean vector length, r) following Rendell and Robertson (1994) for nest tree data to ascertain if nest entrance orientation was correlated with compass direction. Significance was set at $P <$ 0.05. Nest locations were also plotted, based on Global Positioning System (GPS) locations, to calculate accurate densities of nests within the study area (of known area). We were able to calculate the actual density of nesting individuals/ha in the 93-ha study area (and a 19-ha subset of the 93-ha study area where nests were densest) based on documentation of woodpecker pairs at each nest cavity.

RESULTS

Twenty active Black-backed Woodpecker nests were found in 2008 within the 93-ha study area (Fig. 1). Thirty percent of the 20 nests ($n = 6$) were confined to a discrete 19-ha subset of the 93-ha study area, and another was in a clear-cut just outside the 19-ha stand (Fig. 1). One active nest was also found during a 1-hr survey through a stand of mature jack pine ~1 km outside the burn and study area. The overall nest density for the entire 93-ha study area was 0.21/ha, while the 19-ha stand had a nest density of 0.31/ha and also included a successful Hairy Woodpecker (*Picoides villosus*) nest.

The first date of nest excavation was 24 March (Table 1). One nest failed before young were heard (4 June), two nests failed after young were heard (21–26 June) and 17 nests advanced to the stage of single large young visible in the nest entrance (16–26 June). No evidence of nest failure was observed at the 17 remaining nests during the next nest survey, and we projected fledge date estimates for each of the 17 nests, based on the median date between surveys (Table 1). The first young heard in nests were on 4 June and the last young observed in nests were on 29 June. The intermittent nature of visits to each nest (not all nests were visited each survey day), the non-intrusive observation methods, and the 7-day gap in late May and early June limit the exact delineation of nesting phenology.

Nest heights in the 93-ha study area ranged from 0.71 to 8.32 m with a mean $\pm$ SD of 3.18 $\pm$ 2.25 m. Nest tree diameter at breast height (DBH) ranged from 16.51 to 40.64 cm with a mean $\pm$ SD of 23.62 $\pm$ 5.82 cm (Table 1). Eighteen of 20 located nests (90%) were in jack pines, of which 77% were killed by the 2008 fire (Table 1). Orientation of nest entrances did not vary significantly with respect to compass direction, indicating nests were randomly distributed within a 360° field (Rao's $U = 133.85$, $P > 0.10$); mean vector length was

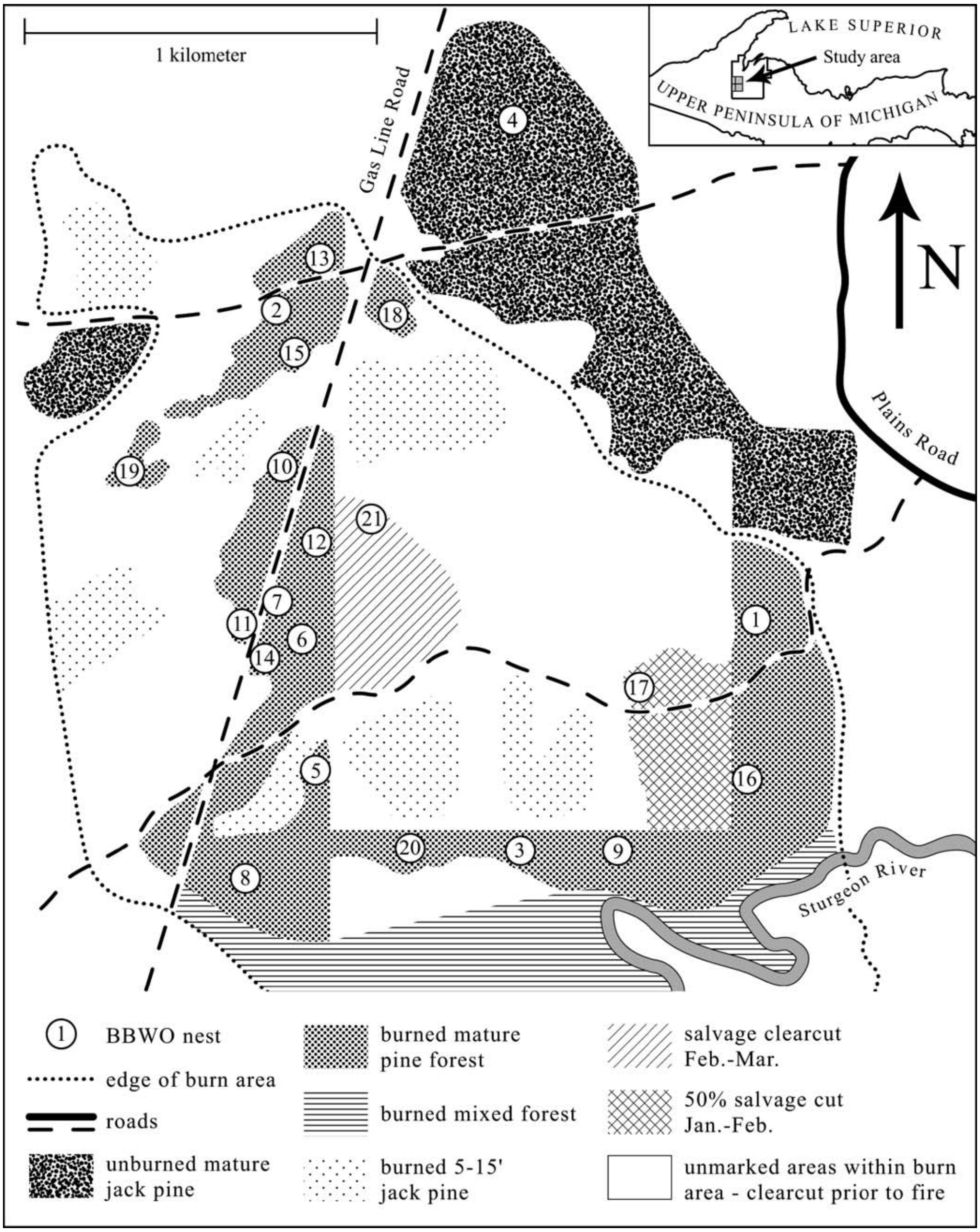

FIG. 1. Black-backed Woodpecker nest locations within a 93-ha study area consisting of burned mature pine forest on the Baraga Plains, Baraga County, Michigan. 2008.

also low, indicating nests were widely dispersed ($r = 0.228$, mean vector angle = 225.9°).

DISCUSSION

Prior to the 2008 burn, Black-backed Woodpeckers were present as rare permanent residents in the general burn area on the Baraga Plains, nesting in small numbers (single nests found in 1999 and 2000) in mature jack pine stands (Binford 2006). Our data indicate high densities of Black-backed Woodpeckers nesting in the 93-ha and 19-ha study areas in comparison to

TABLE 1. Black-backed Woodpecker nest parameters within a 93-ha study area consisting of burned mature pine forest on the Baraga Plains, Baraga County, Michigan. 2008. Projected June fledge dates indicate an estimated date of fledging ± half the number of days between last young heard and date of empty nest.

Nest number	Date of discovery	Date of 1st young heard	Projected June fledge date (days)	Species of nest tree [a]	Type of nest tree [b]	DBH of nest tree (cm)	Orientation of nest opening (°)	Height of nest cavity (m)	Nest outcome
1	21 Apr	4 June	24.5 ± 1.5	JP	KBF	19.05	156	1.82	Fledged
2	5 June	23 June	Failed	JP	Snag	22.86	0	7.31	Failed
3	12 May	10 June	24.5 ± 1.5	JP	KBF	25.4	117	8.32	Fledged
4[c]	16 June	16 June	30.0 ± 1.0	JP	Dead	31.75	144	5.18	Fledged
5	21 Apr	4 June	17.5 ± 1.5	JP	DBF	24.13	269	1.52	Fledged
6	12 May	5 June	24.5 ± 1.5	JP	KBF	17.78	246	3.04	Fledged
7	14 Apr	5 June	17.5 ± 1.5	JP	DBF	17.78	104	3.65	Fledged
8	16 June	16 June	27.5 ± 1.5	JP	KBF	30.48	290	6.40	Fledged
9	7 Apr		Failed	JP	KBF	22.86	223	4.87	Failed
10	14 Apr	4 June	17.5 ± 1.5	JP	KBF	16.51	237	1.95	Fledged
11	12 May	5 June	20.0 ± 1.0	JP	KBF	24.13	293	1.52	Fledged
12	12 May	5 June	17.5 ± 1.5	JP	KBF	24.13	244	1.16	Fledged
13	1 May	4 June	22.0 ± 1.0	JP	KBF	21.59	291	1.21	Fledged
14	4 June	10 June	30.0 ± 1.0	JP	KBF	24.13	250	0.71	Fledged
15	24 March	5 June	17.5 ± 1.5	JP	KBF	27.94	42	3.04	Fledged
16	14 June	14 June	24.5 ± 1.5	JP	KBF	30.48	225	5.18	Fledged
17	8 June	8 June	22.0 ± 1.0	WP	Snag	40.64	167	2.26	Fledged
18	5 June	14 June	27.5 ± 1.5	JP	KBF	16.51	74	1.39	Fledged
19	8 June	10 June	Failed	RP	Snag	20.32	152	0.93	Failed
20	21 Apr	16 June	24.5 ± 1.5	JP	KBF	26.67	67	4.87	Fledged
21	19 June	19 June	30.0 ± 1.0	JP	Snag	19.05	309	2.43	Fledged

[a] JP = Jack Pine, WP = White Pine, RP = Red Pine.
[b] KBF = killed by fire, DBF = dead before fire, Snag = dead long before fire, Dead = dead (but not within burn area).
[c] Nest # 4 was outside the burn area.

the pre-fire forest in March–July 2008, the second breeding season post-fire. Greater food resources per unit of area may be available in burned rather than unburned forests as wood-boring beetles (*Cerambycidae*) capitalize on fire-killed or weakened trees, laying large quantities of eggs which hatch in the cambium as first-instar larvae the first year post-fire (Holsten et al. 1980). Wood-boring beetle larvae are one of the most common prey items of Black-backed Woodpeckers in unburned forests (Dixon and Saab 2000). However, our data support the conclusions of numerous researchers that Black-backed Woodpeckers occur at higher densities in burned forests (Heinselman 1973, Hutto 1995, Murphy and Lehnhausen 1998), most likely because of higher abundance of beetle larvae. We believe the densities in our study for both the 93-ha study area and 19-ha stand are the highest reported in the literature: 0.42 and 0.63 individuals/ha, respectively (2 birds/located nest). These values are 1.68 and 2.52 times higher than the highest reported density of 0.25 individuals/ha in a 67-ha plot of mature white spruce (*Picea glauca*) at a recent burn periphery (Murphy and Lehnhausen 1998). A study by Apfelbaum and Haney (1981) yielded a density of 0.1 individuals/ha higher than the density in our 19-ha stand (0.64 vs. 0.63), but the small area sampled (6.25 vs. 19 ha) and low number of individuals (4 vs. 12) lead us to discount this density from direct comparison. A more comparable 15 individuals/40 ha in uncut burned spruce in central Montana (Dixon and Saab 2000) gives a density of 0.38, slightly lower than the density in our 93-ha study area. Our data indicate a nest density nearly twice as high as recorded in severely burned spruce forest in Quebec (Nappi and Drapeau 2009). It is possible that burned jack pine provides a richer prey base than spruce, leading to higher nesting densities. Higher nest density in our study occurred in a stand of pure burned jack pine compared with stands of mixed pines (jack, white, and red).

Several factors may influence the densities in our study. Black-backed Woodpeckers were observed to do most of their foraging within the burned mature stands, but were also observed foraging outside those stands, indicating a larger area was being used than the 93 ha intensively studied. Conversely, we found an active Black-backed Woodpecker nest in a clear-cut 100 m outside the 19-ha stand and these birds moved into the 19-ha stand to forage. Prior to salvage logging in late April-early March 2008, the 19-ha stand of mature burned jack pine was actually a 35-ha stand (Fig. 1). Sixteen of the 35 ha were clear-cut at that time, creating the 19-ha stand studied. This sudden reduction of habitat early in the breeding season may have introduced an artificial constraint on Black-backed Woodpeckers using the burn, causing pairs to establish nests at higher densities in the remaining 19 ha. Hairy Woodpeckers were also observed displacing Black-backed Woodpeckers from foraging sites during eight of 13 interspecific contacts, partially supporting the observations of Villard and Beninger (1993) that Black-backed Woodpeckers may compete with other *Picoides* woodpeckers for food resources in a burn. Black-backed Woodpeckers were only observed to displace Hairy Woodpeckers five times, all within 50 m of an active Black-backed Woodpecker nest.

The earliest date of nest excavation (24 March) is slightly earlier than reported excavation phenologies (Dixon and Saab 2000). Continued monitoring after nests in the study area were located indicated an 85% projected fledging success rate during the second possible breeding season after the fire (2008). Nests were initially located on surveys at different stages during breeding development, precluding precise delineation of nesting phenology, but projected mean fledge dates in successful nests had a fairly high synchronicity with a standard deviation of 4.41 days over a 14-day range. The high proportion of jack pines selected for nests may be misleading as a majority of nests located in the burn were in stands dominated by mature jack pine. Compass direction was apparently not a key factor in nest entrance placement, although the relatively small sample size may have masked statistical trends.

We believe the high nest densities in this study raise several intriguing questions beyond the scope of the present study. We do not know if high-density nesting, as found in this study, is actually the standard post-fire breeding strategy, or whether individual characteristics of this burn caused the uncommonly high density. Research that may have implications for the high nesting densities in our study, indicates that *Picoides* woodpeckers' saproxylic insect prey are most abundant in trees of early stage decay-classes, limited to recently dead conifers (Saint-Germain et al. 2007). Timing of the fire immediately following snowmelt in early April, may have presented optimal resources to saproxylic insects at a critical point in their life history: following adult emergence 1–3 months after the fire, they were able to quickly exploit the high-quality, freshly-burned substrate, establishing high larval densities that could be used by Black-backed Woodpeckers in the second year post-fire. Burns that occur later in the summer or fall may miss the window for heavy insect colonization the first year after the fire, decreasing the probability that high larval loads are ever established, and limiting woodpeckers to larger range sizes and lower densities. It is also possible the burned habitat in our study area, chiefly mature jack pine forest focused by timber cutting into discrete stands, provided a rich but confined food source for both wood-boring beetles and woodpeckers.

Previous Black-backed Woodpecker studies have generally reported nest densities over the entire burned area regardless of where nests are actually distributed, implying a constant nest density per hectare even in unsuitable habitat. Where high-density nesting occurs, nest densities (not foraging densities) in this format do not reflect the actual clustering of Black-backed Woodpecker nests in a discrete region of a burn. A more precise approach, accurately describing the spatial proximity of nests, would: (1) calculate density via a ''best fit'' approach, delineating a burned area around which a maximum number of nests can be confined (as in this study); or (2) use spatial analysis (point pattern analysis) to correlate nests to an exact area. We believe factors influencing Black-backed Woodpecker nest site selection within a burn could be more easily identified using either of these methods.

We question if the source-sink model described by Hutto (1995) may have limited application to Black-backed Woodpecker dynamics in the Upper Peninsula (near the southern range terminus of the species), where the fire interval is high due to both the isolated geographical nature of pyrophilic boreal forests (surrounded by mesic deciduous forest) and anthropogenic fire suppression (Dickman and Leefers 2006). The fire response distance of Black-backed Woodpeckers in this region would have to be very great for burns to provide the only productive habitat, which are both too infrequent and limited in size to support a high proportion of the total breeding population. Mature and old growth coniferous forests with large numbers of snags in early decay classes may sustain habitat alternatives in unburned forests (Nappi and Drapeau 2009). Burns in the Upper Peninsula of Michigan are likely the optimum habitat (a source), but moderate population-level replacement probably occurs outside of them, as suggested as an alternate model by Hutto (1995). Additional studies in a wide variety of burned habitats and geographic locations within the Black-backed Woodpecker's range are necessary to further identify patterns in nesting density, specifically: (1) reasons for spatial clumping of nests in particular regions of burned forest, and (2) an evaluation of whether unburned forests are sinks, comparing productivity of Black-backed Woodpeckers in burned versus completely unburned old-growth boreal forests.

ACKNOWLEDGMENTS

We thank Jerry Edde for assistance with the field work and Melinda Stamp for the producing the map. We also appreciate the comments of J. A. Jackson and two anonymous reviewers who reviewed the manuscript, and provided many helpful suggestions. Scott Hickman provided valuable expertise on several ornithological questions.

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