Holthausen 1993). Each study area was 1457-1624 ha in size, in mixed coniferous forests, and at 900-1800 m elevation. The study areas contained a mosaic of uneven-aged stands with a range of timber harvest activity; 30-90% of each study area had been harvested (partial overstory removal or regeneration cuts) in the past 30 yr.

I radio-tagged 23 adults in June 1989, one in July 1998, one in November 1998, and six in May and June 1990. Three juveniles (hatched in May but independent of adults at capture) were radio-tagged in September 1989, December 1989, and August 1990. Each bird was equipped with an 11-g transmitter (3-4% of body mass), lasting 5-6 mo. Each transmitter was attached with a backpack harness made of 6-mm tubular Teflon and in a figure-8 configuration with the loops sewn together over the breast bone. Birds captured in the early summer were recaptured once at roost trees in November and December 1989 or 1990 to replace transmitters. Birds captured in the fall were recaptured at nests the following spring. Transmitters were removed from birds at nest or roost trees after monitoring each individual for 5-12 mo. Each radio-tagged bird was located 2-3 times/week from July through September and once each week from October until March.

Thirteen nestling Pileated Woodpeckers from seven nests were radio-tagged within 1 wk of fledging in 1990 with a 2-g transmitter (1 % of body mass) glued to the skin and feathers on their back. The transmitters lasted 4 wk, so these juveniles were recaptured at roost trees after 3 wk, and a 6-g transmitter (3% of body mass) was attached with a backpack harness. Juveniles were located once a week until mid-October.

Survival was estimated for adult Pileated Woodpeckers using the Kaplan-Meier method with a staggered entry of individuals (cf. Pollock et al. 1989). Sample size limited survival estimates to all adult Pileated Woodpeckers without separating by sex.

RESULTS

The probability of survival of adult Pileated Woodpeckers was 0.60 after 6 mo, 0.47 at 12 mo, and 0.35 at 18 mo (Fig. 1) . Of the 31 adults, 14 were killed during the period they were monitored; the fate of one individual was unknown; and one died when its bill caught under the harness. Of the 14 that were killed, seven died between October and February 4-8 mo after radio-tagging; five died in June within 3 wk of radio-tagging; and two died in July after 12 mo of monitoring. The 5 killed in June comprised 17% of the birds radio-tagged that month, and all were still feeding nestlings when killed. At least five adults were killed by accipiters based on evidence found at a pluck site or under a Northern Goshawk *(Accipiter gentilis)* nest; one carcass was observed being carried by an unidentified hawk; coyote *(Canis latrans)* tracks were found at prey remains of one; and only the radio and intact harness were found in seven cases.

Of the three juveniles captured in late summer or fall (two in 1989 and one in 1990), two survived to breed the following year, and the remains

Adult survivorship in the present study was lower than that observed between 1975 and 1983 with 28 color-banded birds. In addition, adult survivorship was less than recruitment of young into the breeding population, assuming a nest success of 83% and average brood size (within 1 wk of fledging) of 2.26 (SD = 0.66) as reported by Bull and Meslow (1988). There are several factors that could partially explain the low survival in the present study. Transmitters may have affected survival. Some adults were observed pecking at the harness within a week of attachment, which may have increased their vulnerability to predation. However, researchers conducting a telemetry study on Pileated Woodpeckers on the Olympic Peninsula did not believe transmitters affected survival (C. M. Raley, pers. comm.). A second explanation for the difference in survival estimates may be the variability in habitat quality between the two studies. A higher proportion of all study areas in the present study had been harvested within 30 yr, resulting in less cover in the overstory canopy and fewer large-diameter snags (Bull and Holthausen 1993) than the study area used during 1975-1983 (Bull and Meslow 1988). Vulnerability to predation likely increases as overstory canopy decreases. A third explanation is the variability observed in annual survivorship rates from year to year as reported by Stacey and Taper (1992) for the Acorn Woodpecker. Mortality may be more pronounced one year for Pileated Woodpeckers because alternative prey sources of predators are less available.

Survival rates for species like the Pileated Woodpecker are difficult to obtain because of the challenge of capturing and monitoring a large sample size for a sufficiently long period to obtain an accurate estimate. Additional demographic research on this species in a variety of habitats and geographic locations is warranted to provide managers with information needed to maintain viable populations across landscapes.

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