Capes/Meadows/

BUNN, D. S., A. B. WARBURTON, AND R. D. S. WILSON. 1982. The Barn Owl. T. and A. D. Poyser, London.

CRAMP, S. [ED.] 1985. The birds of the Western Palearctic. Vol. IV. Oxford Univ. Press, Oxford.

DOR, M. 1947. Examination of the food of the Barn Owl in Israel. HaTeva VeHaaretz 7:337–344, 414–419. (In Hebrew)

DUKE, G. E., O. A. EVANSON, AND A. JEGERS. 1976. Meal to pellet intervals in 14 species of captive raptors. Comp. Biochem. Physiol. 53A:1–6.

GLUE, D. E. 1967. Prey taken by the Barn Owl in England and Wales. Bird Study 14:169–183.

GLUE, D. E. 1971. Avian predator pellet analysis and the mammologist. Mammal Rev. 21:200–210.

HANNEY, P. 1962. Observation on the food of the Barn Owl in southern Nyasaland and a method of ascertaining population dynamics of rodent prey. Ann. Mag. Nat. Hist. 6:705–713.

MENDELSSOHN, H., AND Y. YOM-TOV. 1987. Body and skull measurements of Israeli mammals. Society for the Protection of Nature and Ministry of Defense Publishing House, Tel Aviv. (In Hebrew)

MIKKOLA, H. 1983. Owls of Europe. T. and A. D. Poyser, London.

PERRIN, M. R. 1982. Prey specificity of the Barn Owl in the Great Fish River valley of the Eastern Cape Province. S. Afr. J. Wild. Res. 12:14–25.

SCHMIDT, A. 1977. Zur Ernährungsökologie der Schleiereule, *Tyto alba* Scopoli. Beiträge Vogelkd. 23: 235–244.

SIMON, J. L. 1995. Resampling Stats software. Resampling Stats Inc., Arlington, VA.

SOKAL, R. R., AND F. J. ROHLF. 1995. Biometry. 3rd ed. W. H. Freeman, New York.

STEYN, P. 1983. Birds of prey of southern Africa. David Philip, Cape Town.

YOM-TOV, Y. 1991. Character displacement in the psammophile Gerbillidae of Israel. Oikos 60:173–179.

The Condor 99:976–980

TERRITORIAL RESPONSES OF BOREAL FOREST BIRDS TO HABITAT GAPS[1]

JEAN-FRANÇOIS RAIL[2]
Centre d'Études Nordiques et Département de Biologie, Université Laval, Ste-Foy, Québec, G1K 7P4, Canada

MARCEL DARVEAU AND ANDRÉ DESROCHERS
Centre de Recherche en Biologie Forestière et Département des Sciences du Bois et de la Forêt, Université Laval, Ste-Foy, Québec, G1K 7P4, Canada

JEAN HUOT
Centre d'Études Nordiques et Département de Biologie, Université Laval, Ste-Foy, Québec, G1K 7P4, Canada

Abstract. We used playback trials to determine whether birds will cross treeless gaps to respond to simulated territorial intruders. We evaluated the effect of gap width on responses by five forest bird species. We found that for forest specialists such as the Swainson's Thrush (*Catharus ustulatus*), Golden-crowned Kinglet (*Regulus satrapa*), and the Black-throated Green Warbler (*Dendroica virens*), the probability of crossing gaps decreased sharply with gaps 25–40 m wide. By contrast, control trials showed no significant decrease in their probability of response up to 100 m through continuous stands. Habitat generalists such as the White-throated Sparrow (*Zonotrichia albicollis*) and the Dark-eyed Junco (*Junco hyemalis*) were more prone to cross treeless gaps than forest specialists. Playback studies provide a new tool for understanding birds' responses to microscale habitat discontinuities.

Key words: boreal, breeding birds, forests, forest gaps, logging, Québec, territorial response.

In forest-dominated landscapes, forestry roads, water bodies, and small scale clearcuts are often abundant. Should we consider forests featuring these relatively narrow gaps as continuous breeding habitat for birds? Small-scale forest fragmentation may not alter population processes like dispersal and recolonization by birds, but few studies address its impact on avian activities such as territorial defense. Songbirds may exhibit variation in their behavioral response to habitat gaps depending upon gap width and species involved. For example, it is likely that < 5-m wide gaps in the

[1] Received 13 January 1997. Accepted 24 July 1997.
[2] Present address: Canadian Wildlife Service-Québec Region, P.O. Box 10 100, Ste-Foy, Québec, G1V 4H5, Canada. e-mail: jean-francois.rail@ec.gc.ca

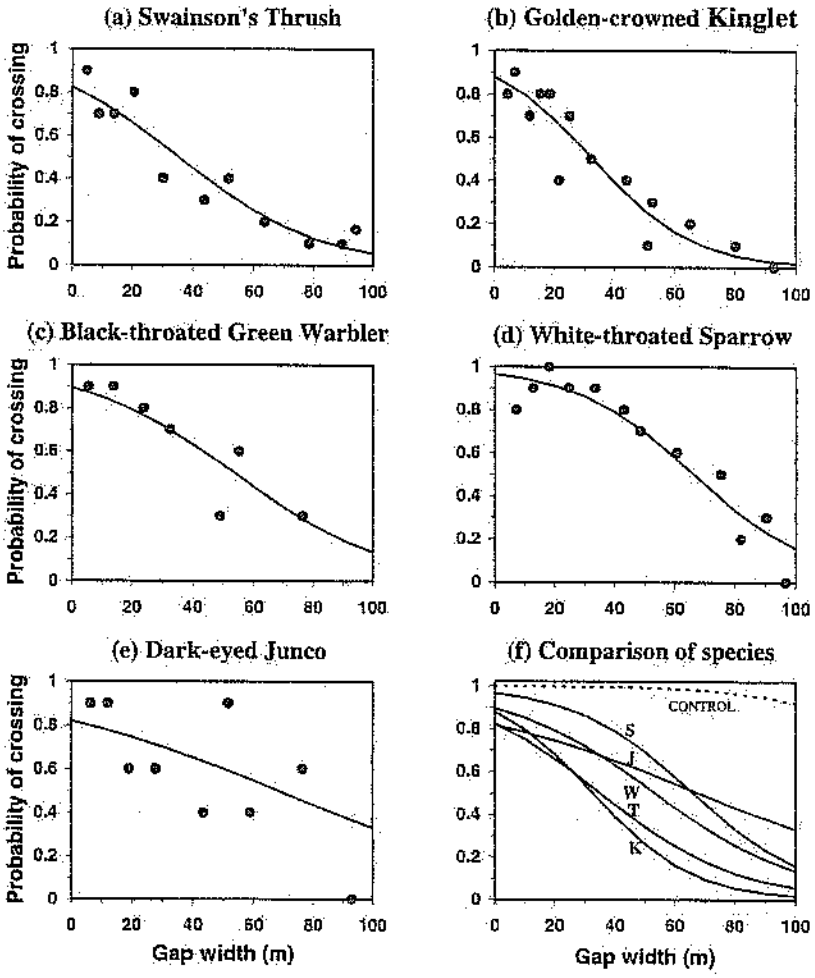

FIGURE 2. Probability of birds' response according to gap width, Forêt Montmorency area, Québec. Curves were fitted using parameters calculated by the logistic regression procedure. Each dot represents the observed proportion of responses in 10 calling trials (a–e). In (f), comparison among species, and with the control curve representing the combined probability of response of the three forest specialists (warbler, thrush, and kinglet) in continuous mature stands.

A year effect on birds' responses was detected for thrushes only ($P = 0.02$).

DISCUSSION

Our results show that the probability of gap-crossing by territorial forest specialists was strongly affected by relatively narrow gaps (< 40 m) in the canopy. These birds were not prone to cross a gap to resume territorial defense. Habitat generalists had response curves similar to, although statistically different from, those of forest specialist birds. In this study and concurrent studies in the same region, we found White-throated Sparrow and Dark-eyed Junco territories (Darveau et al. 1995) and nests (Darveau et al. 1997) in clearcuts, road sides, powerline right-of-ways, and nature trails. Thus, we hypothesized that territorial defense in these species would be less affected by canopy gaps, and our results seem to confirm that. However, because no control trials were done with those species, we cannot determine whether their apparent decrease in response with larger gaps is due to a real gap effect or simply to limited territory size. Further investigations on territorial behavior of habitat generalists would be interesting from a general perspective, but we chose to concentrate our efforts on the forest specialists, which are well known to be negatively affected by forest fragmentation.

Threshold analyses confirmed that treating gap width as a dichotomous variable was as informative as treating it as a continuous metric. Furthermore, this approach enabled us to estimate gap widths where birds' responses changed most rapidly. In this study, the critical gap widths of the three forest specialists were similar (between 25–40 m). Surprisingly, White-throated Sparrows were strongly influenced by gaps, although at larger widths (65–70 m). Perhaps this response expresses their smaller territory size (Martin 1960, Erskine 1977) rather than a gap effect. Responses of Dark-eyed Juncos did not seem to vary abruptly at any gap width, suggesting that gaps did not

have a strong influence on territorial response in this species. However, in juncos and, to some extent, in Black-throated Green Warblers, the relatively low percentage of explained variance might be linked to the lower sampling effort (n = 79–81) compared to the three other species (n = 117–143).

Previous studies on forest-interior species reported decreased densities near treeless corridors 8–23 m wide (Rich et al. 1994), minimal use and edge avoidance of large gaps (Ferris 1979, Chasko and Gates 1982, Kroodsma 1984), and the fact that distinct edges function as a natural territorial boundary for many bird species (Chasko and Gates 1982, Tuomenpuro 1989). However, to our knowledge, our study is the first to address empirically the effect of habitat gap width on territorial bird behavior. Even though playbacks may sometimes attract birds outside their usual territories (Falls 1981), our method allowed us to quantify the relationship between the decision of crossing and gap width.

Our study was not designed to measure typical fragmentation effects such as impeded bird dispersal and recolonization (Wilcox and Murphy 1985, Desrochers and Hannon 1997), increased brood parasitism (the Brown-headed Cowbird, *Molothrus ater*, is absent from our study area), or nest predation. Nevertheless, our behavioral approach could be used in fragmentation studies to determine species-specific definitions of a discrete forest fragment (Rich et al. 1994). Data on the effect of gaps also can help build and improve models that assess the effects of changes in the landscape on birds.

We thank M.-H. Michaud and F. Bédard for their assistance in the field, and J-P. L. Savard for his advice and for reviewing a preliminary draft of this manuscript. This study was funded by the forestry practices component of Natural Resources Canada's Green Plan, the Forêt Montmorency, the Daishowa Company, the University Research Support Fund of Environment Canada, with contributions from the Centre d'Études Nordiques of Laval University, the Canadian Wildlife Service (Québec region), and the Natural Sciences and Engineering Research Council of Canada (NSERC). The first author benefited from a Masters Degree Scholarship awarded by Wildlife Habitat Canada.

LITERATURE CITED

BEAUCHESNE, P. 1991. Effets de la largeur de la bande riveraine de protection sur l'abondance et la diversité de la faune dans la sapinière boréale. M.Sc. thesis, Université Laval, Ste-Foy, Québec, Canada.

CHASKO, G. C., AND J. E. GATES. 1982. Avian habitat suitability along a transmission line corridor in an oak-hickory forest region. Wildl. Monogr. 82:1–41.

CHRISTENSEN, R. 1990. Log-linear models. Springer-Verlag, New York.

DARVEAU, M., P. BEAUCHESNE, L. BÉLANGER, J. HUOT, AND P. LARUE. 1995. Riparian forest strips as habitat for breeding birds in the boreal forest. J. Wildl. Manage. 59:67–78.

DARVEAU, M., L. BÉLANGER, J. HUOT, É. MÉLANÇON, AND S. DEBELLEFEUILLE. 1997. Forestry practices and the risk of bird nest predation in a boreal coniferous forest. Ecol. Appl. 7:572–580.

DAVIES, N. B., AND A. I. HOUSTON. 1984. Territory economics, p. 148–169. *In* J. R. Krebs and N. B. Davies [eds.], Behavioural ecology: an evolutionary approach. 2nd ed. Blackwell Scientific, Oxford.

DESROCHERS, A., AND S. J. HANNON. 1997. Gap crossing decisions by forest songbirds during the post-fledging period. Conserv. Biol., in press.

ERSKINE, A. J. 1977. Birds in boreal Canada: communities, densities, and adaptations. Tech. Rep. Ser. No. 41. Canadian Wildl. Serv., Ottawa, Ontario, Canada.

FALLS, J. B. 1981. Mapping territories with playback: an accurate census method for songbirds. Stud. Avian Biol. 6:86–91.

FERRIS, J. B. 1979. Effects of Interstate 95 on breeding birds in northern Maine. J. Wildl. Manage. 43: 421–427.

KROODSMA, R. L. 1984. Effect of edge on breeding forest bird species. Wilson Bull. 96:426–436.

LIMA, S. L., AND L. M. DILL. 1990. Behavioral decisions made under the risk of predation: a review and prospectus. Can. J. Zool. 68:619–640.

MARTIN, N. D. 1960. An analysis of bird populations in relation to forest succession in Algonquin Provincial Park, Ontario. Ecology 41:126–140.

MELEMIS, S. M., AND J. B. FALLS. 1982. The defense function: a measure of territorial behavior. Can. J. Zool. 60:495–501.

RICH, A. C., D. S. DOBKIN, AND L. J. NILES. 1994. Defining forest fragmentation by corridor width: the influence of narrow forest-dividing corridors on forest-nesting birds in southern New Jersey. Conserv. Biol. 8:1109–1121.

SIEVING, K. E., M. F. WILLSON, AND T. L. DE SANTO. 1996. Habitat barriers to movement of understory birds in fragmented south-temperate rainforest. Auk 113:944–949.

TUOMENPURO, J. 1989. Habitat preferences and territory size of the Dunnock *Prunella modularis* in Southern Finland. Ornis Fennica 66:133–141.

WIENS, J. A., C. S. CRAWFORD, AND J. R. GOSZ. 1985. Boundary dynamics: a conceptual framework for studying landscape ecosystems. Oikos 45:421–427.

WILCOX, B. A., AND D. D. MURPHY. 1985. Conservation strategy: the effects of fragmentation on extinction. Am. Nat. 125:879–887.