Nest Sites and Reproductive Success of the Barred Owls (*Strix varia*) in Michigan

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Abstract.—During 1976-1995 we monitored 114 Barred Owl (*Strix varia*) breeding attempts in northern Michigan. We describe nest sites and report reproductive success for different types of nest sites. Most natural nest sites were tree cavities caused by decay at places where a limb or tree top had broken off. The mean d.b.h. of cavity trees (N = 18) was 48 cm and mean cavity floor area (N = 19) 508 cm^2. Overall, 75 percent of breeding attempts were successful with a mean brood size (N = 75) of 1.97 young/productive nest. Owls nesting in tree cavities (N = 49) and in boxes (N = 52) showed similar productivities. While 80 percent of nests in cavities and boxes combined were productive with mean brood size (N = 81) of 2.01 young/productive nest, only 31 percent of breeding attempts in hawk nests and other open sites (N = 13) were successful with mean brood size (N = 3) of 1.0 young/productive nest. Owlets falling from open nests prematurely, before they were able to climb, is seen as the principal cause of poor productivity. The critical importance to Barred Owls of large trees and snags with cavities is emphasized in their management.

Among the five species of large owls which breed in North America, the Barred Owl (*Strix varia*) is the least well studied. Early accounts of its life history (Bent 1938) include some qualitative information on nest sites and habitat, anecdotal observations of behavior, good data on clutch size, but nothing on breeding success. Most ornithologists at that time were egg collectors and thus a study of "nesting habits" usually ended with the discovery of the nest and collection of the clutch. Following the introduction of nonlethal techniques by Errington (1930, 1932a), food habits studies were in the forefront during the ensuing decades (Errington 1932b, Errington and McDonald 1937, Hamerstrom and Hamerstrom 1951, Korschgen and Stuart 1972, Mendall 1944, Wilson 1938).

Most recent research involving Barred Owls has concerned habitat use, territoriality, relationships with the Great Horned Owl (*Bubo virginianus*) (Bosakowski 1994, Bosakowski *et al*. 1987, Devereaux and Mosher 1984, Elody and Sloan 1985, Fuller 1979, Laidig and Dobkin 1995, McGarigal and Fraser 1984, Nicholls and Fuller 1987, Nicholls and Warner 1972, Yannielli 1991), and range expansion into the Pacific Northwest (Dunbar *et al*. 1991, Hamer *et al*. 1994, Taylor and Forsman 1976). The population dynamics of this widespread and still at least locally common species have not been studied at all and even such basic information as mortality and reproductive rates remain unavailable. The only information on Barred Owl reproductive success we found in the literature is in the papers by Devereaux and Mosher (1984), Dunstan and Sample (1972), and Johnson (1987).

Our objectives were (1) to describe Barred Owl nest sites and cavity trees to determine the range of cavity and tree sizes these owls require for nesting, and (2) to determine reproductive success for nests in tree cavities, nest boxes, and open nests.

STUDY AREA AND METHODS

Study Area

Most observations were from two study areas in Alpena County in the northeastern Lower Peninsula of Michigan (fig. 1). The easterly area, approximately 28 km^2, was located 11 km

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Figure 1.—*Map of Michigan showing the locations of Barred Owl* (Strix varia) *study areas and of single breeding territories included in this study.* ✪ = *study area (see text);* ● = *one breeding territory;* ● = *three breeding territories.*

west of Alpena along both sides of an 11 km stretch of the Lower South Branch Thunder Bay River (LSBTBR) and tributary streams. The riparian habitat was mature riverbottom forest (silver maple, elm, ash); away from the river the forest cover was a patchwork of swampy deciduous/conifer mix, aspen-birch, and oak and pine on higher ground. The larger, but less intensively searched westerly area was centered on two large sportsmen's clubs near Fletcher Pond on the Alpena-Montmorency county line; the forest cover there was mainly second-growth sugar maple-beech with some aspen-birch stands and conifer swamp edge. Nests found opportunistically outside of these two study areas were situated in mature hardwood or mixed forest stands; one open nest was in a pine stand.

METHODS

Nests—natural and boxes—were checked at least twice each breeding season, the first time during April or early May to determine breeding activity. Adult owls seen sitting low in shallow cavities or open nests were assumed to be breeding, as were adults which came out of a cavity or box when the tree trunk or box was tapped or scratched with a stick. We located several cavity nests when adults became agitated and hooted at us when we came close to the nest site. The second visit was undertaken about the third week of May to determine reproductive success, band the young, sketch, describe and measure the nest site (if a tree cavity), and identify or collect prey remains and pellets. If the young were still too small (<2.5-3 weeks) the site was visited later. Our techniques were inadequate for assessing nonbreeding territorial pairs and possibly missed a few early nest failures. Nonbreeding pairs are hard to separate from pairs which may have moved to new, yet undiscovered tree cavities.

Terminology related to reproduction follows that of Postupalsky (1974) with some modifications. A breeding attempt means that eggs were laid or incubation behavior by an adult was observed. A successful attempt or productive nest is one in which at least one young was raised to fledging or near fledging age. Because nonbreeding pairs were not included in this study, productivity here means young/breeding attempt rather than young/territorial pair.

Scheller installed the first nest box in February 1979 after a previously used natural cavity in a dead stub had deteriorated beyond use and the owls had made two unsuccessful breeding attempts in a Red-shouldered Hawk (*Buteo lineatus*) nest nearby. The owls accepted the box the very first year. He then placed several additional boxes in the area, however, it wasn't until 1985 that any of them were accepted by owls. Over the years he has installed 20 boxes for Barred Owls, 18 in the eastern study area west of Alpena and two near Lachine. In 1983 and 1985 we installed 10 boxes built by Papp: eight in the Fletcher Pond study area, one near Lachine and one in southeastern Cheboygan County. Most boxes were placed within recently occupied breeding territories, preferrably where owls had used open nests or deteriorating natural cavities. Several were placed near where owls were seen or heard or in what we judged to be suitable habitat. Papp's boxes measured 30.5 x 25.4 cm on the inside, were 61 cm deep and open on top. Scheller's boxes were approximately 29 x 29 x 60 cm inside and were partially roofed-over; the entrance hole was partly in the roof and partly in the top of one side wall, or on a corner formed by the roof, one side wall and the front wall. All boxes were attached to deciduous trees, 5-6 m above ground.

In 1983 we started sketching and measuring tree cavities and cavity trees and snags used by Barred Owls. These measurements included:

1. Diameter at breast height (d.b.h.) of cavity tree or snag (cm);
2. Tree or limb diameter at the cavity (cm);
3. Height above ground, measured to the lowest point of cavity entrance (m);
4. Cavity depth, measured from lowest point of cavity entrance to cavity floor (cm);
5. Mean inside diameter of cavity, obtained by averaging the widest and narrowest inside measurements taken as close to the floor as possible (cm);
6. Cavity floor area (cm^2).

RESULTS AND DISCUSSION

We recorded 117 breeding attempts and determined breeding success for 114. Of these, 88 (77 percent) occurred in our Alpena County study areas (fig.1). We identified 10 pair territories in the eastern area along the LSBTBR, six near Fletcher Pond, and three sites near Lachine, between the two study areas. The remaining 26 breeding attempts occurred at 10 territories elsewhere in the northern Lower

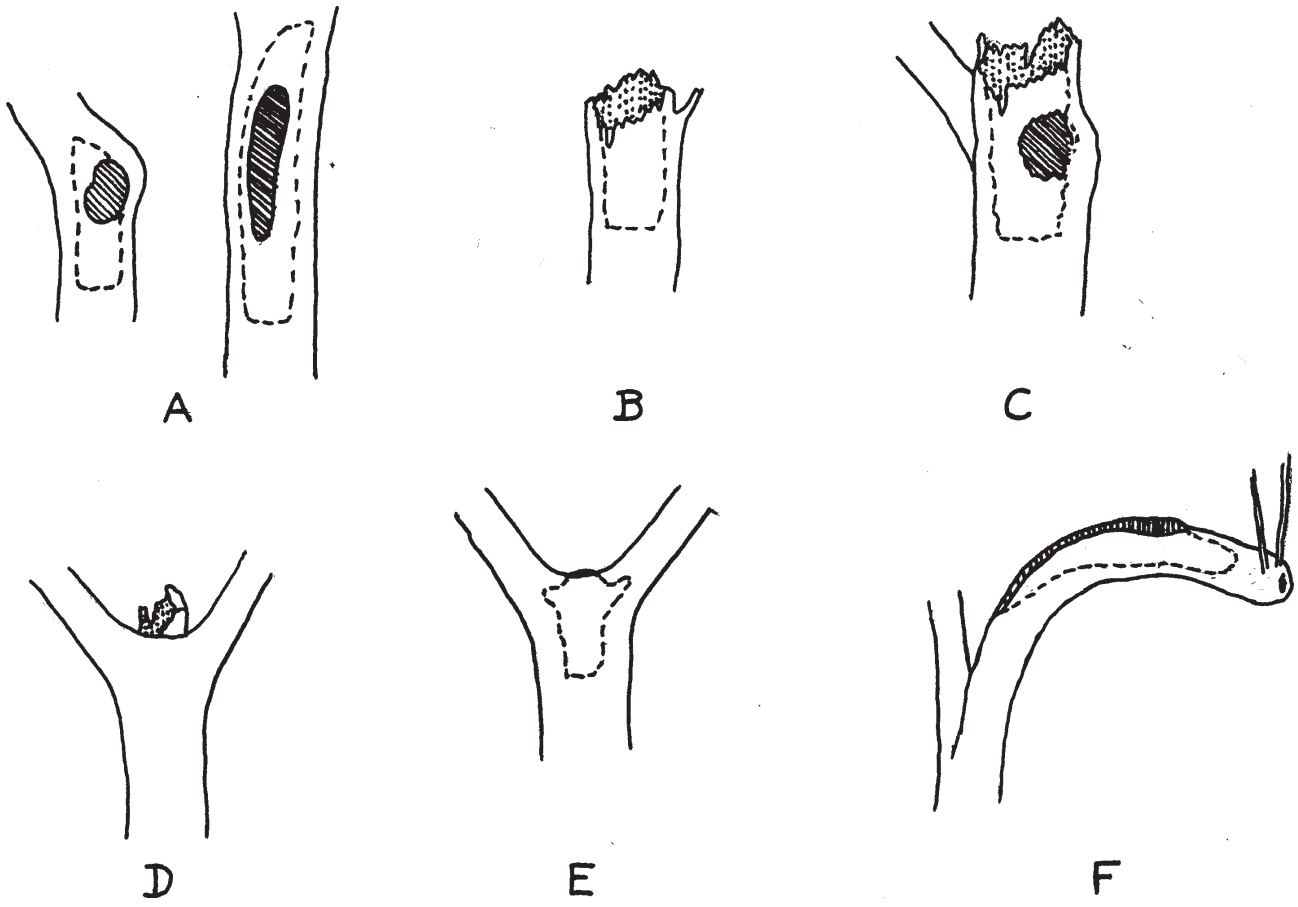

Figure 2.—*Barred Owl* (Strix varia) *nest sites: types of tree cavities and positions of entrance holes and numbers of each type encountered in northern Michigan.*
A.—Side entrance at site of broken-off limb *10*
B.—Top entry (chimney) at top of stub or dead limb *7*
C.—Chimney with second entry hole on side *3*
D.—Tree fork with flat area partly enclosed by remainder of dead limb—no cavity *1*
E.—Chimney in fork of live tree at site of broken-off limb or top *3*
F.—Deformed live tree with cavity in slit within horizontal part *1*

Peninsula, at four sites in the central Upper Peninsula of Michigan, and at one site in north-central Wisconsin (included to increase the sample size of open nests).

Nest Sites

Tree Cavities

Descriptions and Types of Cavities.—Owing to its size, the Barred Owl requires a spacious tree cavity with a large entrance hole for nesting; holes excavated by even the largest surviving North American woodpecker species, the Pileated Woodpecker (*Dryocopus pileatus*) are not large enough for Barred Owls. Most cavities used by Barred Owls can be assigned to one of two basic types: those within a hollow trunk with a side entrance and those with a more or less vertical "chimney" with a top entrance. The former (fig. 2 A) typically form by decay of the heartwood at the site of a broken-off limb. Depths of such cavities may range from a few centimeters below the lower rim of the entrance hole to more than 1 m. The entrance hole is usually more or less round or oval-shaped; in American beeches it often forms a slit, which can be up to 1.9 m long. Chimney-type cavities (fig. 2 B) occur in the tops of snags or large dead limbs, or in topped trees, often with live secondary tops. Chimney cavities ranged from the floor being nearly level

with the lowest portion of the wall to a depth of 92 cm. Deterioration of a snag or topped tree may eventually produce a chimney with both a top and side entrance (fig. 2 C).

Our observations suggest that a natural progression takes place as a dead tree top or vertical limb deteriorates. First, there may be a usable chimney cavity at the top. Then, as the limb gradually decays, only a low shell or partial shell remains, sheltering a flat area within the tree fork (fig. 2 D). As there was no cavity at one such nest site we found, we included it with the open nests. Finally, the remaining shell of the dead limb disappears completely and decay proceeds deeper into the trunk, forming a new chimney-type cavity with an opening in the tree fork (fig. 2 E). Such cavities are all but impossible to see from below.

The interior of snags and trunks of live trees may progressively decay upward from the roots, as well as downward from the top, eventually causing the cavity floor to collapse and thus render the hollow unusable for Barred Owls. In one instance we observed the owl using the upper cavity in the trunk of a beech tree, while an American porcupine (*Erethizon dorsatum*) was resting in the top of the lower hollow, no more than 30-50 cm below where the owl was incubating. On a later visit the porcupine was gone and one owlet was raised.

The strangest tree cavity we found was in a deformed sugar maple, bent over in the form of an inverted letter "L" (fig. 2 F). The horizontal portion was approximately 1.8 m from the ground and contained a long slit forming a shallow trough, which gradually became deeper and the cavity extended for a short distance (ca. 20 cm) beyond the slit into the "head" of the stub. Barred Owls nested in this deformed tree once during our study, raising at least one fledgling.

The numbers of each cavity type encountered are indicated in figure 2.

Cavity Trees.—The types and species of trees containing cavities and their frequency of use by Barred Owls are shown in table 1. Most cavities occurred in American beech trees (35 percent), followed by dead stubs and maples. Together, these three types accounted for 85 percent of 26 cavity sites identified. When frequency of use is considered, American beech becomes even more important; it was used for 48 percent of 50 breeding attempts, followed by maples and dead stubs used in 20 percent of attempts each. These three types together account for 88 percent of breeding attempts recorded in this study. The popularity of American beech may be related to the properties of its wood, which is heavy, rather hard, but not very durable when exposed to the elements (Otis 1931). Therefore cavities form

Table 1.—*Barred Owl* (Strix varia) *nest sites: species of cavity trees and frequency of their use in northern Michigan.*

	Individual trees		Frequency of use	
Tree species	**N**	**Percent**	**N**	**Percent**
American beech (*Fagus grandifolia* Ehrh.)	9	35	24	48
Sugar maple (*Acer saccharum* Marsh)	4	23	8	20
Silver maple (*Acer saccharinum* L.)	1		1	
Red maple (*Acer rubrum* L.)	1		1	
Yellow birch (*Betula alleghaniensis* Britton)	2	8	2	4
Red oak (*Quercus rubra* L.)	1	4	2	4
Quaking aspen (*Populus tremuloides* Michx.)	1	4	2	4
Dead stub	7	27	10	20
Aspen (*Populus* sp.)	(2)		(5)	
Elm (*Ulmus* sp.)	(1)		(1)	
Maple (*Acer* sp.)	(1)		(1)	
Unidentified deciduous tree	(2)		(2)	
Pine (*Pinus* sp.)	(1)		(1)	
Total	26	101	50	100

readily in beech trees and persist longer than in trees with softer wood.

Cavity Size.—Some measurements of nesting cavities are summarized in table 2 and compared to those obtained by Devereaux and Mosher (1984) in western Maryland, the only published Barred Owl cavity measurements we were able to find. Most of our Michigan nest measurement means and low values were somewhat lower than the corresponding data from the Maryland study. This may be due partly to the Maryland trees being generally larger and possibly to our larger sample size.

A d.b.h. of 48 cm should be viewed as the minimum tree size required by Barred Owls. In several trees the trunk diameter at the cavity was slightly larger than at breast height. In the tree with the lowest d.b.h. (27 cm) the cavity was situated within a nearly horizontal bend, and thus its size was larger than the cross-section of the trunk at breast height. As some cavities occur within large limbs, the diameter of such individual limbs is more relevant and the d.b.h. of the main trunk is correspondingly larger.

The lowest cavity was only 1.5 m above ground in the top of a burned-out pine stub; the breeding attempt failed.

Cavity size, as expressed by mean cavity diameter or by floor area, may be important in nest site selection by Barred Owls and may influence reproductive success. We observed that in small cavities the incubating adult appears quite cramped, often with its tail protruding out of the cavity opening or held upright along the inside wall. The relationship between cavity size and the owl's requirements for successful breeding, including adequate space for effective incubation and brooding, storage of prey items, and growth and development of young, needs to be investigated, as does the question whether cavity size affects clutch size and brood size.

Open Nests

Hawk Nests.—We recorded 10 Barred Owl breeding attempts in old hawk nests. Seven occurred in nests of the Red-shouldered Hawk, one in the nest of an unknown species, most likely a Red-shouldered or Broad-winged Hawk (*Buteo platypterus*), and two breeding attempts took place in successive years in the same Northern Goshawk (*Accipiter gentilis*) nest.

Other Open Nests.—We have observations of three breeding attempts in other types of open situations. One was a flat area in the fork of a yellow birch partly enclosed by the shell and overhang formed by the remnant of the third limb (described earlier), one was a ground nest, and the third was a man-made nest platform intended for Great Horned Owls.

Reproductive Success

Annual Monitoring.—During the two decades of this study we monitored between one and 16 Barred Owl breeding attempts each year. Initially (1976-1982) we followed between one and three nests, in 1983-1984 five, and in 1985-1990 between nine and 16. After 1990, due to other work commitments, Barred Owl monitoring was limited largely to Alpena

Table 2.—*Barred Owl* (Strix varia) *nest sites: means and ranges of cavity and cavity tree measurements in northern Michigan and western Maryland.*

	Northern Michigan[1]			Western Maryland[2]		
Measurement	**N**	**Mean**	**Range**	**N**	**Mean**	**Range**
D.b.h. (cm)	18	48.4	27-74	7	61	42-88
Tree diameter at cavity (cm)	14	44.5	30-64	4	46	36-54
Cavity height above ground (m)	22	6.8	1.5-12.8	7	9.1	4-14
Cavity depth (cm)	18	35.2	0-112	6	54	3-130
Mean inside diameter (cm)	19	25	18-44	6	33	22-41
Floor area (cm^2)	19	508	250-1,540	Not measured		

[1] This study.
[2] Devereaux and Mosher 1984.

County; we followed between three and six nests annually during 1991-1995.

The 1996 Season.—For the first time in 20 years we found no breeding Barred Owls in 1996—neither in natural sites nor in boxes. This was very likely a consequence of the hard 1995-1996 winter followed by a cool, late spring. After a brief thaw and rainy period about mid-February, temperatures dropped below freezing again, causing an ice crust to form on top of an already deep snow cover. This occurred along a wide area from Minnesota through northern Wisconsin into northern Michigan. A rash of reports followed of northern owls (mainly Boreal Owls, *Aegolius funereus*) as well as resident Barred Owls being found dead or in emaciated condition. Marge Gibson, a wildlife rehabilitator near Antigo, Wisconsin, received no fewer than 54 Barred Owls from various places in north-central Wisconsin during a 4.5 week period in February and March. All were thin and starving. Most had been picked up near human habitations—on roofs, in barns, near bird feeders, apparently attracted by small birds and rodents. Some were observed hunting during the day; and several were injured (and others killed) on roads while feeding on small roadkills (e.g., rabbits)—all indications of unusual behavior. In more "normal" winters Mrs. Gibson received one or two Barred Owls and no more than five during an entire year (M. Gibson, pers. comm.). Reports of dead and starving owls, including Barred, were also received from the Upper Peninsula and the northern Lower Peninsula of Michigan. Many more likely perished in the woods, undiscovered and unreported. There can be little doubt that over-winter mortality of Barred Owls was high and that evidently few of the surviving individuals were in good enough condition to breed in the late spring of 1996. In 1997 Barred Owls were again breeding in five of Scheller's nest boxes. All five breeding attempts were successful and 10 owlets (3, 3, 2, 1, 1) were produced. No breeding pairs were found in the western study area.

Reproductive Success.—Of 114 breeding attempts, 85 (75 percent) were successful in producing at least one young to fledging or to an advanced stage of development, i.e., banding age at 3-4.5 weeks (table 3). The exact brood size was unknown for 10 productive nests which were checked after the young owls had left the nest site and we were uncertain that we had found the entire brood. Such nests were considered in calculations of percent breeding success (see item B in tables 3-5), but were excluded from calculations of mean brood size. The mean brood size was 1.97 young/productive nest and the breeding productivity was 1.48 young/breeding attempt. The latter value is likely biased high, as we may have missed a small number of early-failing breeding attempts.

Although published data on Barred Owl reproductive success are few and rest on small sample sizes, they can offer some indications. Dunstan and Sample (1972) reported six breeding attempts in 6 years in the same tree

Table 3.—*Reproductive success of Barred Owls* (Strix varia) *in northern Michigan, 1976-1995.*

	Michigan[1]		Minnesota[2]	
Breeding attempts [A]	114		22	
Productive nests (all) [B]	85	(75%)	19	(86%)
Productive nests (known brood size) [C]	75		19	
Nests with 1 young	18	(24%)	1	(5%)
Nests with 2 young	43	(57%)	10	(53%)
Nests with 3 young	12	(16%)	7	(37%)
Nests with 4 young	2	(3%)	1	(5%)
Total young (nests with known brood size) [D]	148		46	
Young/productive nest (known brood size) [D/C]	1.97		2.42	
Young/breeding attempt [D/C x B/A]	1.48		2.09	

[1] This study (49 natural cavities, 52 nest boxes, 13 open nests).
[2] Johnson 1987 (1981-1986, all in nest boxes).

cavity in Minnesota. All six attempts were successful and 10 fledglings were raised, or 1.7 young/productive nest which in this case equals young/breeding attempt. Devereaux and Mosher (1984) studied eight nests in a 2-year study in western Maryland. One failed during the egg stage and seven contained 13 young; however, the outcome was determined for only five nests, of which only two (40 percent) were productive with a total of five fledglings. Mean brood size was 2.5 young/productive nest and productivity of 1.0 young/breeding attempt. Johnson (1987) reported 22 breeding attempts in nest boxes over a 6-year period in Minnesota. Nineteen (86 percent) were productive with mean brood size of 2.42 young/productive nest and productivity of 2.09 young/breeding attempt (table 3). All three measures of reproductive success in our study were lower than those in Johnson's (1987) work; this held also when breeding attempts in our nest boxes alone were compared (table 4). Apfelbaum and Seelbach (1983), using the North American Nest Record Card Program of Cornell University, calculated a mean brood size of 2.0 (N = 20) for Barred Owls in the Midwest and 2.02 (N = 55) in North America; these values are similar to our findings in this study.

More studies of reproductive success in different parts of the Barred Owl's breeding range are needed. Like Johnson (1987), we too have noted individual owls and pairs on their territories during the nonbreeding years. In the closely related Eurasian Ural Owl (*Strix uralensis*) and Tawny Owl (*S. aluco*) which, like the Barred Owl are resident, sedentary, and territorial, large proportions of the resident pairs do not breed (i.e., lay eggs) in low-prey years (Saurola 1989, Southern 1970). Therefore future research into Barred Owl breeding and population dynamics needs to include annual assessments of nonbreeding resident pairs.

Cavities versus Nest Boxes.—We recorded 50 breeding attempts in 26 different tree cavities and determined the success for 49 attempts. Of Scheller's 20 boxes near Alpena, 15 were used by owls for at least one breeding season. Of Papp's nine boxes near Fletcher Pond two were used a total of three times; his tenth box, in southeastern Cheboygan County, was used but once. In all, we monitored 54 breeding attempts in boxes and determined breeding success for 52 attempts.

Comparing reproductive success of Barred Owls in natural cavities to that in nest boxes (table 4), we saw a tendency toward larger broods in boxes. For the Tengmalm's Owl, the European subspecies of the Boreal Owl, Korpimäki (1984) found significantly larger clutches in boxes than in natural cavities; percent of eggs hatching and number of fledglings was also higher, but not significantly so. In another study Korpimäki (1985) reported that clutch size and breeding success in Tengmalm's Owls were related to box size. We do not have direct data on clutch size in Barred Owls, as we did not inspect the contents of nests during incubation. However, breeding success, the percent of breeding attempts producing at least one young, appeared lower in boxes than in natural cavities. The bottom line—productivity—was the same for both groups at 1.6 young/breeding attempt. The floor area in our boxes was larger than that measured in natural cavities ($\bar{x}$ = 508 cm^2, range: 259 - 1,540 cm^2, N = 19; table 2). Scheller's boxes had a floor area of approximately 850 cm^2 and Papp's of 775 cm^2. The relationship, if any, of floor area in cavities and boxes to brood size and other measures of reproductive success in Barred Owls requires further, more rigorous study.

Cavities and Boxes versus Open Nests.—Only one attempt of 10 in open hawk nests was successful and a single owlet was raised to banding age (ca. 3.5 weeks). Four hawk nests where adult owls were observed incubating early in the season were empty and deserted later, when large young should have been present. We found broken eggshells below one nest and a dead small owlet beneath each of two others. One nest which contained one small owlet earlier (seen from an adjacent tree) was empty and deserted on a follow-up visit. In yet another instance we found the nest empty and a 3-week-old owlet on the ground. The owlet was infested with "ear maggots" (*Protocalliphora*) and clusters of fly eggs adhering to feathers on its back. We took it to a rehabilitator for treatment and fostered it to a box 1 week later. As this owlet was unlikely to survive without our intervention, we counted this breeding attempt as unsuccessful.

There were three successful breeding attempts in other open situations. At least one young was raised in the open fork nest, one young fledged from the ground nest (details to be published elsewhere), and one owlet was

Table 4.—*Reproductive success of Barred Owls* (Strix varia) *in tree cavities and nest boxes in northern Michigan.*

	Tree cavities	Nest boxes
Breeding attempts [A]	49	52
Productive nests (all) [B]	42 (86%)	39 (75%)
Productive nests (known brood size) [C]	36	36
Nests with 1 young	9 (25%)	6 (17%)
Nests with 2 young	23 (64%)	20 (56%)
Nests with 3 young	3 (8%)	9 (25%)
Nests with 4 young	1 (3%)	1 (3%)
Total young (nests with known brood size) [D]	68	77
Young/productive nest (known brood size) [D/C]	1.89	2.14
Young/breeding attempt [D/C x B/A]	1.62	1.60

produced in the man-made nest platform. This platform, located in the Mead Wildlife Area in Marathon County, Wisconsin, was one of several Papp had placed in the Stevens Point area for Great Horned Owls. It consisted of an old 33-cm (13-inch) tire with one sidewall cut off and a bottom fastened to the opposite sidewall; the resulting bowl was attached to a tree fork 12.8 m above ground and partly filled with wood shavings. On 20 April 1985 Papp found two eggs, one of them pipped, and on 17 May he banded one owlet, at most 27 days old.

In table 5, Barred Owl reproductive success in enclosed sites—tree cavities and boxes—is compared to that in open nests. Few (31 percent) breeding attempts in open sites were successful and brood sizes at or near fledging age were small—1 young/productive nest. Such minimal brood sizes suggest that some owlets may have prematurely tumbled out of these nests as well; this appears likely in the only partially walled-in site in the tree fork and in the only successful breeding attempt in an old hawk nest. At 0.3 young/breeding attempt, productivity in open nests was less than one-fifth of that observed in cavities and boxes. For old hawk nests alone, productivity was only 0.1 young/breeding attempt, or one sixteenth that in enclosed sites.

In their unpublished study in northwestern Connecticut (1977-1982) Peter DeSimone and Michael Root found Barred Owls making four breeding attempts in open hawk and squirrel nests; all four failed. In contrast, 35 (81 percent) of 43 tree cavity nests were productive (P. DeSimone, pers. comm.).

Table 5.—*Reproductive success of Barred Owls* (Strix varia) *in northern Michigan: tree cavities and nest boxes compared to hawk nests and other open sites.*[1]

	Tree cavities & nest boxes	Open nests
Breeding attempts [A]	101	13
Productive nests (all) [B]	81 (80%)	4 (31%)
Productive nests (known brood size) [C]	72	3
Nests with 1 young	15 (21%)	3 (100%)
Nests with 2 young	43 (60%)	0
Nests with 3 young	12 (17%)	0
Nests with 4 young	2 (3%)	0
Total young (nests with known brood size) [D]	145	3
Young/productive nest (known brood size) [D/C]	2.01	1.0
Young/breeding attempt [D/C x B/A]	1.61	0.3

[1] One open nest in north-central Wisconsin included.

Causes of Poor Success in Open Nests

We conclude that the low success of Barred Owls using open nests is largely due to owlets falling out prematurely, before they are capable of climbing to safety, and either perish on the ground, or are killed outright by the fall. Note that two of the productive open nests did offer some degree of protection by at least partially "fencing" the young: at the flat site in the tree fork the remains of the dead limb served this purpose. Likewise, after the wood shavings had settled down in the tire platform, the owlet there was surrounded by a 8-10 cm high wall. In the ground nest the owlet had nowhere to fall and was brooded and cared for by the adult owl.

Other observers have also noted owlets falling from open nests. Bent (1938) found 38 Barred Owl nests in Massachusetts between 1891 and 1935. Of these, 18 were in old Red-shouldered Hawk and Cooper's Hawk (*Accipiter cooperii*) nests, five in what appeared to be old squirrel nests, and 15 in hollow trees. He provides no information on success in these different nest types, but comments (page 187) that "the increasing activities of the young reduce what was once a well-built and deeply hollowed nest to a smaller and flatter platform; this makes the nest increasingly dangerous as a cradle for the young...". Bent (1938) also reports finding "at least three young, half-grown or less, that have fallen from nests" and notes that he has never seen 4-5 week old owlets on the ground. We suggest that younger owlets would have been soon consumed by ground predators or scavengers, while older young would have climbed suitable trees and thus escaped notice.

In their monograph on the closely related Spotted Owl (*Strix occidentalis*) Forsman *et al*. (1984) write (page 36):

"Nine owlets that were raised in platform nests fell or jumped from the nest when they were 15-25 days old. Of these, 7 were killed by the fall or disappeared before reaching the flying stage. No owlets were lost in this manner from cavity nests, suggesting that cavity nests provided a more secure environment for the young."

Forsman *et al*. (1984) state that normally young Spotted Owls leave the nest when 34-36 days old. Their "platforms" are what we call open nests, that is platforms of sticks or debris on limbs; about one-half (nine out of 17) were in old nests of hawks, squirrels, and woodrats. It then appears that loss of young from open nests is a problem in both owl species.

We propose that Barred Owls are obligate cavity nesters. Historically, there was no selective advantage in the acquisition of the necessary behavior patterns in their developing young to make them stay put in open nests, as young Great Gray (*Strix nebulosa*) and Great Horned Owls manage to do. While many Barred Owl fledglings may end up on the ground after leaving the nest, they are capable of climbing a tree by the time they reach fledging age (Dunstan and Sample 1972). From field tests with a small number of Barred Owl young we tentatively conclude that 3-week-old and younger owlets cannot effectively climb yet and that 4-week-old and older owlets can. Thus, if an owlet tumbles out of an open nest before attaining climbing proficiency, its survival prospects are very low. Obviously, trees with rough bark, such as white pine (*Pinus strobus* L.) are easier for young owls to negotiate than are trees with smooth, hard bark, such as beech.

Barred Owl breeding attempts in open nests, mainly those built by hawks, crows, and squirrels, may be an indication of a shortage of natural cavities resulting from past or current forestry practices and/or from increased competition for existing cavities with raccoons (*Procyon lotor*), opossums (*Didelphis virginiana*), squirrels (*Sciurus, Tamiasciurus*), and other tree-climbing mammals.

MANAGEMENT IMPLICATIONS

Statements that Barred Owls also use open nests are often repeated in the literature; however, until now, no information was available on the success of open nests. Most authors indicate or imply that use of open nests by this species is rare. Only Bent (1938) writes that 23 of the 38 nests of this owl he examined were open nests. We suggest, as has Yannielli (1991), that during the early part of this century Massachusetts second-growth forests may have been too young and lacked enough large trees with suitable cavities, which would have forced the owls to accept open nests. Nevertheless, reports such as Bent's (1938) have led some authors (and managers) to question the

importance of cavities to Barred Owls. Yannielli (1991) expressed the view that "although cavities are preferred...they are not essential." This mistaken belief arises when investigators looking at habitat use and nest site selection pay little attention to reproductive success. Our findings confirm that use of open nests by Barred Owls is rare (11 percent in this study), and by showing that productivity in open nests is negligible, emphasize the critical importance of tree cavities to stable Barred Owl populations.

Forest managers should consider the great value of natural tree cavities in forest management plans. In selective cutting it is usually the dying, topped, diseased, deformed, "unsightly" trees which are removed. We often hear reports of loggers finding a cavity containing Barred Owl nestlings in a tree they had just cut down. Such incidents still occur on state as well as on private forests. The first step in managing for Barred Owls is the preservation of snags and an adequate number and dispersion of large live trees (> 50 cm d.b.h.) which contain, or are likely to develop suitable cavities. Dead stubs are subject to advanced decay, and are unlikely to persist for very long. Cavity trees, even those only partly alive are preferable.

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LITERATURE CITED

Apfelbaum, S.J.; Seelbach, P. 1983. Nest tree, habitat selection, and productivity of seven North American raptor species based on the Cornell University Nest Record Card Program. Raptor Research. 17: 97-113.

Bent, A.C. 1938. Life histories of North American birds of prey: part 2. U.S. Natl. Mus. Bull. 170. Washington DC. 482 p.

Bosakowski, T. 1994. Landsat reveals negative effect of forest fragmentation on Barred Owl distribution. Records of New Jersey Birds. 20: 66-70.

Bosakowski, T.; Speiser, R.; Benzinger, J. 1987. Distribution, density, and habitat relationships of the Barred Owl in northern New Jersey. In: Nero, R.W.; Clark, R.J.; Knapton, R.J.; Hamre, R.H., eds. Biology and conservation of northern forest owls; symposium proceedings; 1987 February 3-7; Winnipeg, Manitoba. Gen. Tech. Rep. RM-142. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 135-143.

Devereaux, J.G.; Mosher, J.A. 1984. Breeding ecology of Barred Owls in the central Appalachians. Raptor Research. 18: 49-58.

Dunbar, D.L.; Booth, B.P.; Forsman, E.D.; Hetherington, A.E.; Wilson, D.J. 1991. Status of Spotted Owl, *Strix occidentalis*, and Barred Owl, *Strix varia*, in southwestern British Columbia. Canadian Field-Naturalist. 105: 464-468.

Dunstan, T.C.; Sample, S.D. 1972. Biology of Barred Owls in Minnesota. Loon. 44: 111-115.

Elody, B.I.; Sloan, N.F. 1985. Movements and habitat use of Barred Owls in the Huron Mountains of Marquette County, Michigan, as determined by radiotelemetry. Warbler. 63: 3-8.

Errington, P.L. 1930. The pellet analysis method of raptor food habits study. Condor. 32: 293-296.

Errington, P.L. 1932a. Techniques of raptor food habits study. Condor. 34: 75-86.

Errington, P.L. 1932b. Food habits of southern Wisconsin raptors. Part I. Owls. Condor. 34: 176-186.

Errington, P.L.; McDonald, M. 1937. Conclusions as to the food habits of the Barred Owl in Iowa. Birdlife. 7: 47-49.

Forsman, E.D.; Meslow, E.C.; Wright, H.M. 1984. Distribution and biology of the Spotted Owl in Oregon. Wildlife Monographs. 87: 1-64.

Fuller, M.R. 1979. Spatiotemporal ecology of four sympatric raptor species. St. Paul, MN: University of Minnesota. 220 p. Ph.D. dissertation.

Hamer, T.E.; Forsman, E.D.; Fuchs, A.D.; Walters, M.L. 1994. Hybridization between Barred and Spotted Owls. Auk. 111: 478-492.

Hamerstrom, F.N., Jr.; Hamerstron, F. 1951. Food of young raptors on the Edwin S. George Reserve. Wilson Bulletin. 63: 16-25.

Johnson, D.H. 1987. Barred Owls and nest boxes—results of a five-year study in Minnesota. In: Nero, R.W.; Clark, R.J.; Knapton, R.J.; Hamre, R.H., eds. Biology and conservation of northern forest owls: symposium proceedings; 1987 February 3-7; Winnipeg, Manitoba. Gen. Tech. Rep. RM-142. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 129-134.

Korpimäki, E. 1984. Clutch size and breeding success of Tengmalm's Owl *Aegolius funereus* in natural cavities and nest-boxes. Ornis Fennica. 61: 80-83.

Korpimäki, E. 1985. Clutch size and breeding success in relation to nest-box size in Tengmalm's Owl *Aegolius funereus*. Holarctic Ecology. 8: 175-180.

Korschgen, L.J.; Stuart, H.B. 1972. Twenty years of avian predator-small mammal relationships in Missouri. Journal of Wildlife Management. 36: 269-282.

Laidig, K.J.; Dobkin, D.S. 1995. Spatial overlap and habitat associations of Barred Owls and Great Horned Owls in southern New Jersey. Journal of Raptor Research. 29: 151-157.

McGarigal, K.; Fraser, J.D. 1984. The effect of forest stand age on owl distribution in southwestern Virginia. Journal of Wildlife Management. 48: 1393-1398.

Mendall, H.L. 1944. Food hawks and owls in Maine. Journal of Wildlife Management. 8: 198-208.

Nicholls, T.H.; Fuller; M.R. 1987. Territorial aspects of Barred Owl home range and behavior in Minnesota. In: Nero, R.W.; Clark, R.J.; Knapton, R.J.; Hamre, R.H., eds. Biology and conservation of northern forest owls; symposium proceedings; 1987 February 3-7; Winnipeg, Manitoba; Gen. Tech. Rep. RM-142. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 121-128.

Nicholls, T.H.; Warner, D.W. 1972. Barred Owl habitat use as determined by radiotelemetry. Journal of Wildlife Management. 36: 213-224.

Otis, C.H. 1931. Michigan trees: a handbook of the native and most important introduced species. Ann Arbor, MI: University of Michigan Press. 362 p.

Postupalsky, S. 1974. Raptor reproductive success: some problems with methods, criteria and terminology. In: Hamerstrom, F.N.; Harrell, B.E.; Olendorff, R.R., eds. Management of raptors: proceedings of the conference on raptor conservation techniques; 1973 March 22-24; Fort Collins, CO. Raptor Res. Rep. Raptor Research Foundation. 2: 21-31. [part 4].

Saurola, P. 1989. Breeding strategy of the Ural Owl *Strix uralensis*. In: Meyburg, B.-U.; Chancellor, R.D., eds. Raptors in the modern world: proceedings of the 3d world conference on birds of prey and owls; 1987 March 22-27; Eilat, Israel. Berlin, London, Paris: World Working Group on Birds of Prey and Owls: 335-340.

Southern, H.N. 1970. The natural control of a population of Tawny Owls (*Strix aluco*). Journal of Zoological Society London. 162: 197-285.

Taylor, A.L.; Forsman, E.D. 1976. Recent range expansion of the Barred Owl in western North America, including the first records for Oregon. Condor. 78: 560-561.

Wilson, K.A. 1938. Owl studies at Ann Arbor, Michigan. Auk. 55: 187-197.

Yannielli, L.C. 1991. Preferred habitat of northern Barred Owls in Litchfield County, Connecticut. Connecticut Warbler. 11: 12-20.