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NEST SITE SELECTION BY URBAN AND RURAL GREAT HORNED OWLS IN THE NORTHEAST

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Abstract.—We studied nest site and habitat characteristics associated with 75 Great Horned Owl (*Bubo virginianus*) nests in Connecticut, northern New Jersey, and southeastern New York. Nest sites were categorized as either urban (30) or rural (45) and were compared to data from available habitat (24 random sites for microhabitat; 70 random sites for macrohabitat). Urban nest trees were significantly larger in diameter and taller than rural nest trees, and accordingly, nests were higher in urban nest trees as well. Urban nest sites were significantly different than random sites for all eight habitat variables, but rural nests were significantly different for only five variables. Urban nests were significantly different than rural nests for five of eight habitat variables. Only urban owl nests had significantly lower site basal area, higher conifer composition, and lower shrub cover. Both urban and rural owl nests showed lower canopy cover and closer proximity to forest edge, paved roads, human habitation, and water than random sites. Although both urban and rural Great Horned Owls demonstrated habitat selection (use different from availability), urban owls showed a stronger degree of selection, probably because of the greater complexity of habitats available in the urban landscape.

SELECCIÓN DEL LUGAR DE ANIDAMIENTO POR PARTE DE *BUBO VIRGINIANUS* EN ZONAS URBANAS Y RURALES DEL NORDESTE DE LOS ESTADOS UNIDOS

Sinopsis.—Estudiamos el lugar de anidamiento y características del habitat asociado al nido de 75 individuos de *Bubo virginianus* en el este de los Estados Unidos. Los lugares de anidamiento fueron categorizados como urbanos (30) o rurales (45) y fueron comparados a datos disponibles sobre utilización de habitats (24 localidades al azar para microhabitat, y 70 también al azar para macrohabitat). Los árboles urbanos utilizados para anidar resultaron ser significativamente más grandes en diámetro y más altos que los árboles rurales e igualmente, los nidos fueron localizados a más altura en las localidades urbanas. Los lugares de anidamientos urbanos fueron significativamente diferentes a los lugares estudiados al azar para ocho variables en el habitat, pero los nidos rurales tan solo difirieron en cinco de las variables. Los nidos urbanos resultaron significativamente diferentes de los rurales para cinco de las ocho variables de habitat estudiadas. Los nidos urbanos tuvieron significativamente menor area basal, mayor composición de coníferos y menor cobertura de arbustos. Tanto nidos urbanos como rurales mostraron menor covertura de docel, y mayor proximidad a borde de bosque, carreteras pavimentadas, construcciones de humanos y agua que los lugares examinados al azar. Aunque tanto buhos rurales como urbanos demostraron selectividad de habitat (uso discriminativo a la disponibilidad), los buhos urbanos mostraron un grado mayor de selección, debido, probablemente, a la mayor complejidad del habitat urbano. El presente

trabajo confirma que el muy adaptable *Bubo virginianus* selecciona habitats boscosos fragmentados por el desarrollo urbano.

The Great Horned Owl (*Bubo virginianus*) is the most widespread owl of the Western Hemisphere and also one of the most studied (references in Clark et al. 1978). Its nesting ecology has been described for many regions of the United States, including New England (Bent 1938), New York (Hagar 1957), New Jersey and Connecticut (Bosakowski et al. 1989), Ohio (Misztal 1974, Siminski 1976), Michigan (Craighead and Craighead 1956), Wisconsin (Orians and Kuhlman 1956, Petersen 1979), Missouri (Baumgartner 1939), Kansas (Fitch 1940), North Dakota (Gilmer et al. 1983), Montana (Sidensticker and Reynolds 1971), California (Fitch 1947), and central Utah (Smith and Murphy 1973, 1979, 1982).

Across their range, nesting Great Horned Owls occupy a wide range of habitat types and qualities. Minor et al. (1993) found that productivity of Great Horned Owls was normal in the urban-suburban environments of Syracuse, New York, but nesting density was about three-fold lower than in rural areas. Based on a macrohabitat analysis around owl locations, Bosakowski and Smith (1997) suggested that Great Horned Owls were habitat generalists in northern New Jersey forests and had a tendency to occupy areas impacted by forest fragmentation from suburban developments. In this paper, we provide a quantitative evaluation of habitat characteristics at 75 Great Horned Owl nests in Connecticut, northern New Jersey, and southeastern New York. In addition, we compare rural and urban nest sites to available habitat to determine if there are differences in habitat selection by Great Horned Owls occurring in urban and rural environments.

STUDY AREA

The study area included Orange and western Rockland counties in New York; Sussex, Morris, Middlesex, and Passaic counties in New Jersey; and Litchfield, Fairfield, and New Haven counties in Connecticut. Physiographic sections included within this area include the Lowland and Highland Piedmont and New England provinces (Braun 1950). Forests are predominately deciduous or mixed stands dominated by oak (*Quercus* spp.), maple (*Acer* spp.), and hickory (*Carya* spp.); smaller tracts of eastern hemlock (*Tsuga canadensis*) or white pine (*Pinus strobus*) are on cooler slopes or in ravines or as plantations. Across the study area, mean annual temperatures range from 7–11 C and mean annual precipitation varies from 112–127 cm/yr, with lesser amounts at lower elevations (Brumbach 1965). Human population densities within this area vary from >1370 people/km^2 in urban centers to suburban and exurban populations of widely varying densities to rural areas with less than 39 people/km^2 in the rural districts (Lewis and Harmon 1986).

METHODS

Great Horned Owl territories were found by a combination of foot and vehicle searches, checks of areas in which Great Horned Owls responded

to playback of tape-recorded song or vocal imitations, and by monitoring previously located nests of other raptors during the course of long-term raptor studies in Connecticut and New Jersey-New York area (Smith and Gilbert 1984; Lynch and Smith 1984; Bosakowski et al. 1987, 1989; Bosakowski and Smith 1992, 1997). Prior to foliage development, known territories were searched for active nests. Nest-tree and nest-site variables were measured after fledging in late summer or early fall.

At 75 Great Horned Owl nests, we measured four microhabitat variables (stand level) and four macrohabitat features (landscape level). We also measured the same microhabitat variables at 24 random sites and the same macrohabitat variables at 70 random sites. All random sites were obtained from computer-generated coordinates, which were plotted on 7.5-min USGS quadrangle maps and then located in the field. Macrohabitat variables measured to the nearest 1.0 m included distance from the nest or random site to the nearest road, nearest forest opening greater than 1 ha, nearest water source, and nearest human habitation.

At the microhabitat level, tree basal area at nest and random sites was measured using a "Cruz-all" 10-factor forestry angle gauge (English scale), and data were converted to metric equivalents. Basal area samples were tallied at the nest tree and at four sites 50 m distant from the nest tree in each of the four cardinal directions. Canopy cover and shrub cover were recorded simultaneously at 10-m intervals along 50-m transects that extended from the nest tree into each of the four cardinal directions. Canopy cover was recorded as positive or negative using an ocular sighting tube (James and Shugart 1970). Shrub cover was recorded if shrubs or saplings greater than 1 m in height but less than 10 cm in diameter were within a 1.7-m diameter circle centered on the observer (Collins et al. 1982). Conifer composition was calculated as a percent of all trees from basal area tree tallies.

Statistical analysis.—In order to prevent pseudoreplication, we only report data from one nest per territory so that each nest represents an independent sample. For analysis, nest sites were categorized as either urban or rural. Urban areas were defined as habitats located in cities, city open space, and suburban developments. Rural areas were defined as predominantly undeveloped landscapes with naturally occurring fields, meadows, woodlands, or wetland habitats. Means were compared by the parametric equal variance *t*-test procedure, or unequal variance *t*-test if variances were significantly different at $P < 0.05$ (Zar 1974).

RESULTS AND DISCUSSION

Nest descriptions.—Nest type was determined at 61 of the 75 nests. Of these, 29 (38.7%) were in old nests constructed by Red-tailed Hawks (*Buteo jamaicensis*), 11 (18.0%) were in old nests of the American Crow (*Corvus brachyrhynchos*), 8 (13.1%) were in gray squirrel (*Sciurus carolensis*) nests, 6 (9.8%) were in old nests of Red-shouldered Hawks (*Buteo lineatus*), 5 (8.2%) were in old Cooper's Hawk (*Accipiter cooperii*) nests, and one each (1.6%) in an old Northern Goshawk (*A. gentilis*) nest and Red

TABLE 1. Nest tree characteristics of Great Horned Owl nest sites in urban and rural areas in Connecticut, southern New York, and northern New Jersey. Data represent the mean (±1 SD).

Variables	Urban nests $n = 30$	Rural nests $n = 45$	P [a]
Nest tree DBH (cm)	56.9 (11.6)	48.5 (10.8)	0.0020
Nest height (m)	15.0 (2.00)	12.4 (2.77)	0.0001
Nest tree height (m)	21.50 (3.71)	17.4 (4.25)	0.0001

[a] *t*-test.

squirrel (*Tamiasciurus hudsonicus*) nest, respectively. The remaining nests were of undetermined origin. Rural-nesting Great Horned Owls used raptor nests significantly more frequently than urban pairs, they most commonly chose crow or squirrel nests ($\chi^2 = 4.01$, df = 1, $P < 0.05$).

Nest tree descriptions and metrics.—Nest tree species was determined at 67 nest sites. Of these, 45 (59.7%) Great Horned Owl nests were in live deciduous trees, mostly oaks and red maple (*Acer rubrum*), three (4.5%) were in dead trees (snags), and 19 (28.3%) were in conifers, primarily white pine, eastern hemlock, and Norway spruce (*Picea abies*). A significantly higher number of urban nests were in conifers compared to rural nests ($\chi^2 = 5.22$, df = 1, $P < 0.05$). Urban nest trees were significantly larger in diameter (DBH) and taller than rural nest trees, and nests were higher in urban nest trees (Table 1). This difference is probably due to the fact that many established urban open space areas and city parks had large trees that were retained for ornamentation, shelter, or shade. Furthermore, small groves, and remnant patches of trees in urban open spaces are in less competition for sunlight, and therefore, growth rates are greatly enhanced over the naturally regenerating second-growth forests of rural nest sites. However, none of the nests in this study were located in isolated trees.

Nest-site habitat.—Urban nests were significantly different from random sites for all eight habitat variables (Table 2), but rural nests were significantly different from random sites for only five variables. In comparing urban and rural nests, five habitat variables were significantly different.

Urban nests had a lower basal area than random sites, but rural nests were not significantly different from random. This difference is probably due to the more open, park-like conditions found in urban open-space environments, whereas rural nest sites were typically in denser, naturally regenerating, second-growth forest. Conifer composition of urban nest sites was significantly higher than at random sites, but not at rural nest sites. Conifer plantations and large overgrown ornamental conifers are more numerous in the urban environment than in most of the oak-hardwood dominated forests that has regenerated naturally. Canopy cover was relatively high at both urban and rural nest sites (70%), but both were significantly lower than random sites. This consistent feature of both urban and rural owl nests indicates that small openings in the canopy

TABLE 2. Habitat characteristics of Great Horned Owl nest sites in urban and rural areas in Connecticut, southern New York, and northern New Jersey and comparison to available habitat (random sites). Data represent the mean (±1 SD).

Microhabitat variables	Urban nests $n = 30$	Rural nests $n = 45$	Random sites $n = 24$
Basal area (m^2/ha)	18.4[ab] (4.87)	22.8 (3.81)	23.7 (4.83)
Conifer composition %	40.2[ab] (32.4)	11.7 (15.2)	8.2 (17.2)
Canopy cover %	70.8[a] (14.9)	71.8[a] (21.0)	82.5 (8.76)
Shrub cover %	52.3[a] (20.5)	60.5 (26.6)	69.0 (27.5)
Macrohabitat variables	**Urban nests $n = 30$**	**Rural nests $n = 45$**	**Random sites $n = 70$**
Distance to water source (m)	168.2[a] (153.8)	143.9[a] (98.3)	250.8 (210.9)
Distance to forest edge (m)	70.7[ab] (41.8)	164.3[a] (98.9)	238.1 (210.0)
Distance to paved road (m)	106.2[ab] (70.8)	329.3[a] (209.5)	501.9 (452.7)
Distance to human habitation (m)	144.8[ab] (80.0)	575.8[a] (302.1)	730.1 (516.5)

[a] Indicates a significant difference from random sites (*t*-test, $P < 0.05$).
[b] Indicates a significant difference from rural sites (*t*-test, $P < 0.05$).

around the nest tree are probably desirable. A more open canopy may make for easier access to nests, more sunlight for developing chicks, and easier visibility for spotting potential nest predators.

Shrub cover was significantly lower in urban nest sites compared to random sites, but rural nest sites were not significantly different from random. This difference was probably due to the fact that urban Great Horned Owls often selected mature open park-like forest stands (artificially grown and maintained by intensive silviculture and horticulture) as opposed to random sites, which cover the whole spectrum of forest types, ages, and densities with a corresponding diversity of shrub cover.

Distance to a water source at urban and rural nest sites was significantly closer than random sites. This situation seems to infer a degree of habitat selection, because both urban and rural owls responded similarly to this variable in the nest selection process. Diets of Great Horned Owls in our studies revealed that riparian and wetland prey species were often taken (Bosakowski and Smith 1992), although their capture may have been fortuitous during other water uses such as drinking and bathing.

Distance to forest edge for urban and rural nests was significantly less than random sites, although urban nests were closest to edge. Urban nests

were situated in a highly fragmented, mosaic of small tree stands, openings, roads, and buildings whereas rural nests were more often situated in areas of contiguous forest with less availability of large forest openings and edge. Other investigations in the Northeast have also found the Great Horned Owl to favor edge habitats (Bosakowski et al. 1987, Laidig and Dobkin 1995, Bosakowski and Smith 1997). In addition to edge, both urban and rural nests were found significantly closer to paved roads than random sites, although rural nests were not as close as urban nests. Great Horned Owls are commonly observed hunting along interstate highways in New York (Bosakowski and Speiser 1984) and, in this study, several of the nests were less than 50 m from major highways, including one nest in a cloverleaf island at a junction of three major highways.

As would be expected from our selection criteria for urban versus rural, urban nests were significantly closer to human habitation than random sites or rural nests. Rural nests were also closer to human habitation than random sites, but not as close as urban nests. Apparently, Great Horned Owls are benefiting from the associated alterations in habitat (edge, fragmentation, openings) and food supply (rats, mice, squirrels, rabbits, skunks, opossum, racoon, farm animals) that result from human settlements.

In conclusion, both urban and rural Great Horned Owls demonstrated habitat selection, but urban owls showed a stronger degree of selection (deviance from random). However, the results also demonstrate that even rural owls will tend to select nest sites in areas with more edge and forest fragmentation created by the impact of suburban/urban sprawl. Bosakowski et al. (1987) and Bosakowski and Smith (1997) analyzed habitat around Great Horned Owl locations and concluded that they were habitat generalists and were more tolerant of suburban habitat fragmentation and disturbance than other sympatric forest raptors, except for the Red-tailed Hawk. Laidig and Dobkin (1995) analyzed owl locations in southern New Jersey and also concluded that they were habitat generalists, but did not mention suburban or urban influences. Previous studies of nest sites have also reported that the Great Horned Owl is a habitat generalist (Petersen 1979, Bosakowski et al. 1989), although Hagar (1957) reported that great horned owls preferred nesting in dense woodlots, generally 8 ha or larger. The present report confirms that the adaptable Great Horned Owl purposely selects forest habitat that is fragmented and altered by urbanization and shows more selectivity in complex habitats (urban mosaic) than in monotonous ones (i.e., contiguous second-growth forest) where there are probably less choices to make during the nest site selection process.

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