Presence, Habitat Use, and Prey Selection of Champlain Valley Owls, New York

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ABSTRACT

In this study we examined species-specific owl occupancy and detection, habitat usage and distance to landscape features, as well as food availability of owl species encountered in Clinton County, New York. Through broadcasting owl vocalizations, we were able to identify and determine owl habitat usage using an inexpensive, non-invasive technique. Lunar cycles were also assessed to determine when the owls were most active. Lastly, we hand collected owl pellets to determine what the owls may be eating in Northern New York. Program PRESCENCE was used to assess presence and occupancy across sites. We encountered barred owls (*Strix varia*) and great horned owls (*Bubo virginianus*) occurring and co-occurring at 100% of our sites. Detection probabilities for barred owls were 29% and only 4% for great horned owls. Through the use of ArcGIS is was determined that agricultural land-use and forests were the dominate habitat types surrounding the broadcasting sites. Roads and wetlands were reoccurring habitat across sites. We observed that owls were more vocal on nights of high lunar illumination. Through the dissection of owl pellets we concluded that small mammals such as grey squirrels and mice (*Peromyscus* spp.) were selected prey of a great horned owl. Understanding owl habitat-use patterns is important for habitat conservation purposes in the future as habitat fragmentation and habitat destruction become more persistent across the landscape. We hope to expand our research to other location including residential areas and urban parks to create a better understanding of owl habitat usage in Clinton County.

Key words: *Strix varia*, *Bubo virginianus*, lunar cycle, barred owl, great horned owl, *Peromyscus* spp.

INTRODUCTION

The barred owl (BARR, *Strix varia*) and the great horned owl (GHO, *Bubo virginianus*) can be influenced by both biotic and abiotic factors. They each have specific environmental requirements that influence prey and habitat selection. BARRs primarily occupy the eastern portion of the United States and parts of Central America; however, they have recently expanded into the Pacific Northwest. These birds prefer contiguous mixed deciduous forests ranging from swampy lowlands to uplands, within the northeastern United States. They inhabit trees with pre-existing nests or cavities (Devereux and Mosher

1984, and McGarigal and Fraser 1985, Cornell 2011). GHOs span the entire United States, Canada, and Mexico preferring secondary growth fields and woodlands, or habitats that have recently been disturbed. Disturbed sites of the northeast tend to succeed into white pine (*Pinus strobus*) stands co-dominated by birch (*Betula* spp.) and aspen (*Populus* spp.). A GHO's home range must include open hunting areas, such as meadows or wetlands, as they cannot hunt in dense forests (Cornell 2011). Smith et al. (1999) found that many GHOs prefer forests with a more open canopy because it provides easier access to cavities and nests, more sunlight for developing chicks, and additional visibility to spot prey.

Broadcasting is a beneficial way to survey local owls (Elody and Sloan 1984). This technique is a non-invasive way to locate individuals and their nests. McGarigal and Fraser (1985) found that when broadcasting BARRs, less than half responded with their territorial short hoots, while the remainder responded to broadcasts in the typical 'who cooks for you who cooks for you all' pattern. When broadcasting, BARRs may remain silent because songbirds, crows (*Corvus* spp.) and blue jays (*Cyanocitta cristata*) will mob during daytime and crepuscular hours (Cornell 2011). Unlike BARRs, who may remain silent while broadcasting, GHOs are most active during crepuscular hours. Thus, broadcasting around twilight is ideal (Cornell 2011). Morrell et al. (1991) found that the probability of receiving a call back from a GHO is greatest within two minutes following the initial broadcast.

Other abiotic factors, such as lunar phase and temperature can influence the nocturnal behavior of owls. Nocturnal activity of owls is not well known, as they are difficult to study and rarely do scientists conduct these studies. The lunar cycle can affect the manner in which owls hunt and communicate. Penteriani et al. (2012) found that eagle owls (*Bubo bubo*) had greater nocturnal vision during a full moon and visually communicate more often during this time. In addition, the common poorwill (*Phalaenoptilus nuttallii*) is more active on nights when the moon is more luminous (Woods and Brigham 2008). An explanation as to why owls are more active when there is greater lunar light is that this affords them more

efficient hunting opportunities due to higher visibility (Ibarra et al. 2014). GHOs are often most active between the quarter and the full moon, and less active during a new moon (Morrell et al. 1991). Rationale for the improved hunting ability under full moon is spurious; however, possibilities include temperature or increased prey activity. Takats and Holroyd (1997) found that as the temperature declined below 0°C, so did BARR callbacks.

Owl sign, in the form of pellets, can serve as an index of density. BARR pellets may consist of mice (*Peromyscus* spp.), eastern chipmunks (*Tamias striatus*), red-backed voles (*Myodes gapperi*), and many other species (Schnurr et al. 2004). In the northeastern United States, GHOs prefer coniferous forest stands, but will occupy mixed hardwoods similar to the BARR. Lobo (2014) noted that stands of white pine and eastern hemlock (*Tsuga canadensis*) were home to meadow voles (*Microtus pennsylvanicus*), southern red-backed voles, white-footed mice (*P. leucopus*), and deer mice (*P. maniculatus*). Weigl and Hanson (1980) also observed that red squirrels (*Tamiasciurus hudsonicus*) were almost always found in coniferous forests, as they forage on pine cone seeds, but will expand into deciduous forests in eastern New York.

The objective of this study was to assess presence of owls in various habitats by broadcasting owl calls. Once presence was detected, distances from landscape features were determined using ArcGIS. Lastly, we determined habitat-specific dietary preference of a GHO reported in Rugar Woods. We hypothesized that BARRs would occur in northeastern hardwood or old growth forests closer to open habitats and farther from water bodies. We expected to find GHOs in mixed conifer stands in proximity to open habitat types (e.g., meadows and wetlands). In terms of diet, we predicted that GHO pellets would consist primarily of voles, mice, and red squirrels. Additionally, we predicted owls would vocalize more on nights when there was more lunar light, as this is the time when they are the most active. We also

hypothesized that there would be increased BARR vocalization on warmer nights. Finally, we hypothesized that roads would not affect the vocalization of owls.

METHODS

Study Site

Five sites within Essex and Clinton County, New York were monitored between July - October 2014 (Fig. 1). All sites are located in the Great Lakes lowlands eco-region, where summers are warm and humid and winters are cold and snowy (USEPA 2013, Kavanagh 2014). Sites range from 18 to 30 m above sea level. Annual precipitation on average is 76-88 cm per year (American Atlas 2005). Broad-leaf deciduous forests and mixed coniferous stands were habitat types selected in this project.

Miner Agricultural Research Institute located in Chazy, Clinton County, New York contained two of our study sites, Barnaby and Vassar Roads. Barnaby Road (44.851161, -73.569689) consisted of a broad-leaf deciduous forest dominated by sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), white birch (*Betula papyrifera*), and red oak (*Quercus rubra*) with a dense understory consisting of both woody and herbaceous vegetation. Vassar Road (44.840359, -73.544671) was comprised of an open field edge to the north and a mixed coniferous stand of eastern hemlock and white pine to the south bordered to the west by Vassar Road.

Wickham Marsh Wildlife Management Area (WMA), located in Chesterfield, Essex County, New York (44.536875,-73.415173) is comprised of a freshwater marsh to the northwest and a mixed forest dominated by sugar maple, American beech, white birch, and white pine with a dense understory of woody and herbaceous plants. To the northeast there is a road and train tracks that served as a barrier between the marsh and Lake Champlain.

Deep Well Way, Peru, New York (44.548674,-73.448092) is a mixed stand consisting of white pine, red oak, white birch, red maple (*Acer rubrum*), bigtooth aspen (*Populus grandidentata*), quaking

aspen (*P. tremuloides*) and pitch pine (*Pinus rigida*). There is a steep and abrupt south-facing slope with a swamp below and a major road (US route 9) to the west that fragmented the forest habitat. The habitat was selectively cut within the last 30 years, abuts the Ausable River, and contains 250 acres of mixed forest that is bisected by snow mobile trails and a sand pit.

Rugar Woods, Plattsburgh, New York (44.676771,-73.478122) is a mixed forest stand, owned by SUNY Plattsburgh, that is dominated by white pine in the canopy and American hazelnut (*Corylus americana*) and has an understory comprised of varying herbaceous plants. This forest tract was surrounded by non-forest cover types that are residential, an abandoned site to the west, the Saranac River to the south and east, and the City of Plattsburgh to the north.

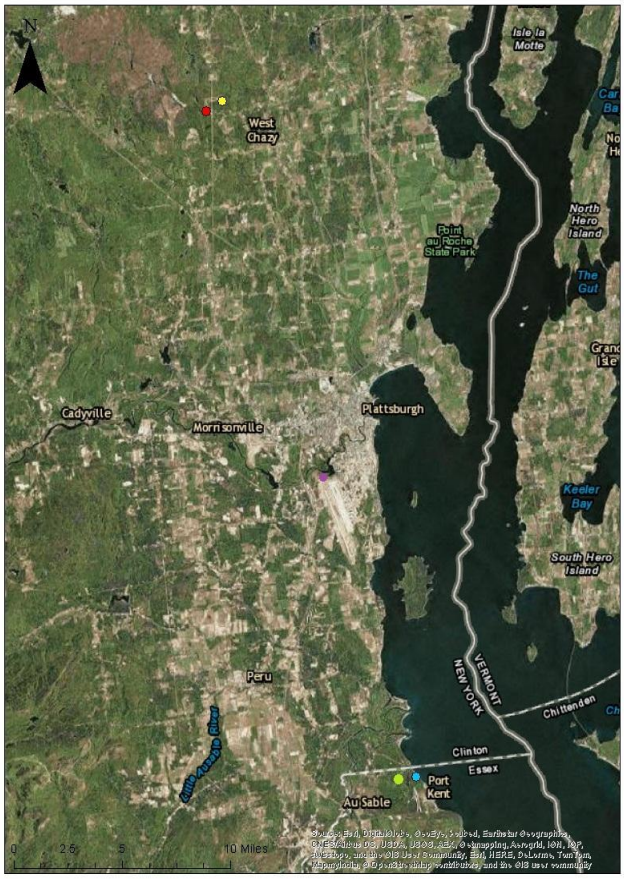

Figure 1: Study sites: Vassar Rd. (yellow), Barnaby Rd. (red), Wickham Marsh WMA (blue), Deep Well Way (green), and Rugar Woods (purple). Map data

Field Broadcasting

Broadcasting was performed using a SHARKK® portable Bluetooth mini speaker which amplified owl calls. Owl calls were obtained from the National Audubon Society owl app for the iPhone. The owls broadcasted consisted of the eastern screech owl (*Megascops asio),* northern saw-whet owl *(Aegolius acadicus)*, barn owl *(Tyto alba)*, barred owl, great horned owl, and long eared owl *(Asio otus).* These owls were selected using Cornell (2011) and represent the common owls during the summer and fall seasons for the Champlain Valley region.

At each site, we cycled through the owl list, commencing with the smaller owls. If the bigger owls were called first, data may have been skewed, for smaller owls may have been deterred from calling in the presence of larger owl (Beaverhill Bird Observatory 2003). Each owl broadcast was played for two minutes with a listening duration of one minute. Broadcast timing and duration were important because if an owl were to be called in, an acclimation period is necessary to give the target species time to detect calls and respond vocally or visually. If the procedure were to be sped up, owl detections could have been missed.

Calls were not broadcast from the Deep Well Way site, as we knew there was a resident pair of BARRs on the premise via video footage from property owner (Garneau, pers. com. 2014). Moon Giant (2014) was later used to determine what lunar phase and percent illumination occurred during owl vocalization encounters. In addition, we recorded the temperature on the night of owl detection to assess influence.

Pellet Collection and Analysis

Rugar Woods was visited twice throughout the duration of project for pellet collection, once in August and October 2014. The pellet's cardinal direction and distance from tree were recorded. Pellets were stored at room temperature in aluminum foil and labeled appropriately for future examination.

Owl pellet content analysis was followed per protocols in Scholastic (2014). Before dissection, the pellet appearance was noted and diameter was measured. The pellet was placed on a white piece of paper and dissected for content analysis. Bones and fur were separated allowing for further identification using the *Illustrated Key to Skulls and Genera of Northern American Land Mammals* (Knox Jones Jr. and Manning 1992). This guide was useful in identifying mammals based on skull structure. Pellet composition was also identified by fur characteristics in *Identification of the Dorsal Guard Hairs of Some Mammals of Wyoming* (Moore et al. 1997). Various small mammal keys were also used for identification.

Data Analysis

Occupancy and detection probability of owls, across all broadcasting sites (Vassar Rd., Barnaby Rd., and Wickham Marsh WMA), were determined using Program PRESENCE (Bailey et al. 2009). The detection of an owl was measured by the vocalization or sighting of an individual and was documented as a "1" versus non-detection following a broadcast as a "0." This met the needs of the encounter history in Program PRESENCE. Assumptions of the PRESENCE, when running occupancy models are as followed: i) occupancy is constant because the system is closed, ii) probability of occupancy is equal across all sites, iii) probability of detection given occupancy is equal across all sites, and iv) detection of species in each survey and in each detection history is independent of each other (Montana State University 2014, USGS 2014). Model parameters were set in PRESENCE and three models were run (See Appendix, Table 2). One single-season two-species model considered if BARRs and GHOs were co-occurring or being co-

detected. Also, two single-season single-species model, one for BARRs and one for GHOs were run to emphasize their occupancy and detection probability independent of time.

ArcMap vers. 10.2 (ESRI, Redlands, CA) was used to conduct analysis of habitat cover and distance to landscape features from each owl broadcasting site. We used a rasterized habitat map to determine habitat selection by BARRs and GHOs across broadcasting sites (Conservation Gateway 2013). Turnstone Environmental Consultants, Inc. (2008) recommended using a 1.5 mile buffer surrounding owl sites; however, because of the proximity of the Vassar Rd. and Barnaby Rd. sites, we used a one mile buffer. The Extract By Mask tool in ArcMap 10.2 was then used to obtain percentage of each habitat type within each buffer. Due to the plethora of habitat types, broad categories were binned (See Appendix, Table 1). The Near Distance Table spatial analyst tool was then used to determine distance in meters to specific landscape features (e.g., streams, roads, Adirondack Park boundary, state lands, bird conservation areas, and wetlands.

RESULTS

Across three study sites (Barnaby Rd., Vassar Rd., and Wickham Marsh WMA), we examined species-specific owl occupancy and detection, percentage habitat type and distance to landscape features, as well as food availability. Overall we encountered two owl species, BARR and GHO. Owls were encountered at all three broadcasting sites from August - October 2014. However, as the end of the sampling season approached, we detected fewer owls across all sites.

Occupancy and Detection

To determine occupancy and detection probabilities of owls at each broadcasting site, models were run in Program PRESENCE (See Appendix, Table 2). A single-season, two species model was run to determine occupancy and detection probabilities across sample sites for the BARR and the GHO. Model 2

had the lowest AIC value (46.58) and was the best model fit (See Appendix, Table 3). The situation parameters used were as follows: BARR occurrence, GHO occurrence, co-occurrence, detection of both species separately and co-detection with co-detection fixed (See Appendix, Table 2). Naïve estimates revealed that a BARR occupied 66.7 % of the sites, while a GHO occupied 33.3% of the sites. However, model two resulted in both the BARR and GHO occurring and co-occurring at 100%. There was 29% detection of BARR and 4% detection for GHO. There was no co-detection present.

We also ran a single-season, single-species model for both the BARR and GHO. For the BARR, model number 1 had the lowest AIC value (32.97) and was the best model fit (See Appendix, Table 4). Parameters used were BARR occupancy, detection, and the model was time independent. Results show that the BARR occupied all sites (100%) and had a probability of detection of 29% +/- 0.92 SE. The GHO model consisted of the following parameters: occupancy and detection, and ran independent of time. This model resulted in the lowest AIC value (12.31) and was the best fit model (See Appendix, Table 5). The model revealed that the GHO occupied 100% of the sites with a detection probability of 4% +/-0.04.

Habitat Selection

Percent land cover was assessed at each broadcasting site to determine species-specific habitat selection differences in home ranges. Vassar Rd. and Barnaby Rd. broadcasting sites had the same percent land cover due to their close proximity (< 1 mi). At Vassar Rd., more than one third of the landscape was agriculture followed by red oak-northern hardwood forest and urban (Fig. 2). The least common land cover was swamps and pine-hemlock dominated forests (Fig. 2). Barnaby Rd. was dominated by agricultural lands followed by northern hardwood forest and urban (Fig. 2). Marsh and rocky outcrop were the least abundant habitat types at Barnaby Rd. (Fig. 2). Agriculture was the dominant landscape within a 1 mi radius of the Wickham Marsh broadcasting site, followed by northern hardwood forests and

urban landscapes (Fig. 2). Acidic swamps, conifer-dominated hardwood forest, and pine-barrens were the least abundant habitat at this site (Fig. 2).

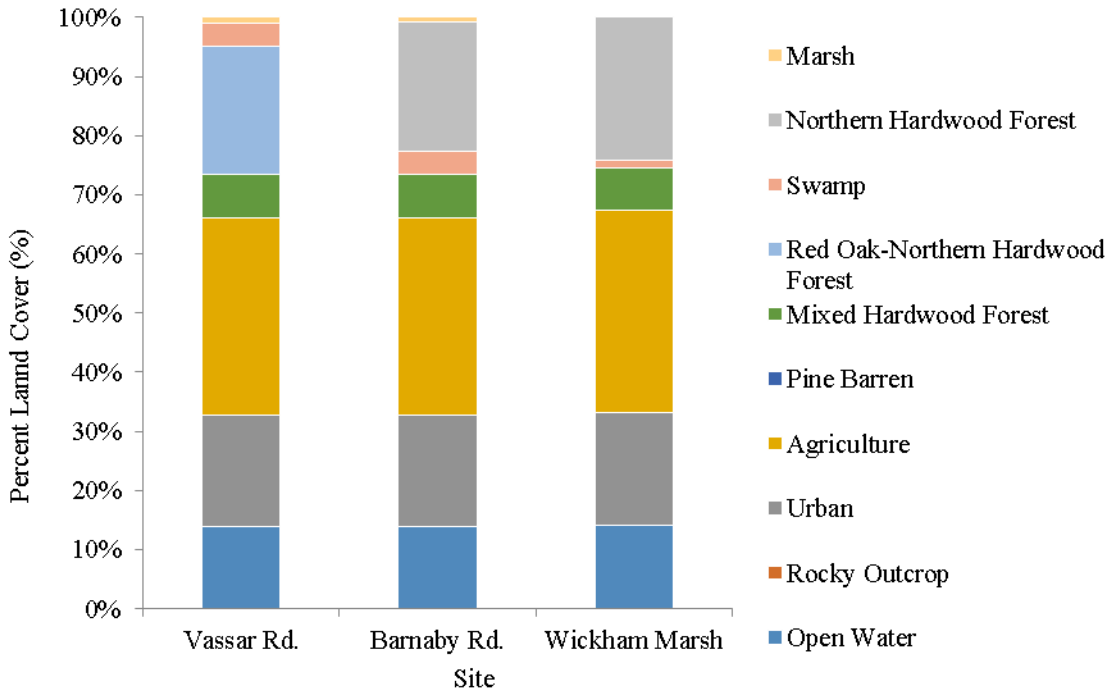

Figure 2: Percent land cover within a 1mi radius of the three broadcasting sites: Vassar Rd., Barnaby Rd., and Wickham Marsh, data extracted from Conservation Gateway (2013).

We also assessed the nearest linear distance that each broadcasting site was from different landscape features (e.g., streams, roads, Adirondack Park boundary, state lands (under the jurisdiction of the NYS Department of Environmental Conservation), and bird conservation areas (e.g., Nature Conservancy properties, Wildlife Management Areas, and wetlands). Wickham Marsh is a wetland located on a state owned wildlife management area encompassed by the Adirondack Park. The marsh was farthest from the road compared to other broadcasting sites (Table 6). Barnaby Rd. was nearest to a stream and road, but the farthest from a wetland (Table 6). Vassar Rd. was the farthest from a stream, the Adirondack Park boundary, and state land, but was the second nearest to a wetland. Both Vassar Rd. and

Barnaby Rd. were approximately the same distance to a bird conservation area. All three sites were located on New York state lands (Table 6).

Table 6: Distance of broadcasting sites to the following landscape features: streams, roads, the Adirondack Park boundary, state lands (NYS Department of Environmental Conservation), bird conservation areas, and wetlands. The nearest features to broadcasting sites are highlighted for ease to reader. Distances were measured in *meters* and determined using the near distance table spatial analysis tool in ArcGIS.

Site	Stream	Road	ADK Park boundary	State Land	Bird Conservation Area	Wetland
Vassar Rd	591.0	6.7	11058.7	3030.8	26380.8	86.3
Barnaby Rd	306.7	3.9	10151.5	2690.5	26239.1	210.6
Wickham Marsh	388.7	17.5	0	0	980.3	0

Moon Phase

We analyzed in which moon phase the resident BARR was detected. The BARR was most often detected when the moon was past a half-moon. Forty three percent of the calls were reported during the waxing crescent moon (Fig. 3) whereas 57% of BARR calls occurred during the waxing and waning gibbous moons (Fig. 3). Waxing and waning gibbous moon phases had the highest light illumination ranging from 66-99% (Table 7).

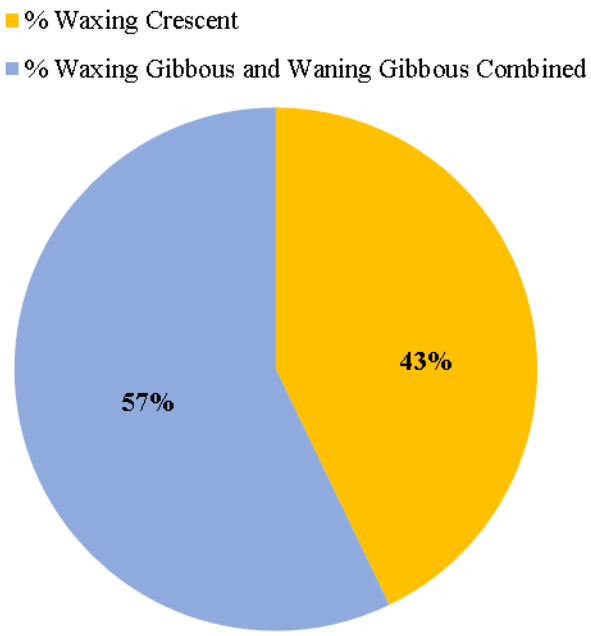

Figure 3: Percent detection of BARR in relation to moon phase at Deep Well Way Peru, NY from August-October 2014. The waxing and waning gibbous moons are combined because these are the moon phases before and after the full moon when there is a high percentage of illumination.

Table 7: Moon phase in correspondence to detection of BARR at Deep Well Way Peru, NY. Percent illumination, temperature, wind speed, and time of call were also recorded.

Date	Moon Phase	% Illumination	Temperature (°C)
8/26/14	Waxing Crescent	1%	24.44
8/30/14	Waxing Crescent	21%	18.33
9/06/14	Waxing Gibbous	90%	21.11
9/08/14	Waxing Gibbous	99%	16.11
9/13/14	Waning Gibbous	76%	8.33
9/14/14	Waning Gibbous	66%	7.77
9/28/14	Waxing Crescent	17%	17.77

Prey Selection

Owl pellets were obtained from a mixed coniferous stand in Plattsburgh, New York, where GHO activity had been recorded. After examination, two skeletons were recovered and were identified as a grey squirrel (*Sciurus carolinensis*) and a mouse (Figs. 4, 5, and 6). Keenan (pers. com. 2013) surveyed small mammals at Rugar Woods, Plattsburgh, NY and determined that northern short-tailed shrew (*Blarina brevicauda*), meadow vole and deer mice were all abundant within the same forest stand. Ellsworth and Peterson (2014) surveyed small mammals at the Barnaby broadcasting site and found that *Peromyscus* spp., northern short-tailed shrews, and southern red-backed voles were the most abundant. This fall, Goldman and Sypek, (pers. com. 2014) captured flying squirrels at the Barnaby Rd. site. All small mammals listed are potential prey for both the BARR and GHO and are present across Clinton County, New York.

Fig. 4: Grey squirrel skull found within a GHO pellet in Plattsburgh, New York, July 2014.

Fig 5 and 6: Mouse skull found within an owl pellet in Plattsburgh, New York, July 2014.

DISCUSSION

Owl detectability and habitat use can be influenced by both biotic and abiotic factors. In this study, one objective was to assess the presence of owls in various habitats. Once owls were detected, habitat type and distance to landscape features were assessed using ArcGIS. Additionally, we sought to determine habitat-specific dietary preference using pellet dissections.

Broadcasting BARR and GHO calls has been used successfully as a non-invasive research tool in order to detect occupancy by individual owls (McGarigal and Fraser 1985; Morrell et al. 1991). BARRs are more vocal and respond 50% of the time to broadcasts, while GHOs are more sensitive to return vocalizing and have the highest probability of returning a call within two minutes of the broadcast (McGarigal and Fraser 1985; Morrell et al. 1991). GHO occupancy was only observed at the Vassar Rd. site and in only one detection event. We hypothesized that the individual calling back was a juvenile floater because of the sole detection, and if we were broadcasting within its territory, the owl would have vocalized more often in territorial defense. Rohner (1996) discovered that no more than 15% GHO fledglings establish a territory within the first year of life, will "float" in the landscape, and are highly detected in open habitat. BARRs occupied, and were detected, across all of our sites. At Barnaby Rd., we hypothesized that the individual was a fledgling who still resided within their parent's territory. The individual at Barnaby returned calls with a communication call of "who cooks for you" or with a territorial warning call. On one occasion, we encountered three BARRs at Barnaby Rd., which suggests that the parent owls were vocalizing a warning call against intruders.

Land cover can influence owl occupancy and detection rates within a region (Devereux and Mosher 1984; McGarigal and Fraser 1985; Smith et al. 1999, Yamasaki et al. 2000; Cornell 2011). BARRs prefer contiguous mixed deciduous forests with ample canopy cover and thick understory

vegetation (Devereux and Mosher 1984; and McGarigal and Fraser 1985; Cornell 2011). Through broadcasting, our BARRs were detected within intact, dense, multilayered forest. At both Barnaby Rd. and Wickham Marsh WMA, BARRs were utilizing northern hardwood forests, which characteristically have ample understory vegetation and canopy cover. Urban and agricultural land covers were co-dominant habitat in each BARRs range. The agricultural and urban/forest interfaces are increasingly becoming more popular to generalist predators, like the owl (Andren and Angelstam 1988). Our results suggest that BARR presence occurs in urban dominated areas, which is in direct contrast to that of Bosakowski and Smith (1997) who detected owls in remote, deep wooded areas.

Coniferous dominated forests are preferred by GHOs with open meadows and wetlands for hunting grounds (Yamasaki et al. 2000; Cornell 2014). We hypothesized that GHOs would occupy and be detected within coniferous dominated systems; however, our results indicate the contrary that the GHOs used a deciduous dominated system. Our results support the Smith et al. (1999) conclusion that GHOs utilize deciduous trees over coniferous because they provide increased cover. The GHOs detected in our study inhabited an area dominated by northern red oak-northern hardwood forests, urban, and agricultural habitats. Again, the agricultural and urban/forest interface may explain why both the BARRs and GHOs were found in similar forest types and land cover (Andren and Angelstam 1988). Results from this project also further support that GHOs are more likely to reside by urbanized areas (Bosakowski and Smith 1997).

Habitat fragmentation creates discontinuity across landscapes, altering species-specific habitat selection, specifically owls (Devereux and Mosher 1984; Hunter et al. 1995; Henry 1997). However, fragmentation can be naturally created by streams and wetlands, or result from anthropogenic actions with the creation of roads and protected lands. BARRs occupy contiguous habitat, with limited fragmentation unless a naturally occurring feature is present (e.g., streams or wetlands) (Devereux and Mosher 1984;

McGarigal and Fraser 1985; Cornell 2011). At Barnaby Rd., the only fragmentation encountered was a limited-use access road. There was also a road adjacent to the Wickham Marsh WMA site where BARRs were detected. We conclude that proximity to road does not affect BARR presence and habitat selection at our sites. In addition, a wetland was located within a mile of the Barnaby site, acting as a hunting ground for the BARR. Similar trends were found at Wickham Marsh and had occurrences of BARRs. Our findings further support research that BARRs reside near and move through wetland areas, specifically marshes (Nicholls and Warner 1972).

Our Vassar Rd. site was located in a suburban landscape and Smith et al. (1999) describes GHO nests as being farthest from roads in addition to containing contiguous forested areas. Vassar Rd., where the GHO was detected, was only 6.7 m away from a road. Bosakowski and Smith (1997) discuss that GHO thrive in urbanized, fragmented habitats and proximity to roads has no effect on their habitat selection. Additionally, Vassar Rd. was proximal to a wetland, where the GHO could have hunted. Additionally, our broadcasting site was at the interface of a forest/meadow. This open area potentially could act as the GHOs hunting ground and provides supportive evidence that GHOs utilize open habitat for hunting (Knight and Erickson 1977).

Ibarra et al. (2014) stated that owls are more active at night when there is greater lunar light because it allows for more hunting opportunities due to higher visibility. During this study, we found we had more callbacks during a waxing and waning gibbous moon. These moon phases had a higher illumination percentage thus, supporting our hypothesis. In addition, Takats and Holroyd (1997) found that as the temperature declined below 0°C owl vocalization declined too. We did not experience temperatures below 0°C due to the time of year we conducted this study. Our temperatures fell between 7.77°C and 24.44°C, indicating that owls will vocalize at an array of temperatures. In the future, we

could extend our study into the winter months to test the role on freezing temperatures on owl vocalization.

As nocturnal predators, owls exert top down pressure on lower trophic levels in ecosystems. They are temporally separated from other birds of prey, giving them a foraging advantage with limited competition. BARRs' diets are comprised of more than 50% small mammals, followed by arthropods and birds (Devereux and Mosher 1984). Ellsworth and Peterson (2014) found that *Peromyscus* spp. were the dominant small mammal population at the Barnaby Rd. site. Because Vassar Rd. and Barnaby Rd. were in close proximity (< 1 mi), we can infer that this was the preferred prey of choice for both owl species detected at these sites. Keenan (pers. com. 2013) found that the small mammal populations at Rugar Woods, Plattsburgh, NY primarily consisted of mice, shrews, and voles. Our owl pellet dissection evidence supports that the GHO of Rugar consumed mice as well as grey squirrels. However, there was no evidence to support that the GHO in Rugar Wood's consumed red squirrels.

To increase scientific understanding of habitat preferences between BARRs and GHOs, we suggest conducting this project with more variable study sites and fewer visitation times per site in order to better fit models in PRESENCE. Additionally, broadcasting within recreational parks, urban forests, and residential areas may help researchers better understand owl habitat use. Lastly, determining if nocturnal owls and diurnal raptors are spatially overlapping in habitat and consuming the same foods could be another avenue of study.

Overall, owl broadcasting is an effective way to determine owl presence at a given site. One limitation includes not being able to estimate population size. Owls can be heard from great distances, and unless the individual is captured and marked, there is no way to estimate population size using broadcasting techniques. Broadcasting can lead researchers to owl nesting sites where population size estimates can be obtained through egg counts (Devereux and Mosher 1984; Smith et al.1999).

Understanding owl habitat-use patterns is important for habitat conservation purposes. In the future, if BARRs and GHOs become threatened, scientists will better understand habitat preferences and can then adapt owl habitat management plans. We recommend land managers, who are interested in promoting preferable owl habitat, promote mixed hardwood forest stands with ample canopy. These forests should be contiguous with open wetland or meadow habitats interspersed, affording abundant hunting opportunities. In future research, road fragmentation should be avoided because such practices may negatively impact permanent occupancy and vocalization opportunities for owls. Furthermore, creating these forests will also support small mammal populations that comprise more than 50% of BARRs and GHOs diet (Devereux and Mosher 1984).

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Appendix

Table 1: Habitat categories used in habitat analysis, descriptions can be found through Conservation Gateway (2013) terrestrial map guide.

Habitat
Open Water
Urban
Agriculture
Mixed Hardwood Forest
Red Oak Northern Hardwoods
Swamp
Marsh
Rocky Outcrop
Northern Hardwood Forest
Pine Barren

Table 2: Description of symbols used for modeling in Program PRESENCE.

Parameter	Description
Ψ(B)	occupancy probability of barred owl
Ψ(G)	occupancy probability of GHO
Φ	co-occupancy probability
$p_B()$	detection probability of barred owl
$p_G()$	detection probability of GHO
Δ	co-detection
t	time
.	fixed, set equal

*Absence of a parameter in the model parameters indicates no interaction in occupancy or detection (Bailey et al. 2005).

Table 3: Single-season, two species model representing that model number 2 was the best fit model to describe our data collected in Clinton County, New York, August – October 2014. Model three was not included in the table because it failed to converge within program PRESENCE.

Model parameters	#	no.Par	AIC	AIC wt
Ψ (B), Ψ (G), p_B, p_G, Δ	2	5	46.58	0.4656
Ψ (B), Ψ (G), Φ, p_B, p_G	4	5	48.43	0.1846
Ψ (B), Ψ (G), p_B (.), p_G (.)	5	6	48.60	0.1696
Ψ (B), Ψ (G), Φ, p_B, p_G, Δ	1	6	49.16	0.1282
Ψ (B), Ψ (G), Φ, p_B (.), p_G (.)	6	7	50.96	0.0521

Table 4: Single season- one species model for BARRs probability of occupancy and detection across sites from August -October 2014.

Model parameters	#	no. Par	AIC	AIC wt
Ψ(B), *p*(B), *t*(.)	1	2	32.97	0.7923
Ψ(B), *p*(B)	2	9	37.10	0.1005

Table 5: Single season- one species model for GHOs probability of occupancy and detection across sites from August 2014-October.

Model parameters	#	no. Par	AIC	AIC wt
Ψ(G), *p*(G), *t*(.)	1	2	12.31	0.9915
Ψ(G), *p*(G)	2	9	21.82	0.0085