COMPARATIVE HABITAT SELECTION AND BEHAVIOR OF MALLARDS (Anas platyrhynchos) AND AMERICAN BLACK DUCKS (Anas rubripes) WINTERING IN THE FINGER LAKES REGION

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COMPARATIVE HABITAT SELECTION AND BEHAVIOR OF MALLARDS (*Anas platyrhynchos*) AND AMERICAN BLACK DUCKS (*Anas rubripes*) WINTERING IN THE FINGER LAKES REGION

by:

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A thesis submitted in partial fulfillment of the requirements for the Master of Science Degree
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ABSTRACT

Adam J. Bleau. Comparative Habitat Selection and Behavior of Mallards (Anas platyrhynchos) and American Black ducks (Anas rubripes) Wintering in the Finger Lakes, 103 pages, 3 tables, 16 figures, 2018. JWM style guide used.

Mallards and American black ducks are closely related species with little niche separation. I sought to identify management actions to promote the Finger Lakes population of wintering black ducks in the face of competition with mallards. Occupancy by black ducks of points on lake shorelines was negatively influenced by building presence. Local black duck colonization varied negatively with proportion of developed land and local black duck extinction varied positively with dock density. Based on GPS tracking, mallards used agriculture and developed habitats more than black ducks. Black ducks selected emergent wetlands to a greater degree than available within their home range. I did not statistically detect behavioral differences between species although proportion time spent foraging when in forested wetlands was eight times greater for black ducks than mallards. Black duck conservation in wintering areas should focus on restoring agricultural areas to emergent marsh and maintaining shoreline areas with limited development.

Key words: American black duck, Anas rubripes, Anas platyrhynchos, behavior, Finger Lakes, habitat, home range, mallard, New York, occupancy

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CHAPTER 1: INTRODUCTION

Competition arises between sympatric species that use the same resources (Newton 1994), and has the potential to limit populations that are of conservation concern. Competition can occur when a species directly uses the same resources as another sympatric species, or indirectly when a species prevents another from using a resource (Mader 1996). Two species using the same resources are unable to coexist in a certain area and extinction of one species can occur unless the competing species undergo some form of niche differentiation (Mader 1996). Competition with barred owls (*Stryx varia*) has been cited as a factor in the decline of northern spotted owls (*S. occidentalis*) (Olson et al. 2005) and competition with redhead ducks (*Aythya americana*) for nest sites during the breeding season has been determined to be a factor in canvasback duck (*A. valisineria*) declines (Peron and Koons 2012). American black ducks (hereafter black duck; *Anas rubripes*) are a species of conservation concern with a population that could be limited by competition with the closely related mallard (*A. platyrhynchos*) (Merendino and Ankney 1994).

Natural History of the Mallard and American Black Duck

Numbers of black ducks decreased dramatically from the 1950s through the 1980s (Black Duck Joint Venture 2008). Since then, black duck populations have stabilized but are still 12% below their long term average population level and 22% below their population goal of 640,000 breeding birds set forth in the North American Waterfowl Management Plan (North American Waterfowl Management Plan 1986). Concurrent with decreased black duck abundance, mallard abundance has increased throughout much of the black duck range (Huesmann 1991, USFWS 2003, USFWS 2017). Hypotheses for range expansion by mallards include movement of these ducks east from the prairies as eastern forests were cleared and annual release of farm-raised mallards in eastern North America (Schladweiler and Tester 1972, Ankney et al. 1987, USFWS...
2003, Osborn et al. 2010, Lavretsky et al. 2014). Currently, mallards are the most common breeding duck in New York and throughout much of New England (Heusmann 1974, Heusmann 1991, USFWS 2017). Hypotheses for the decline in the black duck population include loss or modification of habitat, overharvest, and competition with mallards (Goodwin 1956, Ankney et al. 1987, Heusmann 1988, Longcore et al. 1998, Petrie et al. 2000, Maisonneuve et al. 2006). Hybridization with mallards was also hypothesized to negatively influence the black duck population through introgression, whereby mallard phenotypes become more common through time (Heusmann 1974, Ankney et al. 1986, Merendino et al. 1993, Dwyer and Baldassarre 1994, Lavretsky et al. 2014). However, hybridization has largely been discounted as a cause for black duck decline. Recent DNA sequencing studies indicated a substantial genetic barrier between mallards and black ducks that has been sustained for millennia, suggesting that introgressive hybridization is not occurring between these two closely related species (Phil Lavretsky, UTEP, personal communication).

**Seasonal Aspects of Competition**

Many studies suggest that decline in abundance of black ducks was linked to colonization of eastern North America by mallards (Ankney et al. 1987, Heusmann 1988). Mallards and black ducks are closely related species with little niche separation, increasing likelihood of competition for resources (Bellrose 1980). Competition from mallards for breeding areas may be a factor in black duck decline (Ringelman and Longcore 1982, Dwyer and Baldassarre 1994, Merendino et al. 1995). In southern Ontario, mallards occurred alone or with black ducks on more fertile wetlands while black ducks occurred alone on less fertile wetlands (Merendino and Ankney 1994). Merendino et al. (1993) suggested mallards were filling breeding territories first and displacing black ducks on more fertile wetlands. The mere presence of mallards on a breeding
territory may discourage black ducks from occupying these wetlands, because they treat each other as conspecifics (Seymour 1992, Brodsky and Weatherhead 1984, Petrie et al. 2012). Petrie et al. (2012) observed more black ducks on wetlands following removal of mallards than on control wetlands. Although clutch sizes, nest success, duckling survival (Maisonneuve et al. 2000, Petrie et al. 2000), and adult survival (Nichols et al. 1987) were similar between sympatric mallards and black ducks, increasing mallard populations often coincided with a decreasing black duck population (Collins 1974, Dennis et al. 1989, Merendino et al. 1993, Petrie et al. 2012), suggesting that mallards are filling the functional space of breeding black ducks.

Several studies have suggested that black ducks are less tolerant of landscape change and human encroachment than mallards, making them less-adapted to land conversion to agriculture and human development (Mendall 1958, Spencer 1986, Ankney et al. 1987, Merendino et al. 1995). Ducks often expend energy to avoid human disturbance which can be costly to wintering waterfowl (Pearse et al. 2005). Probability of black ducks occurring in a wetland increased with increasing percentage of forest cover (Spencer 1957, Renouf 1970, Brown and Parsons 1979) and with increasing distance from a human structure (Mendall 1958, Spencer 1986). Also, mallards are often more likely to occupy areas with greater human presence than black ducks (Diefenbach and Owen 1989, Macy and Straub 2015). Petrie et al. (2012) observed black ducks using wetlands surrounded by greater than 75% forest cover to a greater degree than mallards. However, no differences were detected between habitat use of mallards and black ducks in New York during summer (Dwyer 1992, Dwyer and Baldassarre 1994, Macy and Straub 2015). During winter along the Atlantic Coast, Ringelman et al. (2015) found no evidence that black ducks avoided urban areas or roads. However, human disturbance has been suggested as limiting access to available food resources (Lewis and Garrison 1984, Morton et al 1989). Human
disturbance causes physiological stress in black ducks which could impact their winter survival or reduce their fitness during the subsequent breeding season (Morton et al. 1989).

The competition hypothesis can also be applied to resource competition during the non-breeding season. During winter, food and open water are critical for survival, but may be limited for mallards and black ducks at northern latitudes due to snow and ice cover (Schummer et al. 2010, Notaro et al. 2016). Greater fat reserves of mallards than black ducks where they are sympatric during winter suggest that mallards may be outcompeting black ducks for food or at least assimilating food resources more efficiently (Hanson et al. 1990). Mallards could potentially interfere with or exclude black ducks at high quality wintering habitat or food sources (Mank et al. 2004). Studies during the non-breeding season have focused on coastal wintering birds (Diefenbach et al. 1988, Morton et al. 1989, Cramer 2009, Cramer et al. 2012, Ringelman et al. 2015), whereas few studies have focused on the ecology of inland populations of wintering black ducks (Chipley 1995, Robb 1997, Newcomb et al. 2015).

**The Inland Wintering Population of Black Ducks - Finger Lakes Region**

Competition for wintering habitat and food resources between mallards and black ducks could be limiting to black ducks (Heusmann 1974), but few studies have investigated ecological separation during winter at inland locales for black ducks. Black ducks are known to use three main inland wintering areas including the Tennessee National Wildlife Refuge, western Lake Erie marshes, and the Finger Lakes Region (FLR) of central New York (Robb 1997, Newcomb et al. 2015, NYSOA 2017; Winous Point Marsh Conservancy, *unpublished data*). In Tennessee, black ducks used emergent wetlands, forested wetlands, and scrub-shrub wetlands, but avoided agricultural areas (Newcomb et al. 2015). Black duck winter survival in Tennessee was similar to or greater than other black duck survival estimates and winter mortality was not a significant
factor affecting black duck populations in that region (Chipley 1995, Newcomb et al. 2015). Robb (1997) observed black ducks exhibiting greater winter site fidelity than mallards in Lake Erie marshes. There have been no studies focused on ecology of black ducks wintering in the FLR.

The FLR contains several long, narrow lakes that are surrounded by a mosaic of deciduous and mixed forests and scattered primarily row crop agriculture consisting mostly of corn and soybean (Appendix 1). During winter, Cayuga and Owasco Lakes remain fairly ice-free relative to other waters which permits ducks to remain in the area until spring (Appendix 2). Migrant mallards and black ducks typically arrive in the FLR during October - January when emergent marshes and forested wetlands become increasingly ice covered (Notaro et al. 2016). Some mallards and black ducks overwinter in the ice-free areas until early spring (e.g., March and April) when the snow and ice melt and temperatures warm. Mean minimum annual counts from 1973-2016 based on the New York State Ornithological Association January waterfowl count were 7,571 ± 752 mallards and 1,806 ± 170 black ducks in the FLR (NYSOA 2017). When snow and ice do not preclude foraging, mallards and black ducks also use adjacent agriculture fields, emergent and forested wetlands, streams, and rivers. Therefore, the FLR is a critical site for inland wintering birds, and understanding winter ecology of black ducks and competition with mallards is important to black duck conservation.

**Goal and Objectives**

My goal was to identify conservation and management actions that could be applied within the FLR to benefit wintering black ducks. To meet this goal, I developed occupancy models for points along the shores of Cayuga and Owasco lakes, examined habitat use and home range for mallards and black ducks wintering in the FLR based on satellite telemetry, and investigated if
foraging and other behaviors differed between these two species within different land cover types. I compared habitat use of each species to availability within their home ranges to determine if the species exhibit differential habitat selection to identify management actions that could be directed to benefit black ducks. More informed management decisions that reflect black duck habitat preferences could help reverse the decline in black duck populations by increasing their winter carrying capacity in the FLR as well as in other inland wintering sites.

This thesis is organized into two principal chapters. Chapter 2 describes my occupancy methods and analysis. Chapter 3 describes the habitat use and home range methods and analysis. Both chapters are formatted for submission as independent manuscripts for publication in the Journal of Wildlife Management.
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CHAPTER 2: LAKESHORE OCCUPANCY BY MALLARDS AND BLACK DUCKS

ABSTRACT Mallards (Anas platyrhynchos) and American black ducks (hereafter black duck; A. rubripes) are closely related species with little niche separation, increasing likelihood of competition. In the 1950’s, mallards began filling the functional niche of black ducks, now a species of conservation concern, by expanding their range eastward. I investigated ecological separation between mallards and black ducks in the Finger Lakes Region (FLR) of New York, January – March 2016 and 2017. The FLR provides some of the only inland wintering habitat for black ducks. My goal was to identify management actions to help sustain this population of wintering black ducks. I conducted occupancy surveys and used dynamic multi-species occupancy modeling to determine factors affecting the distribution of black ducks along the lakeshores, including the influence of mallards and human development. Occupancy of lakeshore points by black ducks varied negatively with the presence of buildings, local colonization varied negatively with proportion of developed land, and local extinction varied positively with dock density. Local extinction of both species varied by week, and corresponded to seasonal changes in weather. Colonization and extinction of lakeshore points by black ducks were positively correlated with those same parameters in mallards. My results suggest that black ducks are less tolerant of human structures (or human activities) than mallards. Due to the close association of mallards and black ducks, it appears to be difficult to manage black ducks separately when the two species are wintering along the shores of the Finger Lakes.

Key words: American black duck, Anas platyrhynchos, Anas rubripes, Finger Lakes, mallard, New York, occupancy, RPresence, winter
Determining factors that affect the distribution of two competing species can yield important insights for wildlife managers, especially if one of those species is of conservation concern. This competition can occur directly (exploitative competition) when a species uses up resources that another species uses or indirectly (interference competition) when a species prevents another from using a resource (Mader 1996). Competing species are unable to coexist without niche differentiation. Occupancy of secretive black rails (*Laterallus jamaicensis*) in California freshwater marshes, for instance, has been determined to be greater when Virginia rails (*Rallus limicola*) are present suggesting these two species are coexisting through niche differentiation (Richmond et al. 2010). In contrast, the presence of barred owls (*Strix varia*) in Oregon conifer forests caused increased local extinction and decreased local colonization of northern spotted owls (*S. occidentalis*) (Olsen et al. 2005). American black duck (hereafter black duck; *Anas rubripes*) is a species of conservation concern that faces a potential threat of competition from a naturalized, closely-related species, the mallard (*A. platyrhynchos*).

The abundance of black ducks declined significantly from the 1950’s through the 1980’s while mallards have increased their population and expanded eastward into traditional black duck range (Heusmann 1974, Heusmann 1991, USFWS 2003, USFWS 2017). Mallards and black ducks are closely related and use many of the same resources, thus competition may exist between them when they are sympatric. Competition between these species has been studied extensively during the breeding season (Brodsky and Weatherhead 1984, Seymour 1992, Petrie et al. 2012), but few studies have investigated competition during the winter (Conroy et al. 1989, Ringelman et al. 2015). Even fewer studies have investigated inland wintering sites (Chipley 1995).
Winter is an important component of the annual cycle for waterfowl because conditions during winter can potentially affect fitness in subsequent seasons (Heitmeyer and Fredrickson 1981, Kaminski and Gluesing 1987, Sedinger and Alisauskas 2014). Ice and snow cover can decrease accessibility to wetland and agricultural foods that ducks use to sustain lipids (Schummer et al. 2010). Reduced opportunities to acquire food can influence overwinter survival of ducks wintering at more northern latitudes (Conroy et al. 1989, Plattner et al. 2009). Lipids acquired in winter are also used to fuel migration and initiate egg laying (Krapu and Reinecke 1992). Wintering ducks with adequate access to food are able to reduce lipid loss and spend less time foraging than those with less available food (Reinecke et al. 1982) or with lower quality food (Paulus 1988). As such, ducks at foraging sites of greater quality generally have sufficient energy to devote to courtship and maintenance of pair bonds (Brodsky and Weatherhead 1985, Hepp. 1989). Winter can be a stressful period for black ducks, especially juvenile birds, due to low food availability, extreme weather, and high energetic demands (Reinecke et al. 1982). In addition to weather, competition can influence access to winter food resources with dominant pairs forcing subordinate pairs to use lower quality habitat and be more at risk from predators (Hepp 1989, Mank et al. 2004). Mallards may be outcompeting or interfering with black ducks for food resources. In sympatric wintering populations of mallards and black ducks, mallards were discovered to have greater fat reserves (Hanson et al. 1990). If mallards are excluding black ducks from good quality habitat, black ducks could experience poorer body condition, have a decreased survival rate, or delay migration until they acquire enough fat reserves during spring staging. These factors would result in black ducks that are migrating later and arriving on breeding areas after mallards have already set up breeding territories. Black ducks treat mallards as conspecifics (Brodsky and Weatherhead 1984, Seymour 1992, Petrie et al. 2012) so a mallard
pair occupying a breeding territory would make a black duck pair move on to a potentially poorer quality breeding site.

The Finger Lakes Region (FLR) is one of the only available inland wintering sites for black ducks, and to date there have been no studies of black duck winter ecology in the FLR. The region is highly impacted by human activities, including recreation, shoreline development and agriculture (USDA 2012). Understanding factors that affect black duck carrying capacity in the FLR is therefore important for conserving the species. Potential competition exists between mallards and black ducks that winter together in the FLR. Cayuga and Owasco Lakes, along with Seneca Lake, often remain fairly open during most winters while other sources of water in the vicinity are frozen. January waterfowl counts compiled by the New York State Ornithological Association indicate that, on average, $7,571 \pm 752$ SE mallards and $1,806 \pm 170$ SE black ducks overwinter in the FLR (NYSOA 2017). Changes in habitat use by black ducks during the non-breeding season may be related to human activity or site use by mallards, and differentiating these effects is important for managing wintering habitat.

Two-species occupancy modeling can be used to test for competitive exclusion and dominance relationships of two sympatric species, in the face of imperfect detection of a species during surveys (MacKenzie et al. 2002). Occupancy modeling has been used to quantify co-occurrence of northern spotted owls (Strix occidentalis) and barred owls (S. varia) (Olson et al. 2005, Bailey et al. 2009), as well as reptiles (Luiselli 2006) and amphibians (Mackenzie et al. 2004). Occupancy models assume population closure, but when that assumption is clearly violated then dynamic occupancy models provide a framework for analyzing changes in distribution over time (MacKenzie et al. 2002). Two-species dynamic occupancy models yield
estimates of weekly colonization and extinction dynamics at survey plots, accounting for the effects of a dominant species on a subordinate species as well as ecological covariates.

Black ducks have been observed avoiding areas with human disturbance relative to those with little to no disturbance (Morton et al. 1989a). Black ducks also avoid wetlands or areas in wetlands where there is a visible human structure (Diefenbach and Owen 1989). Mallards appear to be more tolerant of human disturbance (Morton 1998). Percentage of forest cover influences the occurrence and distribution of black ducks (Spencer 1957, Renouf 1970, Brown and Parsons 1979, Petrie et al. 2012). Black duck densities in Quebec were greater in forested and dairy farm landscapes than cropland landscapes while mallard densities were similar among each landscape type (Maisonneuve et al. 2006). Modeling such relationships can provide a useful framework for wildlife managers needing to conserve one species in the presence of a competitor.

The goal of my study was to determine factors that influence the presence of black ducks and mallards along segments of the lakeshores, including habitat components and the possible effect of mallard occupancy dynamics on black duck distribution. I hypothesized that black ducks would choose areas along the lakeshore that allow for isolation from human structures and disturbance. I predicted that black ducks would be negatively affected by human development but that mallards would be unaffected. I also predicted than black ducks would choose sites away from mallards. Determining how humans and mallards affect black duck distribution would be useful for wildlife managers attempting to benefit black ducks on the Finger Lakes without also promoting mallards.

**Study Area**

Cayuga Lake (42° 45’ 48.297”,-76° 44’ 7.6446”) is the second largest Finger Lake with a length of 61 km, an average depth of 55 m, and 170 km of rocky shoreline with numerous cottages and
docks (NYSDEC 2017). Owasco Lake (11 km east of Cayuga Lake) is 18 km long, with an average depth of 30 m, and 43 km of rocky shoreline (NYSDEC 2017). Cayuga and Owasco Lakes are located in Cayuga, Seneca, and Tompkins counties. The north end of Cayuga Lake is shallow and contains abundant submerged and emergent vegetation that is an important resource for wintering and migrating waterfowl when not frozen. Winter in the FLR often varies between below and above freezing temperatures, which results in alternating ice formation and melt on the lakes and surrounding wetlands. For Auburn, NY (at the north end of Owasco Lake), average low winter temperature is -10°C and average winter snowfall is 50-80 cm (U.S. Climate Data 2018).

The FLR also contains the 20,000-ha Montezuma Wetlands Complex (MWC) which is located immediately north of Cayuga Lake and contains the Montezuma National Wildlife Refuge (NWR), Northern Montezuma Wildlife Management Area (WMA), and numerous other emergent, forested, riverine, and seasonal wetlands owned by other conservation organizations and private individuals. The MWC supports over 3,000,000 waterfowl use days each year (USFWS 2008; M. L. Schummer, unpublished data). The MWC was designated as an Important Bird Area because of the region’s stopover habitat for a diversity of migratory birds and is a priority focus area in the North American Waterfowl Management Plan (North American Waterfowl Management Plan 1986). The FLR is the largest agricultural region in New York with nearly 600,000 hectares of agricultural land (USDA 2012). The main crops grown in the FLR include corn, soybean, and wheat. This agricultural land provides an additional food resource to wintering and migrating waterfowl when snow cover is minimal. The FLR also contains several rivers, canals, and creeks including the Seneca River which drains Cayuga Lake and the Erie Canal. The New York State Canal Corporation controls the water levels on Cayuga Lake for
navigation and flood control. Water levels on the lake are lowered by one meter each winter, exposing shorelines up to five meters in width, and potentially increasing attractiveness to dabbling ducks such as mallards and black ducks that overwinter in the area.

METHODS

Occupancy Surveys

I conducted mallard and black duck occupancy surveys at 101 points along Cayuga and Owasco Lakes during the winters of 2016 and 2017 following hunting season. Using a random number table to create a starting point, I generated survey points \( n = 101 \) along the shorelines, separated by 500 m to ensure independence of observations by being far enough apart that ducks at one point could not be seen from the next point and, thus, were not double counted if they did not move between points. I created 100-m buffers around each point using the Create Random Points and Generate Points Along Lines tools in ArcMap 10.4 (ESRI, Redlands, CA) to extract covariate information from available Geographic Information Systems layers. I visited points to assess accessibility and feasibility for inclusion in a one-day survey of both lakes. I removed points that were not readily accessible by car or foot, where I was prohibited by a landowner, or which had no view of the lakeshore. I surveyed final occupancy points on Cayuga Lake \( n = 80 \) and Owasco Lake \( n = 21 \) weekly, January - March 2016 and 2017. I conducted seven diurnal surveys at each point in 2016 and six surveys in 2017.

In 2016, I used a single observer during surveys on the assumption that detection rate of ducks in open habitat was 100%. However, over the course of the season I determined that detection was probably not 100%, because buildings, docks, and vegetation obstructed the view at some locations. To control for imperfect detection, in 2017, I used a dual observer approach
Two observers conducted a simultaneous survey of each point, and did not communicate their observations to each other. I treated each observer as an independent visit.

I divided the lakes into quadrants and used a random number table to select a quadrant and point to start at each week. I attempted to attain an even distribution of surveys at each point in each time period (morning [sunrise to 1000], midday [1000 – 1400] or afternoon [1400 to sunset]) by alternating the direction of travel each week. Each observer recorded the number of mallards and black ducks present within 100 m of the sample point, as that was the maximum distance I determined I could reliably estimate on the lakes and accurately identify duck species under varying light and weather conditions. During the first survey, I also recorded distance from the point to the nearest building and to the nearest dock (± 1m) using a Nikon Prostaff 3 laser rangefinder (Nikon, Tokyo, Japan) and counted the number of docks present within 100 m of occupancy points. During each visit, I recorded weather metrics including temperature (± 1°C) and wind speed (± 1 km/hr) using a Kestrel 2000 wind meter (Nielsen-Kellerman Co., Boothwyn, PA) and wind direction using a hand-held compass, and estimated percent ice cover within 100 m of the point to the nearest 5%. I also recorded if a vehicle or other human disturbance (e.g., person walking a dog, car driving close to shore) was observed at the point during the survey. I estimated the percent of land cover classes within 100 m of each occupancy point using the Crop tool in ArcGIS 10.5 (ESRI, Redlands, CA) and the National Land Cover Database 2011 (Homer et al. 2015). I grouped cover types into five categories (open water, agriculture, developed, emergent wetland, and forested wetland).
Occupancy Modeling

I fit two-species dynamic occupancy models (MacKenzie et al. 2004, 2006, Richmond et al. 2010) using RPresence (Hines 2006) in RStudio (RStudio Team 2016). The model parameters included occupancy during the first week ($\Psi$), weekly local colonization ($\gamma$), weekly local extinction ($\epsilon$), and detection (p). I modeled occupancy during the first week as a function of species and variables related to human disturbance and structures to determine if humans affected black duck distribution along the lakeshores (Table 2.1). The model parameterization in RPresence assumes one species to be dominant so I used mallards as the dominant species because their potential effect on black duck distribution was the question of interest. I modeled colonization and extinction as a function of variables related to human disturbance and structures, weather, ice cover, and modeled colonization and extinction by black ducks as a function of presence, colonization, and extinction of mallards (Table 2.1). I modeled detection as a function of variables related to time of day and species interactions to determine if mallard presence or detection affected black duck detection (Table 2.1). I also tested interactions between species and the environmental variables to look for evidence that mallards and black ducks respond differently to those variables. I assumed that detection rate was the same between years, and stacked both years in my dataset. Thus, detection rate estimates based on data collected in 2017 using the dual-observer method were applied in 2017 to inform occupancy, colonization, and extinction rate estimates in 2016.

I selected variables to create reasonable biological models that could inform management in the FLR (Table 2.1). I built models for $\Psi$, $\gamma$, $\epsilon$, and p sequentially, holding the models for the other parameters at their most complex while fitting subsets of the most complex model for the focal parameter (Doherty et al. 2012). I compared model fit using Aikake’s Information Criterion
adjusted for small sample size (AIC_c, Burnham and Anderson 2002) and considered models with a relative likelihood of 0.125 to have some support (Doherty et al. 2012). After identifying the top supported models for each parameter, I combined all the top parameter models into a single occupancy model, then performed further model selection by fitting subsets of the top model (Doherty et al. 2012). I generated predicted values for \( \psi \), \( \gamma \), \( \epsilon \), and \( p \) using the top model, or model-averaging if there was ambiguous evidence for the top model (Burnham and Anderson 2002). I eliminated models that did not converge to three or more significant figures.

RESULTS

Occupancy Modeling

Detection rate differed between the two species, and the detection of black ducks depended on whether a mallard was detected. If both a black duck and a mallard occupied a site and the mallard was detected, then detection of the black duck was 94% ± 6.5%. Detection of black ducks when mallards were present but not detected was 60% ± 7.9%. Detection of mallards was 93% ± 5.6%. Only 4% of occupancy points had black ducks observed to be present at some point during the season in the absence of mallards while 17% of points had mallards observed to be present in the absence of black ducks.

Of 206 models fitted, one contained nearly unambiguous support (Table 2.2) so I used it for further inference. I found evidence for a difference between years in occupancy during the first survey, and an interaction between building presence and species (Table 2.2). When a building was present within 100 m of a point, the probability of black duck occupancy was four times less than when no building was present (Figure 2.1). Mallard occupancy was not affected by the presence of a building (Figure 2.1). Occupancy of mallards and black ducks during the
first week in 2016 was two times greater than 2017 (Figure 2.2). Occupancy after the first week is determined by the colonization and extinction parameters.

I found evidence for an effect of ice cover, percent land cover by development and agriculture, and mallard site use dynamics on black duck colonization (Table 2.2). Probability of black duck and mallard colonization was strongly negatively influenced by percent ice cover (Figure 2.3). Colonization of black ducks was about eight times greater when mallards also colonized the site than when mallards went extinct from the site (Figure 2.3). Black duck colonization was five times greater when mallards were absent from a site than when mallards went extinct from a site, but was two times less than when mallards colonized the site (Figure 2.3). Colonization of both species was negatively influenced by percent of development within 100 m of point (Figure 2.4). Black duck colonization was weakly positively correlated with percent agriculture within 100 m of a point (Figure 2.5). Mallard colonization was strongly positively influenced by percent agriculture (Figure 2.5).

I found evidence for an effect of dock density, season, and mallard site use dynamics on black duck extinction probability (Table 2.2). Mallard and black duck extinction rates were strongly positively associated with increasing dock density within 100 m of point (Figure 2.6). Black duck extinction was also strongly tied to mallard extinction (Figure 2.6). Black duck extinction was about seven times greater when mallards went extinct from the site than when mallards colonized the site (Figure 2.6). Black duck extinction when mallards were absent from a site was three times greater than when mallards colonized the site, but two times less than when mallards went extinct from a site (Figure 2.6). Local extinction of both species varied by week (Figure 2.7).
DISCUSSION

Black ducks in my study were less likely to occur than mallards when there were visible buildings at occupancy points which supports previous research that determined black ducks are not as tolerant of human structures as mallards (Lewis and Garrison 1984, Diefenbach and Owen 1989, Longcore et al. 2000). Black duck in Virginia used refuges where human disturbance was less during the day and only used non-refuge areas during the night when human disturbance in these areas was least (Morton et al. 1989a). At artificial feeding sites in the Chesapeake Bay, mallards swam a short distance away from human disturbance while black ducks flew further away (Morton 1998). Probability of black ducks occurring in a wetland in Maine increased with increasing distance from a human structure (Mendall 1958, Spencer 1986).

The high dependence of black duck site use dynamics on mallard site use dynamics that I observed suggests that black ducks could be selecting sites on the lakeshore with other ducks present, regardless of species, as a signal that the site is safe or has food available. Less territoriality exists between dabbling ducks during winter than during the breeding season, due to their gregarious nature (McNeil et al 1992). The greater occupancy rate of black ducks when mallards were present could suggest the two species are coexisting on the lakeshores. However, because these two species appear to be using the same resources in the same area, they cannot continue to coexist without some form of niche differentiation. For example, black ducks could be modifying their diet by eating more invertebrates (Jorde and Owen 1988).

The difference between years that I observed in first week occupancy was most likely because the first week of surveys in 2017 started out 11°C warmer than the first week of surveys in 2016 and the Montezuma wetlands were not frozen over until the second week of surveys (late January). As a result, few ducks were on the lake during the first surveys of 2017. Increasing ice
cover negatively affected colonization with black ducks much more likely to colonize sites with low ice cover. Generally, Cayuga and Owasco Lakes begin freezing at the north end and the line of ice slowly makes its way south. From my observations, ducks using the north end of the lake appeared to follow the ice line as it advanced south or retreated north, which likely explains seasonal patterns in extinction probabilities. With some exceptions, many of the ducks observed during surveys were within a few km of the ice line. The reason for this distribution is most likely that the north end of the lakes had more shallow water which is required for foraging dabbling ducks. To address this hypothesis, future studies could examine the influence of water depth within 100 m of occupancy points on occupancy, colonization, and extinction of black ducks.

The positive relationship I observed between colonization and percent agriculture within 100 m of a point may be explained by the energetic benefit of agricultural landscapes. Agriculture is likely the best source of high quality food available in the vicinity of the lakes and most of the emergent and forested wetland habitat around the lakes was frozen for much of the winters. Wintering mallards and black ducks in Texas (Baldassarre and Bolen 1984) and Nebraska (Jorde et al. 1983) were observed foraging on waste corn in agricultural fields when snow cover was lacking. Extinction varied by week due to the freezing and thawing periods observed during each field season. When the MWC thawed, ducks would leave the lake in response to this newly available food resource (Legagneux et al. 2009). Black duck and mallard extinction increased with increased number of docks around a point possibly due to the associated human presence with a large number of docks. Human activity (e.g. fishing and construction projects) on many docks was a common occurrence during point count surveys.
Black ducks in the Adirondacks of New York during summer were less likely to occupy areas with increased human presence than mallards (Macy and Straub 2015).

My method of site selection may have led to some biases in the relationship between occupancy parameters and the covariates. The lakes have a lot of perimeter and it takes a long time to drive around them visiting 101 survey points, even with two pairs of observers. In order to accomplish such a task, points selected for surveys had to be fairly easily accessible and able to be surveyed from a vehicle. For this reason, potential points in more remote areas with the least amount of human disturbance were not able to be surveyed and had to be eliminated from the route.

Results from my study suggest a lack of competitive exclusion of black ducks by mallards, or at least a lack of interference competition. Black ducks occurred at 84% of occupancy points, suggesting they are not being excluded from most of the lakeshores by mallards. Mallard and black duck site use dynamics were highly interconnected. Both species could be responding to similar features when selecting an area along the lakeshore, which would not be surprising considering how similar the two species are in their use of habitat (Bellrose 1980, Heusmann 1988). However, black ducks appeared to be more likely to avoid human structures along the lakeshores. Wintering black ducks in Virginia reduced foraging time in response to human disturbance, potentially negatively affecting their fitness and survival (Morton et al. 1989b). I did not study the effect of human disturbance on behavior but did find black ducks to be less tolerant of human development and a behavioral study would be a good next step in determining the effect of humans on black ducks. Another possibility is that mallards are ubiquitous and black ducks are not able to avoid them on the lakeshores. Exploitative competition could exist between mallards and black ducks in the FLR. Mallards could be pre-
empting or depleting resources that black ducks would be using if there were fewer mallards. Determining the diet of mallards and black ducks in the FLR during winter would be one way to determine if there is niche differentiation occurring between mallards and black ducks.

**Management Implications**

I recommend preserving remaining undeveloped shoreline to provide wintering habitat for black ducks. If development promotes mallards and negatively affects black ducks then increased development in the FLR could exacerbate any competition occurring between the two species, potentially leading to the extirpation of black ducks in the region. However, because mallards used areas ubiquitously, if they are behaviorally dominant over black ducks and hinder energy acquisition by black ducks, mallards may preclude population increase by black ducks if they are not aggressively managed by conservation professionals.

**ACKNOWLEDGMENTS**

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Spencer, H. E., Jr. 1957. Waterfowl-beaver relations study. Maine Department of Inland Fisheries and Wildlife Bulletin, 9, Augusta, USA.


Table 2.1: List of variables used for detection ($p$), first-survey occupancy ($\Psi$), colonization ($\gamma$), and extinction ($\varepsilon$) parameters in occupancy modeling of sympatric mallards and black ducks wintering in the Finger Lakes Region of New York (January – March, 2016 – 2017).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p$</td>
<td>SP</td>
<td>Species effect</td>
</tr>
<tr>
<td></td>
<td>INT_o</td>
<td>Occurrence of one species affects detection of other species</td>
</tr>
<tr>
<td></td>
<td>INT_d</td>
<td>Detection of one species changes detection probability of other species</td>
</tr>
<tr>
<td></td>
<td>AM</td>
<td>AM time period (sunrise to 1000)</td>
</tr>
<tr>
<td></td>
<td>MID</td>
<td>Middle time period (1000 - 1400)</td>
</tr>
<tr>
<td></td>
<td>PM</td>
<td>PM time period (1400 to sunset)</td>
</tr>
<tr>
<td>$\Psi$</td>
<td>SP</td>
<td>Species effect</td>
</tr>
<tr>
<td></td>
<td>Dock</td>
<td>Presence of a dock within 100 m of point</td>
</tr>
<tr>
<td></td>
<td>Bldg</td>
<td>Presence of a building within 100 m of point</td>
</tr>
<tr>
<td></td>
<td>DockDist</td>
<td>Distance (m) from center of point to nearest dock</td>
</tr>
<tr>
<td></td>
<td>BldgDist</td>
<td>Distance (m) from center of point to nearest building</td>
</tr>
<tr>
<td></td>
<td>DockDen</td>
<td>Number of docks within 100 m of point</td>
</tr>
<tr>
<td></td>
<td>BldgDen</td>
<td>Number of buildings within 100 m of point</td>
</tr>
<tr>
<td>$\gamma$, $\varepsilon$</td>
<td>SP</td>
<td>Species effect</td>
</tr>
<tr>
<td></td>
<td>SEASON</td>
<td>Season (week) effect</td>
</tr>
<tr>
<td></td>
<td>INT_Ba</td>
<td>Effect of mallard presence on black ducks</td>
</tr>
<tr>
<td></td>
<td>INT_B_a</td>
<td>Effect on black ducks when mallards were present in the previous season and were or were not present in the next season</td>
</tr>
<tr>
<td></td>
<td>INT_Baa</td>
<td>Effect on black ducks when mallards were not present in the previous season and were or were not present in the next season</td>
</tr>
<tr>
<td></td>
<td>INT_Ab</td>
<td>Effect on mallards when black ducks were or were not present in the previous season</td>
</tr>
<tr>
<td></td>
<td>Dock</td>
<td>Presence of a dock within 100 m of point</td>
</tr>
<tr>
<td></td>
<td>Bldg</td>
<td>Presence of a building within 100 m of point</td>
</tr>
<tr>
<td></td>
<td>DockDist</td>
<td>Distance (m) from center of point to nearest dock</td>
</tr>
<tr>
<td></td>
<td>BldgDist</td>
<td>Distance (m) from center of point to nearest building</td>
</tr>
<tr>
<td></td>
<td>DockDen</td>
<td>Number of docks within 100 m of point</td>
</tr>
<tr>
<td></td>
<td>BldgDen</td>
<td>Number of buildings within 100 m of point</td>
</tr>
<tr>
<td></td>
<td>Ice</td>
<td>Percent of ice (± 5%) within 100 m of point</td>
</tr>
<tr>
<td></td>
<td>Disturb</td>
<td>Human disturbance during survey</td>
</tr>
<tr>
<td></td>
<td>Temp</td>
<td>Temperature (± 1°C) at time of survey</td>
</tr>
<tr>
<td>WindSp</td>
<td>Wind Speed (± 1 km/hr) at time of survey</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------</td>
<td></td>
</tr>
<tr>
<td>ABDUA</td>
<td>Number of black ducks within 100m of point</td>
<td></td>
</tr>
<tr>
<td>MALLA</td>
<td>Number of mallards within 100m of point</td>
<td></td>
</tr>
<tr>
<td>Ice*Temp</td>
<td>Percent of ice (± 5%) within 100m of point * Temperature (± 1°C) at time of survey</td>
<td></td>
</tr>
<tr>
<td>AM</td>
<td>AM time period (sunrise to 1000hrs)</td>
<td></td>
</tr>
<tr>
<td>MID</td>
<td>Middle time period (1000hrs - 1400hrs)</td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>PM time period (1400hrs to sunset)</td>
<td></td>
</tr>
<tr>
<td>DEV</td>
<td>Percent of developed landcover within 100m of point</td>
<td></td>
</tr>
<tr>
<td>AG</td>
<td>Percent of agriculture landcover within 100m of point</td>
<td></td>
</tr>
<tr>
<td>PEM</td>
<td>Percent of palustrine emergent wetland landcover within 100m of point</td>
<td></td>
</tr>
<tr>
<td>FORW</td>
<td>Percent of forested wetland landcover within 100m of point</td>
<td></td>
</tr>
<tr>
<td>OPEN</td>
<td>Percent of open water landcover within 100m of point</td>
<td></td>
</tr>
</tbody>
</table>
Table 2.2: Model parameters, parameter counts, and information theoretic model selection criteria for multi-species dynamic occupancy models for sympatric mallards and black ducks wintering in the Finger Lakes Region of New York (January – March, 2016 – 2017) ($N = 101$ points, $n = 1300$ surveys). The model parameters are detection ($p$), first-survey occupancy ($\Psi$), colonization ($\gamma$), and extinction ($\varepsilon$). The top three models and the null model are shown. $AIC_c$ of the top model = 2378.

<table>
<thead>
<tr>
<th>Model</th>
<th>Deviance</th>
<th>$K^a$</th>
<th>$\Delta AIC_c$</th>
<th>Relative Likelihood</th>
<th>$w^b_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p$ (SP + INT$_d$ + Year)</td>
<td>2629.8</td>
<td>31</td>
<td>0.0</td>
<td>1.00</td>
<td>0.863</td>
</tr>
<tr>
<td>$\Psi$ (SP * Bldg + Year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma$ (INT$<em>{Ba}^c$ + INT$</em>{Ba}^d$ + INT$_{Baa}^e$ + Ice * Temp + SP * Dev + SP * Ag + Year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$ (SEASON + INT$<em>{Ba}$ + INT$</em>{Ba}$ + INT$_{Baa}$ + SP * DockDen + Year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p$ (SP + INT$_d$ + Year)</td>
<td>2627.5</td>
<td>33</td>
<td>3.7</td>
<td>0.16</td>
<td>0.137</td>
</tr>
<tr>
<td>$\Psi$ (SP * Bldg + SP * BldgDist + Year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma$ (INT$<em>{Ba}$ + INT$</em>{Ba}$ + INT$_{Baa}$ + Ice * Temp + SP * Dev + SP * Ag + Year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$ (SEASON + INT$<em>{Ba}$ + INT$</em>{Ba}$ + INT$_{Baa}$ + SP * DockDen + Year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p$ (SP + INT$_d$)</td>
<td>2676.0</td>
<td>28</td>
<td>86.6</td>
<td>0.00</td>
<td>0.000</td>
</tr>
<tr>
<td>$\Psi$ (SP * Bldg + Year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma$ (INT$<em>{Ba}$ + INT$</em>{Ba}$ + INT$_{Baa}$ + Ice * Temp + SP * Dev + SP * Ag + Year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$ (SEASON + INT$<em>{Ba}$ + INT$</em>{Ba}$ + INT$_{Baa}$ + SP * DockDen + Year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p$ ($)</td>
<td>3039.6</td>
<td>0</td>
<td>309.6</td>
<td>0.00</td>
<td>0.000</td>
</tr>
<tr>
<td>$\Psi$ ($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma$ ($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$ ($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a*number of parameters

*b*AIC$_c$ weight

*c*effect on black duck colonization or extinction when mallard was or was not present

*d*effect on black duck colonization or extinction when mallard present in previous season and was or was not present in the succeeding season

*e*effect on black duck colonization or extinction when mallard not present previous season and was or was not present in the succeeding season
Figure 2.1: First-survey occupancy probability where buildings were present and absent within 100 m of a survey point for sympatric black ducks (ABDU) and mallards (MALL) wintering in the Finger Lakes Region of central New York (January – March, 2016 – 2017) using regression parameter estimates from the top dynamic multi-species occupancy model (N = 101 points, n = 1300 surveys).
Figure 2.2: First-survey occupancy probability for sympatric black ducks and mallards wintering in the Finger Lakes Region of central New York (January – March, 2016 – 2017) using regression parameter estimates from the top dynamic multi-species occupancy model ($N = 101$ points, $n = 1300$ surveys).
Figure 2.3: Local colonization probability vs. percent ice cover within 100 m of the survey point for sympatric black ducks and mallards wintering in the Finger Lakes Region of central New York during winter (January – March, 2016 – 2017) using beta estimates from the top dynamic multi-species occupancy model made from point count survey data ($N = 101$ points, $n = 1300$ surveys). Predicted black duck occupancy shown when mallards were predicted to colonize a site, were predicted absent from a site, and when mallards went extinct from a site. Mallard colonization is also shown for comparison.
Figure 2.4: Local colonization probability with percent land cover developed within 100 m of the survey point for sympatric black ducks and mallards wintering in the Finger Lakes Region of central New York during winter (January – March, 2016 – 2017). Predictions are based on the top dynamic multi-species occupancy model made from point count survey data ($N = 101$ points, $n = 1300$ surveys). Predicted black duck occupancy shown when mallards were predicted to colonize a site, were predicted absent from a site, and when mallards went extinct from a site. Mallard colonization is also shown for comparison.
Figure 2.5: Local colonization probability with percent land cover agriculture within 100 m of the survey point for sympatric black ducks and mallards wintering in the Finger Lakes Region of central New York during winter (January – March, 2016 – 2017). Predictions are based on the top dynamic multi-species occupancy model made from point count survey data ($N = 101$ points, $n = 1300$ surveys). Predicted black duck occupancy shown when mallards were predicted to colonize a site, were predicted absent from a site, and when mallards went extinct from a site. Mallard colonization is also shown for comparison.
Figure 2.6: Local extinction probability with number of docks within 100 m of the survey point for sympatric black ducks and mallards wintering in the Finger Lakes Region of central New York during winter (January – March, 2016 – 2017). Predictions are based on the top dynamic multi-species occupancy model made from point count survey data (N = 101 points, n = 1300 surveys). Predicted black duck occupancy shown when mallards were predicted to colonize a site, were predicted absent from a site, and when mallards went extinct from a site. Mallard extinction is also shown for comparison.
Figure 2.7: Local extinction probability by week for sympatric black ducks and mallards wintering in the Finger Lakes Region of central New York during winter (January – March, 2016 – 2017). Predictions are based on the top dynamic multi-species occupancy model made from point count survey data (N = 101 points, n = 1300 surveys).
CHAPTER 3: HABITAT SELECTION AND BEHAVIOR OF SYMPATRIC MALLARDS AND BLACK DUCKS WINTERING IN THE FINGER LAKES REGION

ABSTRACT Mallards (*Anas platyrhynchos*) and American black ducks (hereafter black duck; *A. rubripes*) are closely related species that often compete for the same resources. Although once the most abundant duck in eastern North America, black duck populations declined significantly from the 1950’s through the 1980’s. Concurrently, abundance of mallards increased in the breeding and wintering range of black ducks. Mallards and black ducks currently winter sympatrically in the Finger Lakes Region (FLR) of New York, raising concerns that winter competition with mallards could limit the black duck population. During winter 2016 and 2017, I investigated differences in home ranges size and habitat use and selection between mallards and black ducks. My goal was to identify differences in movement and habitat use ecology between mallards and black ducks that could inform management strategies for black ducks in the FLR. I used satellite tracking to compare habitat use, habitat selection, and home ranges between female mallards and black ducks. Mallards used agriculture five times more than black ducks and used developed habitats twice as much as was available within their home ranges. Percent use of emergent wetland by black ducks was four times greater than its percent availability within their home ranges. I also compared behavior of mallards and black ducks within cover types, but did not detect differences in most habitat types. However, percent time foraging when in forested wetlands was eight times greater for black ducks than mallards. My results suggest that black ducks are less tolerant of human structures than mallards and select emergent wetlands. Conservation efforts for black ducks should focus on restoring previously drained wetlands that are being used for agricultural with a focus on areas with limited human development.
Interspecific competition is commonly considered to be a potential limiting factor for wildlife species, and may affect recovery of species of conservation concern. Limited resources drive competition for food, mates, or habitat (Newton 1994, Olson et al. 2005, Peron and Koons 2012). Competition for resources is controlled by the dominant species which often drives the subordinate species to be eliminated from the ecosystem or to exist in low numbers (Tilman 1988). Competition often occurs when a nonnative species is introduced into an ecosystem (MacDougall and Turkington 2005), the invading species becoming the dominant species. The American black duck (Anas rubripes, hereafter black duck) is one such species that is now of conservation concern and faces potential competition from a closely related species that became naturalized in its geographic range, the mallard (A. platyrhynchos) (Heusmann 1988).

Black ducks were once the most common breeding duck in eastern North America, but their population declined substantially since the 1950’s. Concurrently, mallard abundance increased dramatically in the eastern U.S. (Heusmann 1991, USFWS 2003, USFWS 2017). Mallards and black ducks are among the most closely related waterfowl species in North America with similar bill morphology (Belanger et al. 1988), foraging methods (Eadie et al. 1979), and food preferences (Baldassarre 2014); therefore, significant competition between them likely exists when resources are limited (Bellrose 1980, Brodsky and Weatherhead 1984, Heusmann 1988). Due to potential limited food availability in winter and increased energetic demand, it is important for ducks to use the best habitat available to acquire adequate resources to survive periods of harsh weather. Die-offs due to starvation are common occurrences for black ducks.
ducks wintering on Long Island (Conroy et al. 1989, Jorde et al. 1989). Mallards may interfere with or exclude black ducks at high quality wintering habitat or food sources (Mank et al. 2004). Male mallards were found to be more aggressive than male black ducks in territorial behavior during the breeding season (Seymour 1990). However, Hoysak and Ankney (1996) did not find mallards to be dominant to black ducks in captivity during winter. Greater fat reserves of mallards than black ducks where they are sympatric during winter suggest that mallards may be outcompeting black ducks for food (Hanson et al. 1990). Mallards wintering at more northern latitudes have been shown to rely heavily on waste corn leftover in agricultural fields (Jorde et al. 1983). Foraging on energy dense corn is beneficial because mallards can acquire more energy in less time than when foraging on natural seeds and tubers (Baldassarre and Bolen 1984).

Comparing habitat use and selection between two sympatric species is one way to understand how competition is occurring between them. Habitat selection occurs at several hierarchical levels (Johnson 1980); at the first order an individual selects a geographic area, at the second order an individual selects a home range within that area, at the third order an individual selects habitat within their home range, and at the fourth order an individual selects resources within that habitat (Johnson 1980). Comparing habitat selection between sympatric species at several different levels can help determine the scale at which scale competition is occurring. Although mallards and black ducks often overlap in their habitat use, some differences have been observed. Probability of black duck occurrence often increases with increasing percent forest cover (Spencer 1957, Renouf 1970, Brown and Parsons 1979, Petrie et al. 2012). Black ducks are also more likely to occupy more remote areas with less human presence than developed areas (Diefenbach and Owen 1989, Macy and Straub 2015). Competition can increase home range sizes of wildlife when resources are limited, because
animals must search for food over larger areas (Myers et al. 1979). Competition with mallards may result in an increased home range size of black ducks where they are sympatric. Understanding even small differences in habitat use, selection, and home ranges between wintering mallards and black ducks can provide valuable information for habitat conservation to increase carrying capacity of black ducks.

The Finger Lakes Region (FLR) of New York is one of three inland locations that are heavily used by wintering black ducks, and it also hosts a large population of mallards in the winter (NYSOA 2017). Much of the shorelines of the lakes are developed and surrounded by agricultural areas. Given that mallards and black ducks often use similar habitat, comparing their behavior can provide insight into whether competition is occurring between them. Mallards could be foraging more on energy and lipid dense corn in agricultural habitats than black ducks (Jorde et al. 1983), leading to higher fitness and survival in the FLR. Behavioral observations of mallards and black ducks could also be used to determine if each species behaves differently in response to human disturbance. In the Chesapeake Bay, mallards were more tolerant of human disturbance than black ducks at artificial feeding sites (Morton 1998). In Virginia, human disturbance caused reduced foraging times of black ducks during winter, which potentially reduced their fitness and survival (Morton et al. 1989a). Thus, understanding the behavior of wintering black ducks could help managers increase their carrying capacity.

My goal was to understand whether there was any niche separation between mallards and black ducks wintering in the FLR. My objectives were to compare habitat use, home range sizes, habitat selection, and activity budgets within habitat types between mallards and black ducks. If the presence of mallards affects the distribution and behavior of black ducks, then conservation of areas where black ducks are isolated from mallards is important. If mallards are excluding
black ducks from most high-quality wintering habitat, then a reduction in mallard numbers may be the only way to increase availability of these areas to black ducks. These results will be useful for waterfowl managers in the FLR and at other inland wintering areas to determine what components of the landscape are important to wintering black ducks and how competition with mallards affects their behavior and habitat use.

METHODS

Study Area

I compared habitat use and behaviors of mallards and black ducks in the FLR of central New York. The Finger Lakes are long, narrow lakes situated in a north-south orientation and located amid abundant agricultural land (mostly corn, soybeans, and grapes), mixed and hardwood forests, and abundant forested and emergent wetlands. I captured ducks on Cayuga Lake (42° 45’ 48.297”,-76° 44’ 7.6446”) and Owasco Lake (42° 53’ 10.8384”,-76° 31’ 51.9096”). Cayuga and Owasco often remain ice-free throughout much of winter, making them available for wintering waterfowl. Much of the shoreline of each lake is rocky with sections of seasonal camps, cottages, docks, and marinas. The 20,000-ha Montezuma Wetlands Complex (MWC) is located at the north end of Cayuga Lake. Within the MWC are the Montezuma National Wildlife Refuge and Northern Montezuma Wildlife Management Area which are managed federal and state lands with 16 managed impoundments and more than 1,900 hectares of freshwater wetlands (USFWS 2008). The lakes and MWC contain various cover types including dry and flooded agricultural fields, emergent wetlands, scrub-shrub and forested wetlands, and human developed areas.
Field Methods and Data Analysis

In collaboration with the United States Fish and Wildlife Service (USFWS) and New York State Department of Environmental Conservation (NYSDEC), I trapped mallards and black ducks during the winters of 2016 and 2017 using 1.5 m x 7 m x 0.3 m walk-in style traps. I used traps built with 25 mm x 50 mm wire mesh that had a single entrance funnel and two side funnels that opened into holding pens. I set traps on the lakeshore two meters from the edge of the water, lined them with straw, and baited them with corn. I began baiting and trap setup at the conclusion of the local hunting season in mid January and continued trapping through March. To eliminate potential problems of birds not acclimating to transmitters in severe weather as observed by Robb (1997), I left the doors open during wet or inclement weather. I set traps before daylight and checked them within three hours. At the end of each trapping day, I opened the traps. I used a total of 12 traps set at different locations around the northern half of Cayuga \((n = 10)\) and western half of Owasco \((n = 2)\). I aged and sexed all ducks captured according to plumage (Carney 1992) and banded them with aluminum butt-end bands. I recorded several body measurements including weight \((\pm 1 \text{ g})\) and tarsus, culmen, head, and body lengths \((\pm 1 \text{ mm})\) to estimate body size and relative body fat of each bird. I selected female ducks over 1000 g to receive solar powered 25-g \((< 3\% \text{ of body weight})\) backpack-style GPS/GSM transmitters (Ecotone Saker H model, North Star Science and Technology, LLC. Oakton, VA). I only used females to reduce variation in my data.

I set transmitters on the backs of the ducks between the wings and secured them using a 0.38-cm wide Teflon ribbon harness (Bally Ribbon, Bally, PA). I tied the harnesses as tightly as possible to minimize any potential movement of the transmitter during flight which could cause feather wear and loss of thermoregulation (Roshier and Asmus 2009) and then preened the
harnesses into the feathers using a metal probe. All animal capture and handling procedures were approved by the State University of New York College of Environmental Science and Forestry Institutional Animal Care and Use Committee (SUNY-ESF IACUC Protocol 150601).

I set transmitters to record the GPS location of the bird (±18 m) every 3 hours (6 locations per day) to estimate the percent time spent in different land cover times (habitat use) of each bird as well as to determine home range sizes. I marked ducks as quickly as possible (within 30 to 45 minutes for most birds) to minimize handling time and stress on the bird (Roshier and Asmus 2009). To further minimize potential bias in movement and habitat use data due to stress from capture or handling, I excluded the first four days of exposure for each bird from all analyses (Cox and Afton 1998).

**Home Range and Habitat Use Calculations**

I calculated home ranges from the GPS points using the time local convex hull (tLoCoH, Lyons et al. 2013) package in RStudio (RStudio Team 2016), which is a non-parametric kernel method for constructing home ranges that takes into account irregular boundaries (e.g., as lake shores and rivers) and holes in the GPS data (Getz et al. 2007). tLoCoH calculates a time-scaled distance between points to calculate nearest neighbors which creates home ranges that are better at capturing how points are partitioned in time than methods that do not scale by time (Lyons et al. 2013). I chose a scaling parameter ($s$) of 0.003 to keep points greater than 24 hours apart from being considered nearest neighbors because I was interested in daily foraging behavior. I created home ranges using the $k$-method of tLoCoH and used $k$ values ranging from six to 24 (whichever was closest to the square root of the number of points for each duck) to prevent under and over estimation of home range area. For each duck, I created a lake (Lake Region, LR) and MWC home range, because many individuals used those two regions during different portions of the
winter, especially in 2017 when the wetlands thawed for several weeks then refroze. Ducks appeared to use one region or the other depending on the amount of snow and ice cover. If the MWC was not frozen, most ducks would only use the MWC and not the lakes until the MWC froze again. Shapefiles were created from the 95th isopleths of each home range and opened with ArcMap 10.5 (ESRI, Redlands, CA). I determined home range sizes from the shapefiles created by tLoCoH and calculated percent land cover within each home range for each bird (2011 National Landcover Database; Homer et al. 2015). I simplified land cover classes into five categories (open water, forested wetland, emergent wetland, agricultural field, or developed). I assigned duck locations to land cover types using the Join Tables and Summarize Statistics functions in ArcMap 10.5 (ESRI, Redlands, CA) and calculated habitat use as the percent of locations within each of the five habitat types. I only used locations separated by at least 3 hrs to reduce spatial autocorrelation. For each duck, I calculated habitat use separately for the LR and the MWC. I compared habitat use to available habitat within the home range per duck to determine third order habitat selection (Johnson 1980).

I used Blocked Multi-response Permutation Procedure (MRBP, Mielke et al. 1976, Ares et al. 2009) to compare home range sizes and to compare habitat use to availability within home ranges of satellite-marked birds, separately by region of the study area. I used individual animal as the blocking variable. I considered comparisons to be different at $\alpha = 0.05$ and used a Bonferonni-corrected $\alpha$ level when comparing use to availability for individual land cover types.

In addition to satellite-tagged birds, I collected behavioral observations on random samples of female mallards and black ducks along transects using focal animal sampling (Altmann 1974). For lake sites, I generated sampling points along the shorelines, separated by 500 m to ensure independence of observations. On each transect survey, I randomly selected a
sampling point and visited points in a clockwise route around the lakes. At the MWC, a road transect was selected to sample all habitat types of interest, including agricultural fields, emergent wetlands, and forested wetlands. I used a random number table to select a starting point for the MWC route then visited points from north to south. After the route was completed, I selected a new random start for the next survey and started the process over. I visited a total of 149 survey points for behavioral observations each season (101 points around the lakes and 48 points in the MWC).

At each sampled point, I used a random number table to select a female duck of each species to observe. If ducks appeared disturbed by my presence, I waited 10 min to allow ducks to resume their normal behavior before beginning the observation. I used a 10-min observation period and recorded behavior of the selected duck every 15 sec using an Ultrak 496 digital stopwatch to keep time. I used two observers at each sampling occasion to ensure constant observation of the focal duck. I used Vortex Crossfire II 10x42 binoculars and a Vortex Razor 20-60x80 mm spotting scope (Vortex, Middleton, WI) to observe ducks. I categorized behavior as feeding (energy intake), resting (energy conservation), and pooled several others (preening, walking, swimming, courtship) that represented energy expenditure. The number of 15-sec observations in each behavior category was divided by the total number of observations to calculate a percent time in behaviors. If I permanently lost sight of a duck within the first 5-min of an observation period, I chose a new random duck and the observation continued, otherwise I recorded the focal animal as “out of view” until I could observe its behavior again. If no ducks were at a point, I would move to the next point. If both mallards and black ducks were present at a site, I conducted observations on random females of both species to control for environmental variation. I attempted to obtain an equal sample of behavior observations in each time period.
(morning [sunrise to 1000], midday [1000 – 1400] or afternoon [1400 to sunset]) by alternating
the direction of travel when starting the route over. I also recorded weather including
temperature (± 1°C) and wind speed (± 1 km/hr) using a Kestrel 2000 wind meter (Nielsen-
Kellermen, Boothwyn, PA) and wind direction using a hand-held compass for each observation.

I used Multi-response Permutation Procedure (MRPP, Mielke et al. 1976) to determine
behavioral differences between mallards and black ducks. MRPP is a nonparametric analog to
MANOVA that is useful for small sample sizes and does not assume multivariate normality. I
used MRBP on paired observations, where I collected data on mallards and black ducks
simultaneously, with observation as the grouping variable. I used BLOSSOM software (Cade
and Richards 2001) to run the MRPP and MRBP. I considered comparisons to be different at $\alpha =
0.05$ and used a Bonferroni-corrected $\alpha$ level when comparing time spent in individual behaviors
for individual land cover types.

RESULTS

I obtained GPS data from 24 black ducks and 29 mallards. In the LR, mallards and black ducks
spent $>80\%$ of their time in open water areas, and used agricultural lands somewhat less than
expected based on availability within home ranges for both black ducks (Figures 3.1) and
mallards (Figure 3.2). Mallards and black ducks in the LR both tended to use developed and
wetland areas to a greater degree than expected based on the limited availability of those land
cover types within their home ranges, but the differences were not always significant. In the
MWC, median percent use of forested wetlands by black ducks was three times greater than
median percent availability, but the difference was not significant (Figure 3.3). In the MWC,
mallards used emergent wetlands three times more than expected based on availability within their home ranges, but the difference was not significant (Figure 3.4).

Home range size did not differ significantly between mallards and black ducks in either region or between regions for either species (Table 3.1). Although not significant, black ducks had larger home ranges (24.6 km²) than mallards (20.5 km²) when in the LR and mallards had larger median home ranges (15.5 km²) than black ducks (12.6 km²) when in the MWC (Table 3.1). In the LR, mallards had twice as much agriculture habitat available within their home ranges as black ducks (Figure 3.1) while black ducks had twice as much forested wetland habitat available (Figure 3.2), but the differences were not significant. In the LR, mallards used agricultural fields five times more than black ducks (Figure 3.5).

No noticeable differences were observed in the behavior of mallards and black ducks in open water (Figure 3.6), agriculture (Figure 3.7), or emergent wetlands (Figures 3.8). Although the difference was not statistically significant, when in forested wetlands the percent time foraging of black ducks was eight times greater than mallards (Figure 3.9). In forested wetlands, mallards spent seven times more time resting than black ducks (Figure 3.9).

**DISCUSSION**

The selection of emergent wetlands by black ducks in the LR suggests that these are important foraging areas, given that there is little emergent wetland available relative to the extensive open water of the lakes. In general ducks wintering at more northern latitudes often encounter ice and snow cover which reduce availability of food (Jorde et al. 1983, Baldassarre and Bolen 1984). Most emergent wetlands in the FLR were ice covered for most of the winter, thus this potentially important habitat was rarely available. Chipley (1995) found inland wintering black ducks in
Tennessee to preferentially use emergent wetlands. Selection of emergent wetland to this degree suggests foraging habitat may be limited in the FLR. By contrast, mallards wintering in the FLR used agricultural fields more than black ducks while in the LR. Mallards have been observed relying on waste corn in agricultural fields to survive harsh winters at areas north of traditional wintering grounds (Jorde et al. 1983). Mallards in my study had LR home ranges with two times as much agricultural habitat as black duck home ranges, suggesting a difference in second-order habitat selection (Johnson 1980) while black duck LR home ranges had two times as much forested wetlands. Mallards selecting areas along the lake shores with a greater proportion of agriculture (Chapter 2) is consistent with mallards using agricultural areas to a greater extent than black ducks. Using available waste grain that is energy and lipid dense would allow mallards to spend less time foraging and more time resting and engaged in courtship activities (Baldassarre and Bolen 1984, Brodsky and Weatherhead 1984), thus potentially giving them a competitive advantage over black ducks during winter. If mallards can acquire the necessary energy in a shorter time period then they would spend less time exposed to predators while foraging, thus leading to greater survival. Mallards would also have more time for pair bond maintenance which could give them a fitness benefit. However, results from my behavioral observations did not support these hypotheses, because mallards spent an equal amount of time foraging, resting, and engaged in courtship activities as black ducks in most habitat types. Mallards spent more time in agricultural habitats than black ducks, however, were not observed foraging more often than black ducks. I observed mallards resting seven times more than black ducks in forested wetland habitats, suggesting they did not need to forage there because they acquired their necessary nutrients in agricultural habitats. Mallards could be obtaining more
energy dense food relative to black ducks by spending more time in agricultural habitats rather than by feeding more often when in that habitat.

As in my study, behaviors of sympatric mallards and black ducks in Maine were similar during the breeding season (McAuley et al. 1998). No differences have been observed in the courtship behavior of mallards and black ducks (Johnsgard 1960). In my study, both species spent a majority of their time feeding which is common for wintering waterfowl (Paulus 1988, Bergan et al. 1989). Although not statistically significant, the relative prevalence of foraging by black ducks compared to mallards when in forested wetlands is worthy of further study.

Variation was relatively great, reducing my ability to detect a statistical difference between the species. Observations in forested habitats were difficult because of low visibility, lack of accessible roads nearby, and disturbance to ducks in these habitats prior to being able to make an observation. Additional research on foraging by mallards and black ducks in forested wetlands is needed to determine if niche differentiation occurs in this habitat with black ducks selecting different foods than mallards. Forested wetlands are a potentially important habitat for black ducks wintering in the FLR because they appeared to select home ranges with more forested wetland habitat than mallards and also fed more in this habitat type.

Home range sizes of ducks in this study were similar to home range sizes of black ducks wintering along the coast (Ringelman et al. 2015). Small sample sizes of ducks may have affected my ability to detect significant differences between the sizes of mallard and black duck winter home ranges in the FLR. High variation between samples may have also contributed to the lack of significant findings. However, Dwyer and Baldassarre (1994) did not detect significant differences in home range sizes of mallards and black ducks during the breeding season and concluded that mallards and black ducks used similar habitats during that time. The
accuracy of my chosen telemetry units may have impacted my results as well. In many parts of the study area, different habitat types are located close together and some wetlands are actually smaller than the estimated error of our transmitters, potentially indicating a GPS point is not located in the correct habitat. The landcover data I used in my analysis may have influenced my results as well because the habitat on the landscape has likely changed (e.g., increased development, farm lands being abandoned) since 2011.

Marked ducks in my study experienced high mortality during periods of extended, severe weather. Robb (1997) observed birds having difficulties acclimating to transmitters when put on during inclement weather which caused an increased loss due to predation. Ice was observed forming on some units during inclement weather and a large block of ice was found on two recovered transmitters from dead birds. It would seem that ice buildup could have decreased survival by making it more difficult to evade predators. However, both species were affected equally by this mortality and I eliminated the first four days of GPS points while ducks became acclimated to the units (Cox and Afton 1998), so although it affected my sample sizes, it likely did not bias my comparison between species.

Mallards and black ducks wintering in the FLR appear to be using similar habitat with some exceptions. Similar habitat use has also been observed during the breeding season (Dwyer and Baldassarre 1994). Mallards used agriculture more than black ducks and selected developed habitat when in the LR to a greater degree based on availability within their home ranges. Mallards are more adapted to land conversion to agriculture than black ducks and are able to take advantage of abundant waste grain (Mendal 1958, Spencer 1986, Ankney et al, 1987, Merendino et al. 1995). Mallards are often more likely to occupy areas with increased human presence (Macy and Straub 2015). Black ducks wintering in the FLR are utilizing emergent marsh to a
greater degree than is available within their home ranges; this habitat preference may have been more pronounced if emergent wetlands were not ice-covered during a portion of my study periods. My findings suggest that agriculture and development are more favorable to mallards than black ducks wintering in the FLR. In contrast, I did not identify any habitat components that could easily be managed for to increase carrying capacity of the FLR for black ducks.

**Management Implications**

An important component of the home ranges of wintering black ducks in the FLR appears to be emergent wetlands, when locally available and unfrozen; therefore, this habitat should be considered a priority for conservation and restoration activities. Managers should attempt to increase the amount of emergent wetland available in the FLR to increase the carrying capacity of wintering black ducks. I would encourage the restoration of emergent wetland habitat that was drained to use for agriculture or the maintenance of open sections of emergent wetlands during winter using some type of water flow or aeration system (i.e. Ice Eater, The Powerhouse Inc., Owings Mills, MD) to keep ice from forming and allow access for foraging black ducks. However, this may be a cost prohibitive management strategy or increase likelihood of disease. Black ducks in my study also appeared to be less tolerant of human structures than mallards, which means conservation efforts should be focused in areas where there are limited human structures visible to ducks on the shore. Reducing the amount of agriculture within close proximity to the lakes would reduce one advantage mallards have and could possibly allow black ducks to better compete with mallards during winter in the FLR. Converting agriculture around the lakes to emergent marsh would further benefit black ducks. However, habitat management to increase carrying capacity of black ducks in the FLR may not be a practical option due to the limited availability of emergent wetlands in winter and how much overlap there is with mallard
habitat use. Reducing the mallard population in the FLR may be the only option to increase black duck carrying capacity. However, mallards are also a popular duck among New York waterfowl hunters and local residents in the FLR; actions taken to reduce mallard numbers in the region may be controversial.

ACKNOWLEDGMENTS

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Spencer, H. E., Jr. 1957. Waterfowl-beaver relations study. Maine Department of Inland Fisheries and Wildlife Bulletin, 9, Augusta, USA.


Table 3.1: Multivariate median and univariate 25th and 75th percentiles of home range sizes (km$^2$) of black ducks (ABDU) and mallards (MALL) in the Lake and Montezuma Wetlands Complex (MWC) Regions of the study, New York, 2016-2017 (MRPP, Lake test statistic = 0.547, $P = 0.634$, Montezuma test statistic = 0.127, $P = 0.490$).

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Figure 3.1: Multivariate median percent habitat use and habitat availability within home ranges of black ducks in the Lake Region of New York, 2016-2017. Whiskers represent univariate 25\textsuperscript{th} and 75\textsuperscript{th} percentiles. Asterisk indicates significant differences (MRBP, test statistic = -2.72, \( P = 0.010, N = 12 \)).
Figure 3.2: Multivariate median percent habitat use and habitat availability within home ranges of mallards in the Lake Region of the study, New York, 2016-2017. Whiskers represent univariate 25th and 75th percentiles. Asterisk indicates significant differences (MRBP, test statistic = -2.87, $P = 0.014$, $N = 15$).
Figure 3.3. Multivariate median percent habitat use and habitat availability within home ranges of black ducks in the Montezuma Wetlands Complex, New York, 2016-2017. Whiskers represent univariate 25th and 75th percentiles. Asterisk indicates significant differences (MRBP, test statistic = -0.421, \( P = 0.291, N = 13 \)).
Figure 3.4: Multivariate median percent habitat use and habitat availability within home ranges of mallards in the Montezuma Wetlands Complex, New York, 2016-2017. Whiskers represent univariate 25th and 75th percentiles (MRBP, test statistic = -1.86, \( P = 0.053 \), \( N = 19 \)).
Figure 3.5. Multivariate median percent habitat use of black ducks and mallards in the Lake Region of the study, New York, 2016-2017. Whiskers represent univariate 25\textsuperscript{th} and 75\textsuperscript{th} percentiles. Asterisk indicates significant differences (MRPP, test statistic = -2.13, \( P = 0.040 \)).
Figure 3.6: Multivariate median percent time engaged in behaviors from activity budgets of black ducks and mallards in open water, New York, 2016-2017. Whiskers represent univariate 25th and 75th percentiles (MRPP, test statistic = -0.561, $P = 0.647$, $n = 97$).
Figure 3.7: Multivariate median percent time engaged in behaviors from activity budgets of black ducks and mallards in agriculture in New York, 2016-2017. Whiskers represent univariate 25th and 75th percentiles (MRPP, test statistic = -0.542, $P = 0.217$, $n = 53$).
Figure 3.8: Multivariate median percent time engaged in behaviors from activity budgets of black ducks and mallards in emergent wetland in New York, 2016-2017. Whiskers represent univariate 25th and 75th percentiles (MRPP, test statistic = 0.614, $P = 0.680$, $n = 77$).
Figure 3.9: Multivariate median percent time engaged in behaviors from activity budgets of black ducks and mallards in forested wetlands in New York, 2016-2017. Whiskers represent univariate 25\textsuperscript{th} and 75\textsuperscript{th} percentiles (MRPP, test statistic = -0.977, $P = 0.139$, $n = 15$).
CHAPTER 4: CONCLUSIONS

I detected substantial niche overlap between mallards and black ducks wintering in the Finger Lakes Region (FLR) and determined that in most habitats they behaved similarly. The distribution of black ducks on the lakes was strongly tied to mallard distribution corroborating claims that the two species are able to coexist (Brodsky and Weatherhead 1984). Mallards and black ducks may be functional replacements of each other in certain areas (Collins 1974, Dennis et al. 1989, Merendino et al. 1993, Petrie et al. 2012), and because winter resources are limited, the only way to increase the number of black ducks would be to decrease the number of mallards. My results show mallards are using agriculture more than black ducks and are selecting developed habitat on the lakes to a greater degree than it is available within their home ranges. The apparent connection between mallards and human development and agriculture makes sense because of releases of up to 300,000 game farm-raised mallards per year (USFWS 2003). Occupancy of black ducks on the lakes is negatively affected by the presence of a building and black duck local extinction rates increase with increasing dock density.

Black ducks in my study selected emergent wetland habitat to a greater degree than was available within their home ranges on the lakes. Black ducks in Tennessee consistently used moist soil and scrub-shrub wetlands while their use of agricultural habitats varied (Osborn 2015). Ringelman et al. (1989) found black ducks to prefer emergent and forested wetlands for breeding in Maine. Black ducks in Quebec occurred in higher densities in landscapes with more dairy farms and forested habitat, while mallards occurred in higher densities in landscapes dominated by cropland (Maisonneuve et al. 2006). My findings support the idea that mallards are more adaptable to human disturbance and land changes and that black ducks require more undisturbed areas with more natural habitats (Spencer 1986, Ankney et al. 1987, Merendino et al. 1995).
In order to increase the carrying capacity of wintering black ducks in the FLR, and possibly other inland wintering sites, emergent wetlands and other natural wetlands should be protected and restored and development in these areas should be limited. Much research has been focused on black ducks during the breeding season with little consensus as to what caused the decline in the black duck population. Although disproportionately not studied, winter is an important time of year, especially for black ducks wintering at more northern latitudes (Reinecke et al. 1982). Winter conditions can decrease fitness and survival of black ducks, not just during the winter, but also in future seasons. Ducks in poorer condition during winter will have to catch up by acquiring fat reserves during spring staging which could delay their migration and arrival to breeding areas (Heitmeyer and Fredrickson 1981, Kaminski and Gluesing 1987). Thus, higher quality breeding locations may be already claimed and late arriving ducks would be forced to settle for lesser quality habitat. Lower quality breeding habitats would make it more difficult to replenish nutrient reserves post hatch and put their offspring at a disadvantage as well (Sedinger and Alisauskas 2014). Most black duck winter research has been focused on coastal populations, but the understudied inland populations could hold keys to the causes of population decline.

**Future Directions**

The difference between the species in foraging behavior in forested wetlands was large enough to merit further study with larger sample sizes and a more concentrated effort. Due to the difficulty in obtaining forested wetland behavioral observations, a larger, concentrated effort would have to focused on this habitat type would also be necessary to get an adequate sample size. Looking into fourth order habitat selection or selection of food resources (Johnson 1980) might be beneficial to researchers and waterfowl managers working in the FLR. A diet analysis could inform management of habitats to increase food sources favored by black ducks more than
mallards. Black ducks in the FLR spent >80% of their time on the lakes, but only foraged there to a limited extent. Sampling the different habitats to determine what foods are available during the winter would also be beneficial to researchers and waterfowl managers. These types of information would allow managers to determine the quality of the habitat on the ground and what activities are needed to improve available habitat quality to benefit wintering black ducks.

**Continuation of occupancy surveys along the lakeshores may also be beneficial to understanding black duck distribution.** Since I was unable to survey many of the more remote areas along the lakeshore due to logistical concerns, many of my occupancy points contained developed landcover. This could have been related to why black duck colonization was only moderately affected by increasing developed landcover. A low proportion of more remote occupancy points may also have been why only four percent of occupancy points contained black ducks in isolation from mallards. It would be useful to waterfowl managers to determine if there are remote locations on the lakes that contain concentrations of black ducks, especially if they are isolated from mallards, because those areas may have the greatest importance to wintering black ducks.

**Problems associated with our transmitter equipment did limit my ability to determine habitat use by both species.** Increased transmitter accuracy would benefit this type of habitat study, allowing for more fine scale habitat selection and more accuracy when habitats are small and many different types are located in close proximity. A different style of transmitter may be beneficial as well since I did experience a potential effect on survival of marked ducks during extreme weather. Paquette et al. (1997) found mallards with radio backpacks had significantly lower survival rates than mallards with implanted transmitters. However, implantable transmitters would require more effort in deployment than backpack style transmitters and would
be hindered by the lack of a solar panel to maintain a charge. Cox and Afton (1998) found just capture and handling of waterfowl to increase the likelihood of death, mainly due to predation. Sedinger et al. (1990) found no effect of backpack-mounted radio telemetry units on Pacific black brant energy expenditure; however, that study was on captive birds that did not fly or have to stay warm in adverse winter weather.

Additional satellite telemetry research on mallards and black ducks wintering in the FLR with a larger sample size may help evaluate differences in home range sizes and habitat use and selection. Slightly larger home ranges of black ducks than mallards in my study suggest competition exists between the species in the FLR. Black ducks may need larger home ranges to meet their energy requirements while mallards are able to meet their energy requirements more efficiently, possibly because they are using agricultural habitats that contain energy dense corn. Due to small sample sizes, I did not examine differences in habitat selection between the species based on time of day, which could be informative. Looking more closely at the area surrounding each GPS point would also be interesting. Rettie and McLoughlin (1999) suggest animals are not selecting a habitat based on a point, but rather the surrounding area. Adding a buffer around GPS points to determine the surrounding habitat characteristics, rather than describing all cover types contained within a home range, may help researchers determine why black ducks are selecting certain areas over others. Using the data I collected, one could create a lake buffer to compare home range selection by mallards and black ducks around the lakes, or second order habitat selection (Johnson 1980). Documenting and describing each of the emergent and forested wetland habitats (e.g., size, type and amount of vegetation/open water, ice cover, exposure, distance from lake, presence of a visible human structure) that black ducks used would be valuable for managers trying to determine which habitats to conserve. Getting this type of
information would allow managers to provide the best possible habitat for black ducks and may indicate minor habitat preferences by black ducks that mallards are selecting or using.

Performing behavioral observations from a ground blind would be useful to ensure observing the ducks would not influence their behavior and to eliminate the need for a settling period upon arrival to a point. However, this would have taken more time than I had available. Conducting nighttime behavioral observations may also have enhanced my research, but would also have required additional time, effort, and equipment.

Although I found differences in habitat selection and factors affecting lakeshore occupancy between black ducks and mallards, management of black ducks wintering in the FLR without also promoting mallards will be difficult. Restoration of emergent wetlands in the FLR may help increase the winter carrying capacity of black ducks. However, low availability due to ice cover may make this type of management infeasible. Preserving undeveloped areas of shoreline may be beneficial to black ducks, however, this may also be difficult or infeasible due to the amount of privately owned lakeshore and the region’s attractiveness to humans. Reducing mallard abundance to allow for increased carrying capacity of black ducks wintering in the FLR could be an option, but that comes with challenges as well.
LITERATURE CITED


Appendix 1: Map of the Finger Lakes Region of New York showing the study area of wintering mallards and black ducks.
Appendix 2: Aerial photo of the Finger Lakes Region of New York from early March 2014 showing snow and ice cover of the study area of wintering mallards and black ducks.
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Education

State University of New York College of Environmental Science and Forestry, Syracuse, NY
Master of Science, May 2018
Major: Fish and Wildlife Conservation and Management
GPA: 3.925/4.000
Recipient of the 2016 Roy E. Glahn Memorial Scholarship from Central NY Wildfowlers

St. Lawrence University, Canton, NY
Bachelor of Science, May 2010
Major: Biology. Graduated cum laude.
Major GPA: 3.437/4.000; Overall GPA: 3.312/4.000
University Scholar (Fall 2006 to Spring 2010)
Dean's List (Fall 2008, Spring 2009)
Recipient of the Bausch & Lomb Honorary Science Award.

Work Experience

State University of New York College of Environmental Science and Forestry
August 2015-Present
Research Project Associate and Teaching Assistant (Syracuse, NY)

Teaching assistant during fall semesters for a mammal diversity class which included facilitating class discussions, setting up lab exercises, lecturing during lab, administering and grading lab practicals and quizzes. Research Project Associate working on Black Ducks and Mallards wintering in the Finger Lakes Region of New York State. Duties included planning research project, preparing research proposals, establishing contacts with State, Federal, and non-profit conservation organization wildlife biologists as well as private landowners, setting up and operating walk-in and swim-in duck traps, banding and attaching VHF or GPS/GSM transmitters to hundreds of ducks, behavioral observations of ducks, point count surveys of waterfowl, spring waterfowl counts, conducting winter waterfowl survey in fixed wing aircraft, preparing and delivering reports and presentations for various stakeholders, data analysis using various computer and statistical programs, using GPS units and creating maps with ArcGIS 10.5, interviewing and hiring interns to assist with the project, creating intern schedules and supervising interns.

New York State Department of Environmental Conservation
May 2012-September 2017
**Fish and Wildlife Technician**  
*(Watertown, NY)*

Working with private landowners to develop co-operative agreements and enrolling land in the Landowner Incentive Program for grassland conservation. Banding and sexing of various waterfowl species including ducks, geese and swans using water and land-based traps. Monitoring and managing of water levels at several wetlands on state lands. Various management activities on several of New York’s wildlife management areas. Creating maps with GPS and ArcGIS 10.5. Helping the public with wildlife problems and answering questions. Double-crested Cormorant management including nest counts, nest removal and egg oiling according to NYSDEC’s USFWS Depredation Order. Nest counts of other colonial waterbirds on Lake Ontario and the St. Lawrence River. Turkey trapping with rocket nets for banding and attaching a satellite transmitter. Banding colonial waterbirds. Deer aging. Data entry into computers and data analysis. Report writing. Familiar with various conservation plans by state, federal and private organizations including the North American Waterfowl Management Plan. Invasive species monitoring and eradication. Worked on several wildlife population surveys including breeding waterfowl, grassland bird, marshbird, black tern, short-eared owl, chorus frog, nightjar and colonial waterbird surveys each with their own specific monitoring protocols. Public outreach including teaching firearms safety and manning educational booths about New York’s native wildlife. Worked on habitat restoration and mitigation projects with various conservation partners including Ducks Unlimited. Selling hunting and fishing licenses annually at the New York State Fair.

**Atlantic Testing Laboratories**
June 2010-May 2012

*Environmental Technician*  
*(Canton/Watertown, NY)*

Air and surface sampling for asbestos and mold abatement projects along with project monitoring duties to ensure compliance with NYS Code Rule 56, concrete testing duties in both the lab and field, cleaning laboratory, data collection and entry into computers, and report preparation upon completion of projects.

**Lowes Home Improvement**
March 2011-April 2012

*Customer Service Associate II*  
*(Ogdensburg, NY)*

Helping customers locate products and assisting them in determining what they need to complete their project in all departments in the store, down stocking products and putting away freight, and appliance delivery.

**Volunteer Work**

**St. Lawrence University Chapter of Ducks Unlimited:** Fundraising and working at the annual banquet.

**SUNY ESF Chapter of Ducks Unlimited:** Fundraising and working at the annual banquet.
New York State Department of Environmental Conservation: Working with several biologists on the Wild Turkey Hen Survival and Distribution Study. This involved rocket netting hen turkeys for data collection, banding and attaching satellite transmitters.

Skills


General: Very reliable, hard worker that can follow directions and accomplish tasks ahead of schedule without the need of direct supervision. Also works well with other individuals in a team setting. Pays very close attention to detail to make sure tasks are accomplished without error. Excellent oral and written communication skills. Physically fit and able to work in various work environments both indoors and outdoors even during inclement weather conditions. Very comfortable towing and operating motor boats of all sizes as well as canoes, kayaks, and ATVs. Many years of experience raising waterfowl and other animals. Many years experience handling and shooting firearms.

Biology: Ample experience with data collection/analysis for field and lab research such as point count surveys, aerial surveys, determining population structure/density, community interactions and conservation techniques. Experience using mist nets, walk-in and swim in traps, rocket nets, etc. to catch ducks, geese, swans, turkeys, cormorants and terns for banding and data collection. Able to identify most local species of plants and animals including many birds solely by call.

Training and Other Information

NYSDEC certified in waterfowl banding including rocket net use (2016)
North American Banding Council certified waterfowl bander (2016)
NYSDEC “Firearms safety” training (2017)
NYS Safe Boating Course (2015)
NYSDEC flat ice rescue training (2015)
NRCS “Utilizing working lands to benefit wildlife” workshop (2015)
Certified in CPR and with the use of AED by AED Safetrack (2017)
Trained in the chemical immobilization of animals by Safe Capture International (2014)
NYSDEC “Advanced wetland delineation” training (2014)
NYSDEC “Wildlife pathology” workshop (2014)
NYSDEC “Handling dangerous reptiles” training (2013)
NYSDEC “Chainsaw safety” training (2013)
Imapinvadives training (2012)

Research Presentations

Banding and transmitter attachment seminar at Montezuma National Wildlife Refuge as part of the Ducks Unlimited State Convention (2017)
Powerpoint presentation at the Cayuga Lake Sportsman’s Banquet in Auburn, NY (2017)
Powerpoint presentation at the New York Waterfowl and Wetlands Network Student Symposium at the Montezuma Audubon Center (2017)
Poster presentation at The Wildlife Society Annual Conference in Albuquerque, NM (2017). Received 2nd best student poster award.
Powerpoint presentation at The Wildlife Society Annual Conference in Albuquerque, NM (2017)
Powerpoint presentation at the Northeast Fish and Wildlife Conference in Burlington, VT (2018)

Related Coursework


References

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Andrew MacDuff
Wildlife Manager; NYS DEC
317 Washington Street
Watertown, NY
315-785-2254
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