6

OCCUPANCY, DETECTION, AND CO-OCCURRENCE RATES OF AMERICAN BLACK AND MALLARD DUCKS IN THE SARANAC LAKES WILD FOREST AREA

GARY A. J. MACY AND JACOB N. STRAUB[1]

Center for Earth and Environmental Science, State University of New York-Plattsburgh, 101 Broad Street, 135 Hudson Hall, Plattsburgh, NY 12901, USA

1. Present Address: 175 East Fourth Street, Oswego, NY 13126, phone: 315.532.3333

ABSTRACT

American black duck populations have steadily decreased across the northeastern United States prompting researchers to examine causes of decline including habitat loss, hybridization with mallards, and competitive exclusion by mallards. We designed a survey of lakes and wetlands of the Saranac Lakes Wild Forest and estimated occupancy and detection rates for each species. Given the predominantly forested landscape and the low density of humans, we predicted American black ducks would have greater occupancy rates than Mallards. Our results show each species was approximately equally likely to occur and to be detected, and there was no evidence that mallards excluded American black ducks from habitats. Mallards did show greater affinity for habitats with more humans present compared to American black ducks. Less than half of the lakes and wetlands we surveyed were occupied by either species indicating there is an abundance of unoccupied habitats that could have population-level ramifications for both species.

KEYWORDS:

Adirondacks, Occupancy modeling, Waterfowl habitat, American black duck, Mallard

INTRODUCTION

Range expansion into the northeastern United States and release of farm-strain mallards (*Anas platyrhynchos*) has coincided with range wide population declines of American black ducks (*Anas rubripes*; hereafter black duck) (Ankney, Dennis, and Bailey 1987). Hypotheses regarding population trajectories between these species are complicated by their ability to hybridize and produce viable offspring (Heusmann 1974). Possible causes of black duck decline include habitat loss (Conroy et al. 1989), introgressive hybridization (Ankney et al. 1987), and competitive exclusion by mallards (Merendino and Ankney 1994; Merendino, Ankney, and Dennis 1993). However, few studies have specifically investigated black duck and mallard co-occupancy and interactions in the lakes, ponds, and streams of the Adirondacks with the exceptions of Brown and Parsons (1979), Dwyer and Baldassarre (1994), and Benson (1968).

The Adirondack region represents a unique part of the Eastern Forest Boreal Transition zone. Mean annual temperatures are cooler than the surrounding lowlands of the Champlain and St. Lawrence valleys, and the landscape has less human development than the area surrounding it. From a botanical and climatological standpoint, the Adirondacks bear resemblance to boreal landscapes in Canada (Jenkins and Keal 2004). Much of the Adirondack Park is a mosaic of small ponds, lakes and wetlands with maturing forests throughout. Black duck populations appear to be stable in boreal forest habitats of Canada (Conroy, Miller, and Hines 2002), and, given similarities in habitat types, the Adirondacks may offer a refuge in which they can seek isolation from competitive mallards. Habitat isolation for the purpose of this study refers to an area or habitat type where black duck occupancy is greater than mallards in comparison to surrounding areas. Brown and Parsons (1979) and Benson (1968) counted relatively few mallards in their studies of the Adirondacks in the 1960s and 1970s. Less than 20 years later Dwyer and Baldassare (1994) found mallards and black ducks were mostly sympatric. These studies highlight the rapid expansion of mallards into the Adirondacks, but, excluding Dwyer and Baldassare (1994), they lack investigation into the forces driving mallard range expansion and black duck range contraction.

Given these knowledge gaps we explored spatial relationships between the two species in the northwestern section of the Saranac Lakes Wild Forest Area (SLWFA). Specifically, we aim to test hypotheses regarding occupancy probability, for mallards and black ducks separately, relative to the degree of human influence (e.g., boat density, distance to campsites) and the configuration of the landscape (e.g., size of lake, amount of "edge" per lake). We also tested hypotheses regarding the probability of black ducks and mallards to co-occur in the SLWFA. Co-occurrence probabilities represent the degree to which each species 'spatially separated themselves' (MacKenzie et al. 2006) in the SLWFA. Given the known synanthropic qualities of mallards and the assumed shyness of black ducks (Ankney et al.

1987), we expected mallard occupancy of lakes would be positively related to the degree of human activity and predicted an inverse relationship with black ducks. We also expected that mallard occupancy rates would be greater than black ducks on larger lakes and lakes with less edge to open water area and that co-occurrence would reflect spatial avoidance or exclusion between the two species.

METHODS

Study Area

The study area included a > 30,000 hectare mosaic of public land in the Adirondack Western Foothills ecozone (Will, Stumvoll, Gotie, and Smith 1982). Specifically, it consisted of the water bodies contained in a rectangle beginning on Floodwood road in the Town of Santa Clara, NY extending 4.8 km south and beginning on State Route 30 in the Town of Santa Clara extending 7.2 km west (Figure 1). The study area ranged from 478 to 481 m above sea level with a mean precipitation of about 90 cm per year and mean temperatures ranging from -11 ^{o}C in winter to 15 ^{o}C in summer (Kavanagh et al. 2014).

Study Design

We surveyed approximately half of the lakes, ponds, and streams (hereafter sites) which are part of the northwestern section of the SLWFA. We constrained selected sites to those which could be accessed by canoe in a single day with portages of less than 1 km and total trip distances of less than 24 km. Thirty one discrete sites (Figure 1) were visited from one to six times on six separate canoe trips for a total of 94 site visits. One field researcher performed all surveys, therefore size of the study area and number of site visits was a reflection of very limited resources. Sites were visited as frequently as logistically possible while avoiding hazardous weather and still maintaining contiguous and unique routes through the area. Contiguous bodies of water were often subdivided into smaller sites that balanced areas of similar habitat type with easily identifiable features that aided accuracy on subsequent revisits. Therefore, a single researcher could visit discrete segments of larger water bodies and record presence or absence of our targeted species. Subdivision of contiguous water bodies into smaller sample sites was in the interest of achieving a finer resolution of habitat preferences and increasing the number of sampled sites. However, this approach could bias results because we are unaware to the extent the closed system assumption in occupancy modeling was violated (MacKenzie et al. 2006). This caveat is discussed later, however we suggest this method is sufficient for the accuracy of results needed in an observational study. Weather was mild for most site visits with winds < 10 mph, no precipitation, mean temperatures between 4.4 and 16.6 ^{o}C, and minimal cloud cover. Favorable weather and only one observer conducting surveys likely kept the effects of human error and environmental interference on detection probabilities consistent throughout site visits.

Data Collection

We surveyed all sites using Eagles Optics © 8 X 42 binoculars on six separate dates in 2013 (5/30, 6/5, 6/20, 8/12, 8/24, and 9/27). For each surveyed site, we recorded the presence or absence of mallards and black ducks after visually scanning the site for 30 minutes. We recorded latitude, longitude, and total counts of each species including ducklings, cloud cover, wind speed and direction, precipitation, number of boat/canoes present, a GPS track of the canoe path, and habitat type. We classified habitats as the general type of near shore terrain visible from the water level including descriptions of foliage and development. Due to the challenges of identifying black duck and mallard hybrids, each bird was classified as either species by the sum of traits according to discrete plumage between the two species (Carney 1992); therefore, we did not record any hybrids.

Geospatial Data Processing

To gather information about potential explanatory landscape variables, we used ArcGIS 10.1. orthoimages of the study area, campsite locations, and hydrographic shapefiles (State 2014). These variables along with boat count data that we collected on each survey allowed us to derive covariates for maximum boats, patch size, length of patch edge, and mean distance to campsites. The campsites shapefile was missing campsites at Fish Creek Ponds campground and Rollins Pond campground, thus we digitized these from the orthoimages to establish a more representative human influence data layer. Maximum observed boats ranged from 0 to 24 at our sites, with the greatest amount in south Fish Creek and north Fish Creek Pond. Mean Euclidean distances to campsites ranged from 72 m to 454 m across sites. Patch sizes of the sites ranged from 54,000 m^2 to 825,000 m^2 with the largest sites occurring mostly on Rollins and Follensby Clear Pond. The ratio of open water to edge ranged from 1150 m to 4360 m. The output table from the data derived in ArcGIS was then opened in a spreadsheet program and used to calculate and standardize a covariate value following MacKenzie's technique (2012).

Data Analysis

Two-Species Model

PRESENCE is a modeling program which uses detection histories applied to the principles and methods described by MacKenzie et al. (2002) to make estimates of site occupancy when detection probabilities are less than 1. We used a spreadsheet program to prepare data for import into PRESENCE, creating species specific detection histories for every visit date at all 31 sites. As described by MacKenzie et al. (2006), the presence of the target species was designated "1", absence designated "0", and missed site visits were input as "-". The two-species model estimates five parameters which include: ψ = probability a site is occupied by a species, ϕ = the ratio of how likely a species is to co-occur at a site compared to what would be expected under an assumption of randomness, p = detection probability

of a species in the absence of the other, r = detection probability of a species in the presence of the other and δ = the ratio of how likely a species is to be co-detected at a site compared to what would be expected under an assumption of randomness. For more details on these parameters see MacKenzie et al. (2006) and Bailey et al. (2009).

We used a single season two-species model that used detection histories of mallards and black ducks to estimate the parameters mentioned above. Our two species model would not numerically converge when covariates were included (in the absence of covariates the model did converge) therefore we could not test whether covariates influenced any of the parameters above. We found this two-species model valuable because we were able to test our hypothesis regarding co-occurrence and detection probabilities of mallards and black ducks (although not relative to covariates). Eight competing models were ranked in order of greatest support by using Akaike's Information Criteria (AIC) and we considered all models < 2 AIC units from the smallest value to be the most explanatory given our data. We also provided model weights (ω_i) which represent the relative weight of evidence for each model, and model-averaged parameter estimates were computed using all models < 2 AIC units from our best model (Burnham and Anderson 2002). All graphical depictions of model parameters were back-transformed to show the dependent variable on the original scale.

Biological rationale for candidate model sets

To test hypotheses regarding occupancy, detection, and co-occurrence relative to landscape configuration and human influence covariates, we built ecologically relevant candidate models and evaluated support for each through model selection (Burnham and Anderson 2002; Table 1). We addressed whether mallards and black ducks co-occurred independently or if there was evidence of competitive exclusion (i.e., $\phi < 1$). To address this hypothesis we fit models with and without the occupancy interaction factor (ϕ). For sites occupied by both species, we explored whether the detection process was independent (i.e., $\lambda \approx 1$) or whether detection of one species influenced the probability of detecting the congeneric species during a given survey (i.e., $\lambda \neq 1$). To examine our detection probability assumptions we included models where r and p were constrained to be equal but varied between species denoted by $p(S)$ and models were r and p were estimated separately. We explored whether the presence of mallards influenced the detection of black ducks (e.g., $r_j^{ABDU} < p_j^{ABDU}$) and vice versa (e.g., $r_j^{MALL} < p_j^{MALL}$). All combinations of these parameter structures were combined into eight competing models using a species-specific occupancy structure, ϕ (S) (Table 1).

Single-Species Models

Because our initial goal was to examine how co-occurrence probabilities were influenced by site-specific covariates, and numerical convergence issues were preventing us from doing so with the two-species model, we ran separate single species models for mallard and black duck data. Although results of single-species models do not investigate spatial relationships between mallard and black ducks, they do examine species-specific occupancy relative to

habitat covariates. Our habitat covariates served as surrogate variables for potentially explanatory responses by mallards and black ducks. For example, maximum boat counts and distance to campsites serve as proxies for a 'disturbance,' whereas as patch size and length of patch edge serve as 'habitat configuration' proxies. Single-species models included two parameters, ψ = probability a site is occupied and p = probability of detecting a species. Our base model consisted of only ψ and p with no covariates. To examine the influence of site-specific covariates on occupancy we applied the following variables to our base model: mean Euclidean distance to campsites (mdc), maximum boats (mp), patch area (pa), and ratio of open water to edge (o/e). We suspected the relationship of occupancy to these covariates might be non-linear; therefore, we built separate models with a second-order polynomial term for each covariate. In addition, we examined support for a global (i.e., saturated) model which was an additive model of all first-order covariates. Both single-season models were assessed for goodness-of-fit by using a bootstrapping method on the global model to calculate c-hat (MacKenzie et al. 2006). C-hat for the mallard and black duck models were 1.53 and 4.52, respectively, which indicated overdispersion (MacKenzie et al. 2006). We adjusted for overdispersion by ranking all models using Quasi-Akaikes Information Criteria (QAIC), and we considered all models < 2 QAIC units from the smallest value (i.e., "best model") to be the most explanatory given our data (Burnham and Anderson 2002).

RESULTS

Data summary

Among all 94 site visits, 57 adult black ducks and 127 adult mallards were observed. The naïve occupancy rate (i.e., rate of detecting a species not accounting for detection probability) was 0.258 for mallards and 0.290 for black ducks.

Two-Species Model

We considered two models (i.e., AIC < 2.0) to explain patterns in species-specific occupancy, co-occurrence, species-specific detection, and co-detection probabilities between mallards and black ducks (Table 2). Our best model (0.468 ω_i) contained five parameters and estimated a species specific occupancy probability (ψ; k = 2), co-occurrence (ϕ; k = 1), and probability of detecting each species (p; k =2). Our second-ranked model (ω_i = 0.179) was identical to the best approximating model but it contained an additional parameter for estimating co-detection (λ).

Model selection and associated parameter estimates indicate no evidence that mallards excluded black ducks spatially from sites in the SLWFA during summer 2013. The model-averaged co-occurrence estimate (ϕ) of 2.021 (SE = 0.538) indicated strong evidence that mallard and black ducks tended to co-occur more often than would be expected under an assumption of randomness (MacKenzie, Bailey, and Nichols 2004; Table 5).

Detection probabilities of both species were not influenced by the presence of the opposite species because both competing models had parameters where $p = r$. Detection probabilities were slightly greater and less variable for mallards (mean = 0.394, SE = 0.084) compared to black ducks (mean = 0.342, SE = 0.091). We found no strong or consistent interaction in the co-detection probability (λ). The top model fixed λ at 1, and our second model estimated it at 1.100 (SE = 0.286) indicating detection probabilities for each species were independent.

Single Species Models

Our best single-species model (Table 3) for black ducks was a model with no covariates and only parameters for occupancy and detection ($\omega_i = 0.291$). The second-ranked model ($\omega_i = 0.116$) was an additive model that linked variation in occupancy to mean Euclidean distance to campsites. We also considered a model ($\omega_i = 0.112$) where variation in occupancy was related to maximum boats observed at a site. None of the remaining models that we considered had greater support, including models that incorporated patch area, ratio of edge to open water, or any quadratic (i.e., non-linear) combinations of any covariate (Table 3). The model-averaged estimate of black duck occupancy was 0.493 while the model averaged estimate of detection was 0.319. The relationship for occupancy and Euclidean distance to campsites was non-linear while the relationship with maximum boats was linear and positive (Figures 2 and 3).

The best single-species model (Table 4) for mallards was an additive model with parameters for occupancy and detection as well as linear covariate data for observed maximum boats ($\omega_i = 0.475$). The second-ranked model ($\omega_i = 0.227$) was also an additive model that linked variation in occupancy to the quadratic covariate for observed maximum boats. None of the remaining models that we considered had greater support, including models that incorporated patch area, ratio of edge to open water, mean distance to campsites, or any quadratic (i.e., non-linear) combinations of any covariate (Table 4). The model-averaged estimate of mallard duck occupancy was 0.417 while the model averaged estimate of detection was 0.314. Mallard occupancy increased in a non-linear fashion with increased observed boats (Figure 4).

DISCUSSION

To our knowledge, this is the first study to estimate occupancy and detection probabilities for these two species in the Adirondack region. If mallards were displacing black ducks from habitats in this region, we would have expected to see greater occupancy rates for mallards compared to black ducks and less frequent co-occurrence of the two species, suggesting possible avoidance or competitive exclusion. This scenario would be consistent with predictions of Merendino et al. (1993) and Merendino and Ankney (1994), who suggest competition for habitat between mallards and black ducks is the cause of decline in black ducks. Our analyses provided no evidence of a negative association between occupancy of

a site by the two species. Our co-occurrence estimate indicated that species tended to co-occur more often than would be expected if they were distributed randomly (MacKenzie et al. 2004). In other words, using our methodology there was little evidence that mallards competitively excluded black ducks (or vice versa) from sites in the SLWFA during summer 2013. As such, our findings are more consistent with Maisonneuve et al. (2006), who studied mallard and black duck interactions at the landscape scale in southern Quebec. They found mallard presence increased the odds of black duck presence by 200% and suggest that where habitat conditions are adequate those habitats are generally attractive to both species. Unlike Maisonneuve et al. (2006), our study was conducted at a much smaller spatial scale and in an area of the Adirondacks that has many lakes, beaver ponds, and associated wetlands that are surrounded by forests. Because a heavily forested landscape type is apparently preferred by black ducks (Maisonneuve et al. 2006, Morton, Kirkpatrick, Vaughan, and Stauffer 1989), we were somewhat surprised that black duck occupancy did not exceed mallards in this region. Instead, both species were approximately equally likely to occupy sites in the SLWFA.

Although we found similar naïve and estimated occupancy probabilities for mallards and black ducks across the SLWFA, we did see differences in how each species responded to site-specific landscape covariates. For instance, our best model for predicting black duck occupancy indicated that the covariates we measured had no strong or consistent influence on occupancy of a site. However, our second and third best models (which were statistically competitive) showed weak and somewhat conflicting evidence that black duck occupancy was a function of human-related activities. Black duck occupancy was greatest at sites where campsites where furthest away from site centers, while at the same time occupancy was positively related to observed boat traffic. Our finding that occupancy was less in areas with nearby campsites suggests black ducks are more secretive than mallards or are seeking seclusion during this time period; this is consistent with others findings (Ankney et al. 1987, Seymour and Titman 1978). However, we are curious and unsure why occupancy increased with observed boat traffic. A positive relationship with boat numbers may be the result of minimal disturbance (i.e., low hunting pressure) in this area, boaters feeding ducks, or it may also reflect hybrids with synanthropic qualities identified as black ducks. Regardless, we caution readers regarding inferences from these single-season black duck models because our most predictive model suggested covariates had no strong or consistent influence on occupancy of a site.

In contrast to black ducks, mallards showed a clear and strong affinity for sites with greater human influence. The synanthropic qualities of mallards are well known, and this study supports that assessment observationally and numerically (Heusmann 1974). Our best model predicts that sites with greater than 15 boats on avearge will have mallard occupancy close to 100% while less than 10% occupancy is expected on sites with no boats.

This suggests that mallards greatly preferred sites with more human activity. The strong preference may be the result of humans feeding ducks and minimal disturbance in state campgrounds and the surrounding landscape. The influence of humans and the presence of state campgrounds may also reduce the predation of nests and ducklings by birds of prey and other natural predators creating a refuge-like scenario.

We emphasize some caveats associated with inferences about occupancy and detection models from program PRESENCE. First is the assumption that the occupancy state is "closed" (MacKenzie et al. 2006). In our study, this implied that mallards and blacks ducks did not enter or leave sites during the time we monitored them. While there are some disjoint sites, many are connected via swimmable waterways and walkable corridors between water bodies. We are unsure of the extent these species moved among our sites, but we acknowledge that it likely occurred with some frequency. Violation of the closure assumption was likely reduced by the facts that both species were undergoing a wing feather molt and many should be flightless during the majority of the time we surveyed (Heitmeyer 1988, Leafloor and Ankney 1991). Second, hybrids were not accounted for but rather were identified as mallards or black ducks based on their plumage traits. This practice undoubtedly counted some hybrids as black ducks or mallards, which in turn may have falsely attributed species identifications. This inaccuracy may have had an effect on model estimates including occupancy and detection rates. Hybrids of these species have shown to retain attributes of one parent species and this may allow them to successfully access a wider range of habitat than the more limited other parent in terms of duckling success (Barnes and Nudds 1991). In our study, hybrids counted as black ducks may have been exhibiting synanthropic qualities of the mallard parent. Third, our inferences of co-occurrence (and thus competition) are based on observational patterns of species presence rather than directly observed interactions. Studies that focus on direct relationships such as behaviors of aggression, competitive exclusion, and mixed-species copulations can provide a different and deeper resolution to the degree of population-level competition between these two species. Additionally, our two-species models with covariate data applied did not produce usable results and instead indicated numerical instability, possibly due to the number of missed site visits. This prevented us from investigating human influence and landscape configuration on habitat preferences in the absence and presence of each species.

Overall, less than half of the sites in the SLWFA were occupied by either species, even after accounting for failed detections. Furthermore, we never recorded presence of a single mallard or black duck at most sites. This finding surprised us because the SLWFA is a region of the Adirondacks with a great density of lakes and associated wetlands with diverse habitats. If this induction were applied to all lakes and wetlands in the Adirondacks then there is an abundance of potentially unoccupied habitats that could have population level ramifications for both species. Further research that attempts to identify features of the predominately occupied and unoccupied habitat areas is clearly needed.

On a similar note, we were surprised by our relatively low detection rates (<40%) for each species. Given the caveat mentioned above, it is possible that some of our failed detections were a result of movement among or out of sites (i.e., a true absence). The other reasons for failed detections (i.e., false absences) include not encountering ducks because they were hiding or otherwise simply not encountered. Although we actively searched for ducks for ~30 minutes at each site per sampling occasion, we believe that "flush counts," whereby we actively search dense vegetation and shoreline structure, should increase detection probability.

CONCLUSIONS

Managers and researchers seeking to better understand interactions between black ducks, mallards, and hybrids should consider the effects of human influence in their management areas. We found densities of campsites and boat traffic are strongly related to the presence of mallards and the absence of black ducks. We observed several "feeding" events by humans in state campgrounds and mallards were often observed following canoes. Humans have likely aided the success of mallards in certain parts of the SLWFA. Curtailing these feeding events may help reduce the park-like conditions in which mallards succeed particularly well (Heusmann 1974).

We found some regions of SLWFA where black ducks apparently seek isolation from boat traffic and campsites. These locations include the embayments on Follensby Clear Pond and the western shore and bays of Rollins Pond. The most distinctively plumaged black ducks were frequently observed in these ponds. Multiple breeding pairs of black ducks were observed nesting among downed trees along the western shore of Follensby Clear Pond. Future research in the SLWFA could focus on site-specific characteristics of these ponds to discover more about the preferences of black duck habitat choices. A more detailed study that includes hybrid counts would allow for more accurate estimates of occupancy and co-occurrence relative to covariate data.

If introgressive hybridization with mallards is the main driving factor in the displacement/reduction of black duck populations (Ankney et al. 1987), managers may need to consider methods to reduce the current population of mallards. A lack of habitat isolation in the SLWFA combined with the synanthropic qualities of mallards may have advanced introgressive hybridization in parts of our study area frequented by outdoor recreationists.

Table 1 (see next page). *Eight biological hypotheses tested between mallards and black ducks to estimate occupancy, co-occurence, detection, and co-detection probabilities from lakes and ponds in the SLWFA in summer 2013.*

CANDIDATE MODEL	OCCUPANCY PROBABILITY (ψ)	CO-OCCURENCE (ϕ)	DETECTION PROBABILITY (p, r)	CO-DETECTION
$\psi^A(S), \phi^B(.),$ $p^C(S)$	varies by species	a spatial relationship *does* exist*	varies by species, is the *same* regardless of presence of other species	detection of one species *does not* influence the probability of detecting the congeneric species
$\psi(S), \phi(.), p(S)$ $\lambda^D(.)$	varies by species	a spatial relationship *does* exist*	varies by species, is the *same* regardless of presence of other species	detection of one species *does* influence the probability of detecting the congeneric species
$\psi(S), p(S)$ $r^E(S)$	varies by species	a spatial relationship *does not* exist*	varies by species, is *different* and *unique* if the other species is present	detection of one species *does not* influence the probability of detecting the congeneric species
$\psi(S), \phi(.), p(S),$ $r(S)$	varies by species	a spatial relationship *does* exist*	varies by species, is *different* and *unique* if the other species is present	detection of one species *does not* influence the probability of detecting the congeneric species
$\psi(S), p(S)$	varies by species	a spatial relationship *does not* exist*	varies by species, is the *same* regardless of presence of other species	detection of one species *does not* influence the probability of detecting the congeneric species
$\psi(S), p(S),$ $r(S), \lambda(.)$	varies by species	a spatial relationship *does not* exist*	varies by species, is the *same* regardless of presence of other species	detection of one species *does not* influence the probability of detecting the congeneric species
$\psi(S), \phi(.), p(S),$ $r(S), \lambda(.)$	varies by species	a spatial relationship *does* exist*	varies by species, is *different* and *unique* if the other species is present	detection of one species *does not* influence the probability of detecting the congeneric species
$\psi(S), p(S), \lambda(.)$	varies by species	a spatial relationship *does not* exist*	varies by species, is *different* and *unique* if the other species is present	detection of one species *does not* influence the probability of detecting the congeneric species

* tested if mallards and black ducks co-occurred independently or if there was evidence of competitive exclusion

Table 2. *Model selection statistics for two-species occupancy models fit to mallard and American black duck detection data from lake and ponds in the SLWFA, Adirondacks, New York in the summer 2013. The terms in parentheses represent the sources of variation in the model parameter; with "S" denoting species-specific differences, and "." indicates a parameter set equal across species and survey times. Absence of ϕ or λ implies no interaction in occupancy or detection, respectively. Absence of r implies r = p. K indicates number of parameters in the model.*

MODELS	AIC	△AIC	Ω^i	K
$\psi^A(S), \phi^B(.), p^C(S)$	168.7	0.00	0.46	5
$\psi^A(S), \phi(.), p(S) \lambda^D(.)$	170.6	1.88	0.18	6
$\psi^A(S), p(S), r^E(S)$	171.3	2.59	0.13	6
$\psi(S), \phi(.), p(S), r(S)$	172.7	3.97	0.06	7
$\psi(S), p(S)$	173.1	4.34	0.05	4
$\psi(S), p(S), r(S) \lambda(.)$	173.2	4.50	0.05	7
$\psi(S), \phi(.), p(S), r(S) \lambda(.)$	174.6	5.84	0.03	8
$\psi(S), \phi(.), p(S), \lambda(.)$	174.7	6.01	0.02	5

A. probability of occupancy | B. probability of co-occurrence | C. probability of detecting species given other is not present
D. probability of co-detection | E. probability of detecting species given both are present

Table 3: *Model selection statistics for the top ten single-species models used to estimate occupancy (ψ) and detection (p) for American Black Ducks in the SLWFA study sites for summer 2013. Ranks are based on QAIC (Akaike's information criteria adjusted for lack of model fit) and habitat covariates in parentheses were mean Euclidean distance to campsites (mdc), maximum boats (mb), patch area (pa), length of edge habitat—open water edge (e/o). A covariate with a superscript indicates a quadratic function while (.) denotes no covariate was used. K indicates number of parameters in the model.*

MODELS	QAIC	ΔQAIC	Ωᶦ	K
$\psi(.), p(.)$	21.8	0.00	0.29	2
$\psi(mdc), p(.)$	23.6	1.83	0.12	3
$\psi(mb), p(.)$	23.7	1.90	0.11	3
$\psi(pa), p(.)$	23.8	2.00	0.11	3
$\psi(e/0), p(.)$	23.8	2.00	0.11	3
$\psi(mb + mb^2), p(.)$	24.5	2.70	0.08	4
$\psi(pa + pa^2), p(.)$	24.9	3.10	0.06	4
$\psi(mdc + mb), p(.)$	25.5	3.75	0.5	4
$\psi(mdc + mdc^2), p(.)$	25.6	3.78	0.04	4
$\psi(e/o + e/0^2), p(.)$	25.7	3.92	0.04	4

Table 4: *Model selection statistics for the top ten single-species models used to estimate occupancy(ψ) and detection (p) for Mallard Ducks in the SLWFA study sites for summer 2013. Ranks are based on QAIC (Akaike's information criteria adjusted for lack of model fit) and habitat covariates in parentheses were mean Euclidean distance to campsites (mdc), maximum boats (mb), patch area (pa), length of edge habitat—open water edge (e/o). A covariate with a superscript indicates a quadratic function while (.) denotes no covariate was used. K indicates number of parameters in the model.*

MODELS	QAIC	ΔQAIC	Ωᶦ	K
$\psi(mb), p(.)$	55.6	0.00	0.48	3
$\psi(mb + mb^2), p(.)$	57.1	1.48	0.23	4
$\psi(.), p(.)$	59.2	3.57	0.08	2
$\psi(mdc + mb + pa + e/o), p(.)$	59.5	3.84	0.07	6
$\psi(mdc + mdc^2), p(.)$	6.10	5.36	0.03	4
$\psi(e/o), p(.)$	61.0	5.38	0.03	3
$\psi(mdc), p(.)$	61.1	5.44	0.03	3
$\psi(pa), p(.)$	61.2	5.53	0.03	3
$\psi(e/o + e/0^2), p(.)$	63.0	7.35	0.01	4
$\psi(pa + pa^2), p(.)$	63.1	7.52	0.01	4

Table 5: *Model averaged parameter estimates of two-species occupational models for American Black and Mallard Ducks in the SLWFA study sites during summer 2013. The terms in parentheses represent the sources of variation in the model parameter; with "S" denoting species-specific differences, and "." indicates a parameter set equal across species and survey times. Absence of ϕ or λ implies no interaction in occupancy or detection, respectively. Absence of r implies r = p.*

MODEL= $\psi^A(S)$, $\phi^B(.)$,$p^C(S)$			MODEL= $\psi(S)$, $\phi(.)$,$P(S)$ $\lambda^D(.)$			MODEL AVERAGED	
PARAMETER	ESTIMATE	SE	PARAMETER	ESTIMATE	SE	PARAMETER	ESTIMATE
ψMALL	0.413	0.127	ψMALL	0.415	0.129	ψMALL	0.414
ψABDU	0.420	0.132	ψABDU	0.423	0.133	ψABDU	0.421
ϕ	2.029	0.538	ϕ	2.002	0.537	ϕ	2.021
p MALL	0.394	0.084	p MALL	0.393	0.084	p MALL	0.394
p ABDU	0.342	0.091	p ABDU	0.342	0.091	p ABDU	0.342
p^EMALL	0.394	0.084	p^EMALL	0.393	0.084	p^EMALL	0.394
p^EABDU	0.342	0.091	p^EABDU	0.342	0.091	p^EABDU	0.342
λ	1.000	Fixed	λ	1.100	0.286	λ	1.028

A. probability of occupancy | B. probability of co-occurrence | C. probability of detecting species given other is not present
D. probability of co-detection | E. probability of detecting species given both are present

Figure 1: *Saranac Lakes Wild Forest Area and study sites (filled-in light gray) where mallard and black ducks were observed during summer 2013.*
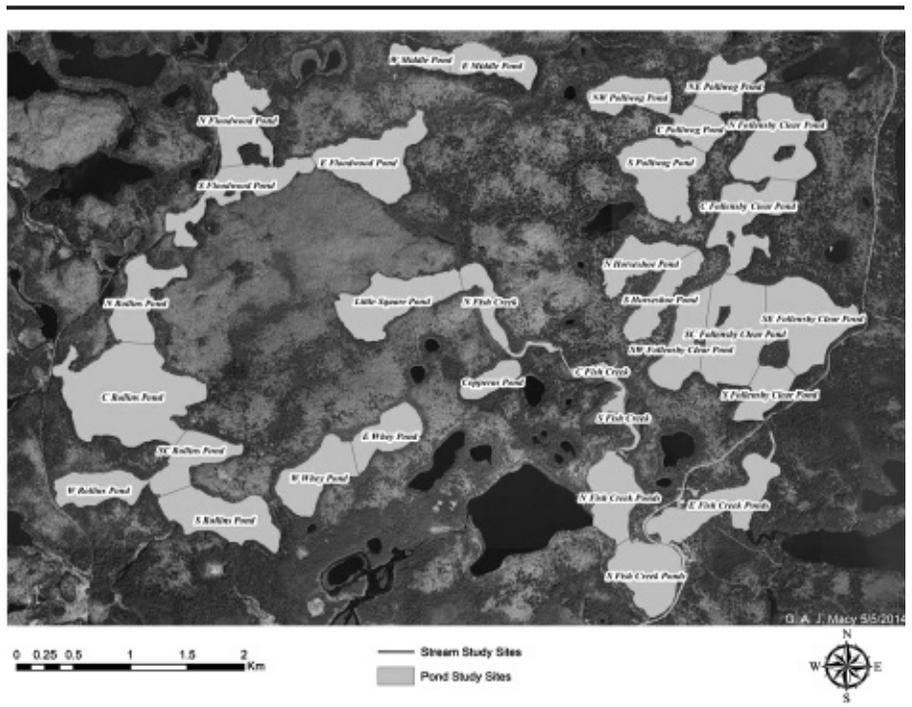
Figure 2: *Relationships between estimated American black duck occupancy and mean Euclidean distance to campsites in the SLWFA during the summer of 2013. Relationship was modeled using top models in a single-season model in Program PRESENCE.*
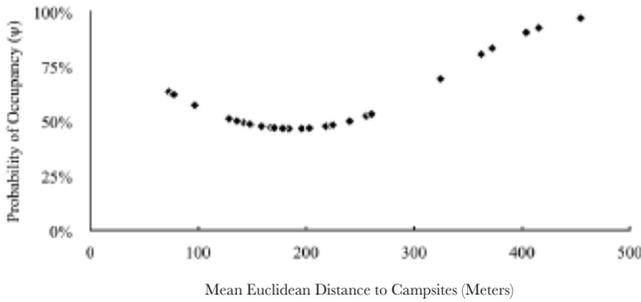

Figure 3: *Relationships between estimated American black duck occupancy and boats in the SLWFA during the summer of 2013. Relationship was modeled using top models in a single-season model in Program PRESENCE.*
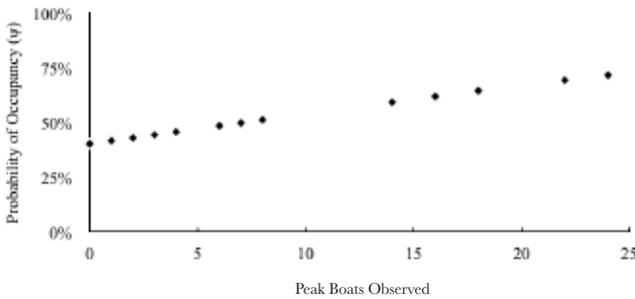

Figure 4: *Relationships between estimated mallard duck occupancy and boats in the SLWFA during the summer of 2013. Relationship was modeled using top models in a single-season model in Program PRESENCE.*
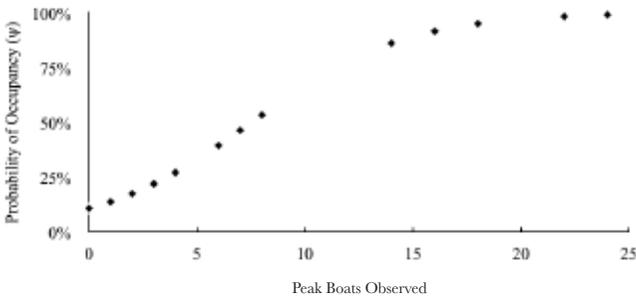
LITERATURE CITED

Ankney, C.D., D.G. Dennis, and R.C. Bailey. 1987. "Increasing mallards, decreasing American black ducks: coincidence or cause and effect?" *The Journal of Wildlife Management*, 53(4), 523-529.

Bailey, L.L., J.A. Reid, E.D. Forsman, and J.D. Nichols. 2009. "Modeling co-occurrence of northern spotted and barred owls: accounting for detection probability differences," *Biological Conservation*, 142(12), 2983-2989.

Barnes, G.G., and T.D. Nudds. 1991. "Salt tolerance in American black ducks, mallards, and their F1-hybrids," *The Auk*, 108(1), 89-98.

Benson, D. (1968). *United States Situation*. Paper presented at the Black Duck Evaluation, Managment and Research, Chestertown, MD.

Brown, M.K., and G.R. Parsons. 1979. "Waterfowl production on beaver flowages in a part of northern New York," *New York Fish and Game Journal*, 26(2), 142-153.

Burnham, K.P., and D.R. Anderson. 2002. *Model selection and multimodel inference: a practical information-theoretic approach*. Fort Collins, Colorado: Springer.

Carney, S.M. 1992. *Species, age and sex identification of ducks using wing plumage*. US Department of the Interior, US Fish and Wildlife Service Washington, DC Jamestown, ND.

Conroy, M.J., G.G Barnes, R.W. Bethke, and T.D. Nudds. 1989. "Increasing mallards, decreasing American black ducks: No evidence for cause and effect: A comment," *The Journal of Wildlife Management*, 53(4), 1065-1071.

Conroy, M.J., M.W. Miller, and J.E. Hines. 2002. "Identification and synthetic modeling of factors affecting American black duck populations," *Wildlife Monographs* (150), 1-64.

Dwyer, C.P., and G.A. Baldassarre. 1994. "Habitat use by sympatric female mallards and American black ducks breeding in a forested environment," *Canadian Journal of Zoology*, 72(9), 1538-1542.

Heitmeyer, M.E. 1988. "Protein costs of the prebasic molt of female mallards," *The Condor*, 90(1), 263-266.

Heusmann, H.W. 1974. "Mallard-black duck relationships in the northeast," *Wildlife Society Bulletin*, 2(4), 171-177.

Jenkins, J. C., and A. Keal. 2004. *The Adirondack atlas: a geographic portrait of the Adirondack Park*. Syracuse, New York: Syracuse University Press.

Kavanagh, K., L. Gratton, M. Davis, S. Buttrick, N. Zinger, T. Gray, et al. 2014. "Eastern forest-boreal transition." Available at http://www.worldwildlife.org/ecoregions/na0406.

Leafloor, J.O., and C.D. Ankney. 1991. "Factors affecting wing molt chronology of female mallards," *Canadian Journal of Zoology*, 69(4), 924-928.

MacKenzie, D.I. 2012. PRESENCE User Manual.

MacKenzie, D.I., L.L. Bailey, and J. Nichols. 2004. "Investigating species co-occurrence patterns when species are detected imperfectly," *Journal of Animal Ecology*, 73(3), 546-555.

MacKenzie, D.I., J.D. Nichols, G.B. Lachman, S. Droege, J. Andrew Royle, and C.A. Langtimm. 2002. "Estimating site occupancy rates when detection probabilities are less than one," *Ecology*, 83(8), 2248-2255.

MacKenzie, D.I., J.D. Nichols, J.A. Royle, K.H. Pollock, L.L. Bailey, and J.E. Hines. 2006. *Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence*. San Diego, California, USA: Academic Press.

Maisonneuve, C., L. Belanger, D. Bordage, B. Jobin, M. Grenier, J. Beaulieu, et al. 2006. "American black duck and mallard breeding distribution and habitat relationships along a forest-agriculture gradient in southern Quebec," *The Journal of Wildlife Management*, 70(2), 450-459.

Merendino, M.T., and C.D. Ankney. 1994. Habitat use by mallards and American black ducks breeding in central Ontario," *The Condor*, 96(2), 411-421.

Merendino, M.T., C.D. Ankney, and D.G. Dennis. 1993. "Increasing mallards, decreasing American black ducks: more evidence for cause and effect," *The Journal of Wildlife Management*, 57(2), 199-208.

Morton, J.M., R.L. Kirkpatrick, M.R. Vaughan, and F. Stauffer. 1989. "Habitat use and movements of American black ducks in winter," *The Journal of Wildlife Management*, 53(2), 390-400.

Seymour, N.R., and R.D. Titman. 1978. "Changes in activity patterns, agonistic behavior, and territoriality of black ducks (*Anas rubripes*) during the breeding season in a Nova Scotia tidal marsh," *Canadian Journal of Zoology*, 56(8), 1773-1785.

State, N.Y. 2014. NYGIS Clearinghouse. Accessed July, 2014 from https://gis.ny.gov.

Will, G.B., R.D. Stumvoll, R.F. Gotie, and E.S. Smith. 1982. "The ecological zones of northern New York," *New York Fish and Game Journal*, 29(1), 1-25.