

Knowing the Double Crested Cormorant:
Behavioural Ecology and Public Education of Double-crested Cormorants
at Tommy Thompson Park

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Foreword

This project includes both a scientific research paper and a public education poster focused on double-crested cormorants (*Phalacrocorax auritus*) at Tommy Thompson Park, Toronto, ON. Since my master's includes wildlife ecology and environmental interpretation, I wanted to study cormorants from both scientific and education perspectives. Together with Gail Fraser, I collected observational data on male cormorant advertising displays over the 2014 nesting season. From the results of this behavioural ecology study I wrote a formal scientific research paper which is included in this report. In the literature, cormorant research has been focused primarily on management and topics associated with human-cormorant conflict, leaving a gap in knowledge regarding understanding of basic cormorant behaviours including advertising. Outcomes of my research may have management implications, but my study's primary focus was a greater understanding of cormorant behaviour.

A deep understanding of ecological processes, wildlife, and ecosystems is an important foundation for environmental education. Knowledge gained through ecological research enables environmental educators to provide accurate, pertinent information to the general public. With suggestions and advice from Karen McDonald, Park Manager at Tommy Thompson Park, I created a public education poster on cormorants. Cormorants are a controversial bird. Their reputation is clouded by misconceptions and a long history of human-wildlife conflict. Focusing on the same subject from both scientific and education perspectives was rewarding as I was able to practice and facilitate different ways of knowing: I believe that it is by knowing and experiencing the natural world that we can begin to live in right relationship with the land.

The Double-Crested Cormorant: The Most Controversial Waterbird on the Great Lakes¹

The double-crested cormorant (*Phalacrocorax auritus*, hereafter cormorant) is the most controversial waterbird on the Great Lakes. Supported by a long culture history of human-wildlife conflict, current perceptions and attitudes toward cormorants indicate that cormorants' cultural carrying capacity is much lower than their biological carrying capacity (Conover, 2002; Wires & Cuthbert, 2006, p. 9). The greatest sources of conflict include cormorants' landscape transformative presence at nesting sites, their assumed impact on fishing industries, and their perceived impact on co-occurring colonial waterbirds (Weseloh et al., 2002; Wires & Cuthbert, 2010). Although irreversible tree damage occurs at nesting sites, demonstrating this species' impact on fishing industries is complex, and public perception of cormorants as competitors for sport fish is generally not supported by scientific evidence (Andrews, 2008; Duffy, 1995; Bedard, Nadeau, & Lepage, 1995; Koh et al. 2012; Hebert et al., 2005). Also, there is conflicting evidence regarding cormorants' impacts on other colonial nesting species, with the literature recommending site specific analysis (Cuthbert et al., 2002; Somers et al., 2011). Cormorants nesting in the Great Lakes illustrate the importance of identifying ecological interactions and ecological uncertainty as well as the importance of communicating scientific information to the public. Cormorants are native birds that fill a particular niche in the Great Lakes' ecosystem. In my research I strove to construct a scientifically based foundation on which to foster accurate perceptions regarding this controversial bird. This chapter is a result of my background research.

¹ The following paragraphs focused on cormorant controversy were adopted from: Mc Rae, M. (2014) *Misconceptions and management of the double-crested cormorant*. Unpublished manuscript, Applied Ecology, York University, Canada.

In the Great Lakes, the human-cormorant conflict has grown in recent years because of cormorant population expansion (Chastant, King, Weseloh, & Moore, 2014, p. 3; Latta & Faaborg, 2008). As of 2014, cormorant populations on the Great Lakes are expanding beyond previously published numbers, although there is some evidence that expansion may be stabilizing (Weseloh et al., 2002; Chastant et al., 2014). The cormorants' recent population success is largely due to legislative protection, the banning of DDT, and aquaculture expansion in wintering grounds (Cuthbert et al., 2002, p. 151; Boutin et al., 2011; Glahn et al., 1996; Nettleship & Duffy, 1995). On the Great Lakes, cormorant population numbers prior to the 20th century are unknown (Wires & Cuthbert, 2006), but documentation exists for range expansion into the Great Lakes early in the 20th century (Weseloh et al., 1995).

Foster and Fraser (2013) suggest that cormorants are a foundation species because of their ability to transform the landscape of their nesting areas. Ecosystems are inherently dynamic, which means change is expected and intrinsic. In the Great Lakes, cormorants typically begin nesting in trees. As their nest building activities and acidic guano destroy the trees, the trees die and fall, and some of the colony begins to nest on the ground (Boutin et al., 2011). Rush, Dobbie, and Fisk (2013) suggest that the effects of altered nutrient levels from cormorant guano can be reduced if cormorants are managed in a low nest density range of ≤ 96 nests ha⁻¹ (p. 306). Other studies indicate that there are non-negative aspects to cormorant habitat modification. A recent study on great cormorants (*Phalacrocorax carbo*) on a Stockholm archipelago indicated that arthropod diversity and abundance remained largely unaffected by cormorant density (Kolb, Palmberg, & Hamback 2013; Kolb et al., 2012). Also, even when great cormorant presence decreased species richness on a particular island, the resulting change in species composition increased overall archipelago diversity (Kolb et al., 2012).

A direct example of interspecies benefit from cormorant habitat modification concerns ground-nesting waterbirds (Leung, 2005; Hatch & Weseloh, 1999). While many migrating songbirds seek dense tree cover for protective resting places, ring-billed gulls (*Larus delawarens*), common terns (*Sterna hirundo*), herring gulls (*Larus argentatus*), and Caspian terns (*Hydroprogne caspia*) are ground nesting species that benefit from cormorant induced habitat modification (Leung, 2005; Hatch & Weseloh, 1999; Foster & Fraser, 2013). Increased presence of ground nesting birds may alter broader ecosystems by supporting terrestrial carnivore species such as coyotes (Foster & Fraser, 2013). This research suggests that cormorant-induced habitat modification can have positive outcomes.

Demonstrating cormorants' impact on fishing industries is complex and involves a public perception that is generally not supported by scientific evidence (e.g. Wires et al. 2003; Duffy, 1995). The highly visible presence of this piscivorous waterbird allows for the perception of appropriately directed blame for depleted fish stocks (Duffy, 1995). Andrews, Fraser, and Weseloh (2012) investigated cormorant fish consumption and prey preference at Tommy Thompson Park, Toronto, Ontario. Although prey competition with sport fish was not considered, and results were biased toward chick diet sampling, researchers concluded that it was improbable that cormorant feeding directly affected the sport fishing industry. The alewife (*Alosa pseudoharengus*) and round goby (*Neogobius melanostomus*) are invasive fish species that are common in the Great Lakes and, since the cormorant is opportunistic, the majority of its diet in the Great Lakes is composed of these invasive species (Andrews, Fraser, & Weseloh, 2012; Hatch & Weseloh, 1999; Duffy, 1995). As of 2008, there were four published studies indicating that cormorants negatively impact sport fishing, and eighteen published studies indicating that cormorant predation impacts are negligible (Andrews 2008). Cormorants likely

have only a negligible impact on fish populations because it is difficult to demonstrate scientifically that cormorant predation is additive rather than compensatory (Hatch & Weseloh, 1999; Wires et al. 2003). Assumed causation, when correlations between declines in fish populations and increases in cormorant populations are noted, has historically led to aggressive, unscientific management action (Dorr, 2010; Wires et al. 2003). At the population level, negative impacts of cormorants on commercially important fish are not scientifically supported (Duffy, 1995).

The rising population of double-crested cormorants has increased the concern that other waterbird species are being displaced because of nest site competition and limited nesting materials. Though it has been reported that irreversible tree damage occurs at nesting sites in less than three years, the literature indicates that this does not correlate with negative impacts on other waterbird species (Cuthbert et al., 2002; Bedard et al., 1995; Koh et al. 2012; Hebert et al., 2005). The concern that cormorants negatively affect co-occurring colonial nesting waterbirds such as black-crowned night herons (*Nycticorax nycticorax*) and great blue herons (*Ardea herodias*) on a regional scale is not supported by the past 20 years of scientific documentation (Cuthbert et al., 2002). Research also indicates that the local impact of cormorants is limited (Cuthbert et al., 2002). Due to the inconsistent results attributed to variations in context and species involved, cormorant effects on other colonial waterbirds cannot be generalized as negative. Rather, documentation of interspecies interactions should be collected and results evaluated on a site specific basis to determine if interspecies impacts should factor into local cormorant policy (Cuthbert et al., 2002; Somers et al., 2011).

Negative impacts of cormorants on both the Great Lakes' commercially valuable fish and on other waterbirds are not supported by scientific evidence (e.g., Andrews et al. 2012; Duffy,

1995; Cuthbert et al., 2002; Duffy 1995; Somers et al., 2011). An in-depth study of the literature indicates that the strong influence of anthropogenic factors on cormorant management comes from public outcry that is based primarily on perceived, rather than documented, impacts (Chastant et al., 2014). Unfortunately, many of the complexities and intricacies of this colonial waterbird are buried under negative folklore. Implications of this background research include the importance of conducting local studies on cormorant impacts as well as the importance of scientifically based cormorant management.

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Microhabitat and frequency changes in double-crested cormorant (*Phalacrocorax auritus*) advertising display in a tree-nesting colony

Abstract

Male double-crested cormorants (*Phalacrocorax auritus*) perform advertising displays at spring breeding grounds to attract females. Although these displays are described in the literature, their variations in frequency over time and their associations with habitat features are unpublished. In this study, cormorants were observed at a tree-nesting colony at Tommy Thompson Park, Toronto, ON, over the 2014 nesting season. Advertising behaviour was observed from its initiation in April (April 10) until its termination in July (July 7) using frequency scans ($n = 484$) to monitor changes in advertising frequency over time and detailed random subsamples ($n = 827$) to monitor changes in microhabitat selection over time. Plumage was also noted. The observation period was divided into pre-incubation, incubation, and chicks-present categories based on a subsample of nests that were followed for the nesting season. The total number of cormorants advertising per minute dropped by 66.0% during incubation, and 96.6% when chicks were present. The generalized linear model fitted to the detailed random subsample indicated that there were week:nest ($p=0.002$), nest:height ($p= 0.04968$), and week:density ($p=0.002$) interactions. According to the model, most cormorants were predicted to advertise without nests until mid-incubation and cormorants advertising without a nest tended to advertise in high locations compared to mid locations and mid locations compared to low locations relative to tree height. Until week 3, cormorants advertised in trees with <10 nests or >30 nests and then advertised in trees with <10 nests until mid-incubation. All but two (99.8%) advertising cormorants had complete definitive alternate plumage ($n = 827$). Cormorants advertise for three

months at their summer nesting grounds and some aspects of their microhabitat selections change over time. Temporal variation in habitat predictors may be useful for estimating population expansion over time, colony density, habitat impact, as well as orientation within the breeding chronology. Understanding cormorant behaviour and knowing how cormorants interact with their environment is important for cormorant management and monitoring.

Introduction

Understanding variation in behavioural displays during the breeding season can provide insights into how birds settle in their environment. In an otherwise monomorphic species, the advertising display is the only visually differentiating identifier of the male double-crested cormorant (*Phalacrocorax auritus*, hereafter cormorant). Elaborate advertising displays of cormorants are characterized by a unique, strained body position including the elevation of the tail and the head which is pointed upwards and forwards over the back. In this position the male completes a series of showy, fluid wing-flaps (wing-waving, wing flipping, or singing display) where the wing tips move upwards and outwards (van Tets, 1965; van Tets, 1959) and each wing-flap is accompanied by a low, guttural vocalization. The rate of the display is typically less than two wing-flaps per second (van Tets, 1965; Lewis, 1929). Advertising displays are initiated soon after cormorants arrive in their colonial spring breeding grounds and continue well into the summer.

Though there is some scientific literature describing cormorant advertising displays (van Tets, 1959; Van Tets, 1965; Lewis, 1929), to our knowledge, there are no publications that discuss its frequency changes over time or its associations with habitat features. Observing variations in

these factors over the breeding season and over multiple years could provide insights into colony dynamics and ecological impacts (e.g., see Serrano et al., 2004; Helm et al., 2006). Observation of the microhabitat distribution of cormorant advertising displays could be a useful tool for management and conservation planning. This paper describes the frequency, habitat, and age characteristics of cormorant advertising displays in a tree-nesting colony over the 2014 breeding season.

Materials and Methods

Study site

Tommy Thompson Park (TTP \approx 160 ha; 43° 37' N, 79° 20' W) is located on a 5 km human-made peninsula (Leslie Street Spit) that extends into Lake Ontario from Toronto, Ontario (Toronto and Region Conservation Authority [TRCA], 2000). In 2000, the park was designated as a globally significant Important Bird Area (Wilson & Cheskey, 2001). The Spit was colonized by cormorants in 1990; since then, populations of cormorants have dramatically increased within the park to their current peak of 12,488 nests distributed primarily over two sub-peninsulas (B & C, see Fig 1; TRCA, unpub. data). In 2014, 37% of cormorants nested in trees, most of which were dead or dying as cormorants were non-lethally deterred from nesting in healthy trees (TRCA, unpub. data). TTP offers a unique opportunity for behavioural observation because, while most cormorants nest on islands where human presence is rare and causes much disturbance (Kolb, 2012), cormorants can become acclimatized to human presence (Lewis, 1929) and the cormorants at TTP are accustomed to human activity (Mc Rae & Fraser, pers. obs.).

Sampling design

Fixed sampling stations on the tree-nesting areas of Peninsulas B (n=2 stations) and C (n=4 stations) were used to decrease the likelihood of repeatedly sampling the same (unmarked) individuals (Fig. 1). Station size ranged from 100-420 m² with tree densities of 0.7-1.0 trees/m² (Mc Rae, unpub. data). Boundaries of the stations were marked with flagging tape or indicated by discrete changes in vegetation. The sample sequence for stations was reversed on alternating days with corresponding time periods so that independence of observations could be assumed (different days and times). Observations were discontinued when advertising was not observed on two consecutive data collection days.

We hypothesized that advertising behaviour and location (habitat characteristics) change as the breeding season progresses since time in the season is limited, prime breeding sites are limited, and timing of bird arrival is sexually and demographically based (Dorr et al., 2014; Lewis, 1929; Palmer, 1962). Data on advertising males were collected approximately three times per week (Monday-Friday) at three different start times (8:00, 10:00, & 12:00). We collected frequency data in one minute scans (Altmann, 1974) at the beginning and end of each 10 min detailed random subsample sampling period to determine an average rate for the number of advertising cormorants per station per minute over time (April 16 - July 10, 2014). In the 10 min detailed random subsample periods for each station, advertising individuals were located and several spatial and habitat descriptors were recorded: 1) relative height in the tree (low mid, high); 2) whether the bird was advertising on a nest (none, partial, full); 3) cormorant nest density in the tree (none (0), few(<10) moderate (10-30), high (>30)); and 4) tree health (dead/dying or stable/healthy) (April 10 - July 10, 2014). Plumage (i.e., whether the advertising bird had definitive alternative plumage; Rasmussen, 1987) was also noted.

Based on breeding chronology, the advertising data collected at each station were divided into sequential time block categories of pre-incubation (week 1-4; April 10-30), incubation (week 4-11; May 1-June 18), and chicks-present (week 11-14; June 19-July 16). Breeding chronology was determined based on a sample of nests in focal trees on Peninsula C followed for the entire nesting season (Fraser, unpub. data; the number of nests varied each week in focal trees ranging from 24 to 78). The status of nests was recorded approximately once per week. Breeding category transitions were determined when 50% or more of nests that were followed had transitioned into the next category.

Statistical analysis

Stepwise generalized linear models (GLM) were used to observe both changes in frequency and location of birds advertising based on predictors. The linear spline function was used to divide the data into three temporal periods based on breeding chronology as the number of birds advertising over time showed neither a linear, quadratic, nor cubic trend (Friendly & Azadbakhsh, pers. comm.). Changes by week, station, and time of day were evaluated using the one min frequency scans. The detailed random subsample from the 10 min collection periods was used to evaluate changes in location based on microhabitat descriptors including whether or not the bird was advertising on a nest, relative height in the tree, cormorant nest density in the tree, station, and tree health.

To evaluate the variation in the number of birds advertising per minute, station, time of day, and breeding chronology were used in a GLM. The sampling unit of “breeding category” was used with an offset for the time of day. To further explain the variation in the number of birds advertising per minute, a marginal model for week and bird count was explored. For this

marginal model, the sampling unit of “week” was used with an offset for the number of data collection days.

To evaluate the change in the number of birds advertising in relation to various habitat and spatial factors over time, a GLM with all two way interactions was used. The sampling unit was “week” with an offset for the number of data collection days.

With stepwise selection, the significant interactions were kept in the final multi-variable models. Poisson distribution was used since the response was a count variable. All data were analyzed using SPIDA, ggplot 2, effects and lattice packages with R software, version 3.1.2 (R Development Core Team, 2014). Reported results are mean values of the number of advertising cormorants calculated from data averaged over week (\pm sd).

Results

Advertising cormorants were observed from April 10 to July 7, 2014. Sampling ceased on July 10 after two sampling days where advertising was not observed. We sampled 827 advertising cormorants in the 10 min periods and counted a total of 484 in the one min scans.

In general, many of the predictors had significant interactions with week and/or breeding category which indicated changes in where birds advertise over time (Table 1; Table 2). There were also some significant habitat interactions (Table 2).

Frequency changes in advertising cormorants through the nesting season

Averaged over station and week, the number of advertising cormorants per minute varied between 0 ± 0.2 (week 13) and 3.8 ± 3.1 (week 4). For the number of cormorants advertising per minute at each station there was an increasing trend over the pre-incubation category (2.9 ± 2.6)

followed by a decline during the incubation category (1.0 ± 2.6) and a further decline during the chicks-present category of the breeding chronology (0.1 ± 0.3 ; Fig. 2). The total number of cormorants advertising per minute dropped by 66.0% during incubation, and 96.6% when chicks were present. Although the frequency remained quite low as the season progressed, advertising was observed until July 7, 13 weeks after cormorant arrival.

The GLM fitted to the frequency scans indicated that, when all other factors were fixed at their baseline, station was significant ($p < 0.001$) and time of day was a significant interaction with breeding category ($p < 0.001$). The station furthest from the base of Peninsula C had significantly fewer advertising cormorants compared to all the other stations. During the pre-incubation category more cormorants were observed advertising between 10am - 12pm than between 12pm - 2pm and more advertising was observed between 12pm - 2pm than 8am - 10am.

The marginal model for week and bird count fitted to the frequency scans revealed that cormorant advertising reached its peak about three weeks into the pre-incubation period (April 24-30; Fig. 3). After this peak, the model predicted that the number of advertising cormorants declined significantly over time until the chicks-present stage of the breeding chronology (week 12, June 26 – July 2) ($p < 0.001$; Fig. 3). Following this transition, the model indicated that the advertising frequency may increase until week 14 (July 16).

Microhabitat selection and temporal locational changes of advertising cormorants

The GLM fitted to the detailed random subsample indicated that when all other factors were fixed at their baseline, there were significant week:nest ($p = 0.002$), nest:height ($p = 0.04968$), week:density ($p = 0.002$), and station:tree_health ($p < 0.001$) interactions. According to the model, most cormorants were predicted to advertise without nests until mid-incubation. This initial

trend was unimodal and peaked just before the transition to the incubation category. The model suggested that cormorants advertising without a nest tend to advertise in high locations compared to mid locations and mid locations compared to low locations relative to tree height. From initiation to mid-incubation, more cormorants advertised in trees with <10 nests than in trees with 10-30 nests. From just prior to the transition to the incubation category until mid-incubation, more cormorants advertised in trees with <10 nests than in trees with >30 nests. In general, cormorants advertising closest to the base of the peninsulas were more likely to advertise in stable and healthy trees.

Demographics of advertising cormorants

All but two (99.8%) advertising cormorants had complete definitive alternate plumage (n = 827). One of the individuals had slight brown mottling on its breast (June 5, Peninsula B Station 2) and the other had brown mottling on its entire breast (May 26, Peninsula C Station 2). These birds either had incomplete alternate or immature plumage (Rasmussen, 1987).

Discussion

The frequency and habitat use of advertising cormorants changed over the breeding season. In this study we found that male cormorants advertise for three months at their seasonal nesting grounds. Both the data and the predicted values from the GLM indicated that cormorants initiate advertising soon after arrival in April and peak after about 3-4 weeks, which is at or just prior to the transition into the incubation category. Although advertising begins to decline, as expected, during incubation, this behaviour continued to be observed relatively late, too late for cormorants to nest successfully. With reproduction initiated between 2-3 years of age (Bedard et al., 1995), perhaps colonies provide an opportunity for younger individuals to sample potential future mates

and future nesting sites. Some of the late advertising males may have been prospecting for the following year or attempting a re-lay in response to a failed nest or missing partner. Waves of incoming birds may explain some of the variation in the data set: cormorants' arrival to spring breeding grounds is staggered over an extended period of time, with immature birds arriving last (Palmer, 1962; Dorr et al., 2014; arrival continued into June, Mc Rae, pers. obs.).

The significant differences between stations was likely due to the variation in station size, but may be correlated with tree health as cormorant colonies tend to initiate on island edges or peninsula tips and move inland over the years as tree health deteriorates (TRCA, unpub. data; see also Koh et al., 2012). During the pre-incubation category, cormorants tended to advertise mid-morning, which may have been influenced by the particularly cool spring of 2014.

Our study indicated that male cormorants tended to advertise in specific microhabitat locations and some of these selections exhibited temporal plasticity. We hypothesized that there would be a temporal shift in microhabitat selection since time and space in the season is limited, and since timing of bird arrival is sexually and demographically based (Dorr et al., 2014). It is thought that older, more experienced male cormorants arrive at the colony first and select the highest quality nesting sites. In cormorant species, early breeders generally raise the most young (McNeil & Leger, 1987; Childress & Bennun, 2000; Childress & Bennun, 2002; Dorr et al. 2014; Grieco, 1999) and first arrivals are likely older, healthier males (Lewis, 1929; Palmer, 1962). Breeding site choice is a crucial component of an individual's fitness (e.g., Reed, 1999), yet the process of nest site selection is poorly understood (e.g., Walters, 2000). Since cormorants advertise where they nest (Fraser, pers. obs.; Dorr et al., 2014), the habitat interactions with week may indicate the shift from more to less desirable potential nest site locations within a breeding season.

Although more work is required to tease apart the variables, nest stability is important for fledgling success which means males advertising on nests may have an increased chance of being selected by females. Siegel-Causey and Hunt (1986) found pre-existing nests were the nesting location of choice for early arrival cormorants at a ground-nesting colony. In our study, the limited availability of pre-existing nests may explain the high numbers of cormorants advertising without nests until mid-incubation. After mid-incubation, nest vacancy due to nest failure and the increased length of time available to build nests may have contributed to the increase in the number of males advertising on nests. Also, nest importance increases for late advertising birds because of limited nesting time.

While it is unknown if males on nests found mates faster than those advertising without a nest, the observations of several nest takeovers (sometimes in series) where advertising males were chased off of full nests by other males that then proceeded to advertise, suggests that nests may be important for attracting a mate and/or important for individual males as they allow for expedited laying (Mc Rae, pers. obs.). Males without a nest may increase their advertising duration and/or rate to compensate for the lack of nest though male quality is likely also reflected in the rate of the advertising display (Simmons, 1988; Charge et al., 2010; Mather & Robertson, 1992). While it is likely advantageous to use pre-existing nests, this factor is not the only one considered in nest site selection (Siegel-Causey & Hunt, 1986).

Higher locations within a tree were likely selected since they offer multiple nesting benefits including increased chick security, as they are less accessible to tree climbing predators (Koh et al., 2012; Minias & Kaczmarek, 2013; Lewis, 1929). In a study done on the great cormorant (*P. carbo*), nest height was identified as an important aspect of nest site quality (Minias & Kaczmarek, 2013). Also, reproductive success and chick body condition were positively

associated with nest height in tree-nesting colonies of cormorant species (Blomme, 1979; Childress & Bennun, 2000; Minias & Kaczmarek, 2013). Higher locations within a tree may allow for better projection of the advertising vocalisation and could be more sanitary (Childress & Bennun, 2000). Many of the pre-existing nests were in high locations but, because these nests were quickly occupied, perhaps cormorants that were forced lower in the trees tended to advertise with partial nests (rather than no nest) to try to increase their chances of attracting a mate.

Until week 3, cormorants advertised in trees with <10 nests or >30 nests and then advertised in trees with <10 nests until mid-incubation. The initial advertising in trees with high nest densities was likely correlated with the selection of pre-existing nests. Cormorants advertising in trees with low nest density could indicate colony expansion or constraints correlated with tree canopy size. The majority of the trees at the stations were eastern cottonwoods (*Populus deltoides*) and many were missing limbs and branches from cormorant nesting behaviours. It is not unusual for cormorants to nest in trees with low nest densities (<6 nests per tree was noted as normal by Lewis, 1929). For future studies, we recommend recording nest density in smaller increments as this observation may provide valuable insights into the degree and location of colony expansion.

The significant station:tree_health interaction is indicative of an inland movement of the cormorant colony over time which was likely instigated by population expansion and/or deterioration of the original tree-nesting sites (Koh et al., 2012) on Peninsulas B and C. Cormorants prefer to nest in canopy trees (Koh et al., 2012), but will relocate when their current nesting sites become unstable (e.g., pied cormorants (*P. varius*), Rippey et al., 2002). The dynamic nature of ecosystems allows for changes to be observed even within a breeding season.

During the 2014 breeding season we observed multiple treefalls in stations due to both beaver activity and tree death resulting from multiple years of cormorant nesting (Mc Rae & Fraser, pers. obs.). General expansion into areas with no previous nests was observed at the beginning of the incubation period (TRCA, unpub. data).

Although our findings suggest that advertising is performed primarily by males with definitive alternative plumage, Palmer (1962) suggests that feathering is not an accurate indicator of age in the cormorant (undocumented age banding study of G. van Tets). Breeding of great cormorants (*P. carbo*) with immature plumage has been observed but is described as rare (Grieco, 1999).

Temporal variation in habitat predictors may be useful for estimating population expansion over time, colony density, habitat impact, and orientation within the breeding chronology. Though these results present promising potential trends, because our study is limited to the 2014 breeding season, we recommend future, multi-year studies to validate these advertising behaviour patterns. We recommend TTP as a site for observing how non-lethal deterrence affects advertising behaviour as well as exploring variation in the rate of advertising behaviour.

Acknowledgements

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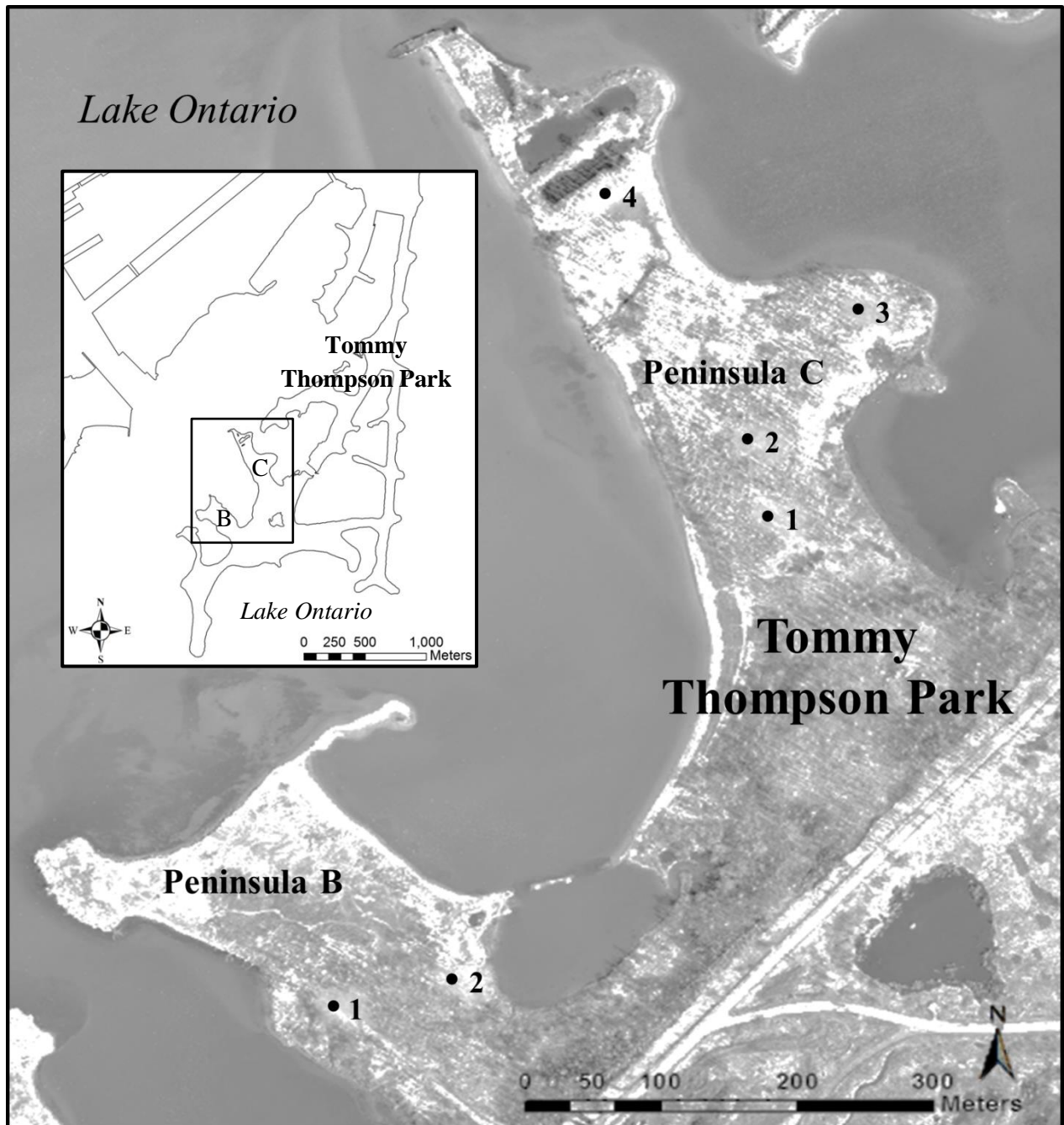


Figure 1: Peninsula B and C were the locations where double-crested cormorant (*Phalacrocorax auritus*) advertising was observed at Tommy Thompson Park, Toronto, ON, during the 2014 nesting season. Numbers indicate station locations.

Table 1: Significant predictors of frequency changes from a generalized linear model based on data from frequency scans of advertising cormorants (*P. auritus*) observed at Tommy Thompson Park, Toronto, Ontario in 2014.

Predictor	Effect
Category	Category, Category:Period
Station	Station
Period ^a	Period, Category:Period

^atime of day

Table 2: Significant predictors for male cormorant (*P. auritus*) advertising location from a generalized linear model based on data from detailed random subsamples of cormorants observed at Tommy Thompson Park, Toronto, Ontario in 2014. The linear spline function, based on pre-incubation, incubation, and chicks present divisions in breeding chronology, was used for week.

Predictor	Effect
Week	Week, Week:Density, Week:Nest
Nest ^a	Nest, Nest:Height, Nest:Week
Height ^b	Height, Height:Nest
Density ^c	Density, Density:Week,
Station	Station, Station:Tree_health
Tree_health	Tree_health:Station

^a whether the bird was advertising on a nest

^b relative height in the tree

^c cormorant nest density in the tree

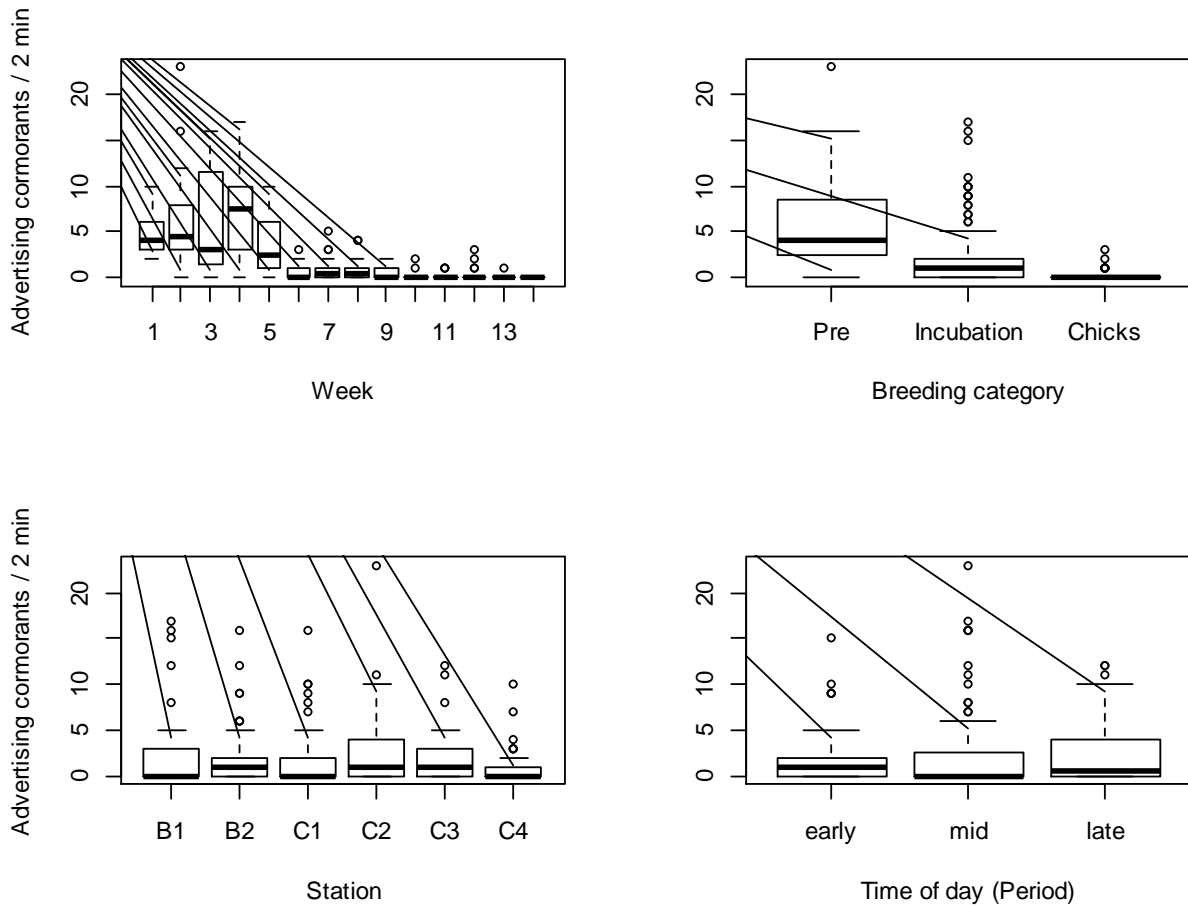


Figure 2: Frequency changes in advertising double-crested cormorants (*P. auritus*) through the 2014 nesting season at Tommy Thompson Park, Toronto, ON.

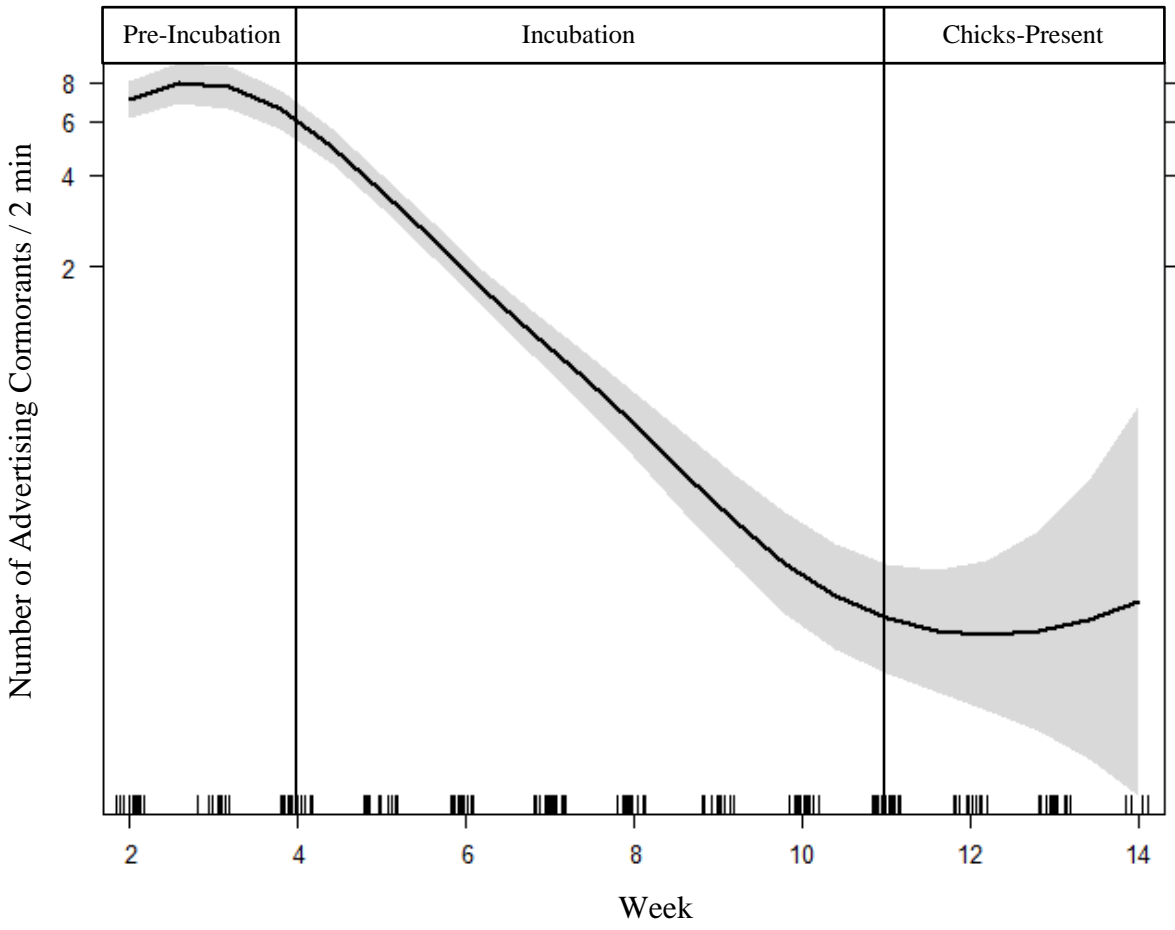


Figure 3: Marginal model for double-crested cormorant (*P. auritus*) advertising frequency over the nesting season. The model was based on data collected on advertising cormorants through the 2014 nesting season at Tommy Thompson Park, Toronto, ON (April 10 – July 16). The model used Poisson distribution, the sampling unit of “week,” and an offset for the number of data collection days. The linear spline function was used to divide the data into three temporal periods based on breeding chronology.

The Importance of Design in Graphic Interpretation²

Effective communication is one of the greatest barriers in the field of ecology. Scientific knowledge is necessary to impact and inform public policy, community goals, and individual decisions, but too often scientific insights and knowledge are ineffectively communicated to the public. If a scientific idea matters, then the communication of that idea matters (Carter 2013 p. 3). Graphic interpretation is a form of scientific communication that is particularly challenging because it demands a lot of effort from the viewer. Since interaction is limited, audience feedback, questions, and reactions must be anticipated (Tilden 2007; Rand 1990). Eager to learn more about the methods and design for graphic interpretation, I wrote a paper titled, “Effective Poster Communication in Resource Management: The Art of Gaining and Holding Attention through Graphic Interpretation.” Research for this paper helped direct my design and style for a poster that I prepared for Tommy Thompson Park focused on double-crested cormorants. This park is a unique, human-made peninsula in suburban Toronto and is home to a large population of cormorants. The park management plan regarding the cormorants includes public education (Karen McDonald, personal comm.) and my poster is a contribution to this effort.

Public controversy surrounding cormorants made communication of ideas through poster format especially interesting. There is very little supportive literature on how to communicate effectively through non-formal interpretative graphics when barriers of misconceptions exist. Born, Massey, and Lutter (1993) suggested that careful wording can alter naïve notions. Also, clarity of information and relevant questions allow the viewer to engage without feeling threatened. Mere-exposure effect is a psychology theory that suggests that positive feelings

² The following was adopted from: Mc Rae, M. (2014) *Effective poster communication in resource management: The art of gaining and holding attention through graphic interpretation*. Unpublished manuscript. Resource Management, York University, Canada.

increase as exposure or familiarity with something increases (Zajonc 1968 as cited in Wood et al. 2014). This idea may be important in altering misconceptions as graphic public education allows for increased exposure and familiarity with various topics.

Editing to produce the most succinct story is the largest factor in poster success (Van Dalen et al. 2002; Carter 2013). Most viewers will benefit from an informal style and nontechnical vocabulary. Since the target audience for posters is typically the general population, it is suggested that text be accessible to a grade 7-9 reading/comprehension level (Karen McDonald pers. comm.; Van Dalen et al. 2002). To engage advanced readers, Rand (1990) suggested using complex concepts rather than complex terminology.

Reaction and response is the goal of graphic interpretation. Topic relevance and familiarity allows for minimized viewer effort (Bitgood 2000) and if the material presented connects with what the reader already knows, experiences, understands, and feels, the chance of connection and response increases (Tilden 2007). Tilden (2007) stated that, “the chief aim of interpretation is not instruction, but provocation” (p. 34). Understanding connections and relationships is understanding ecology, and it is these relationships that environmental educators seek to relay through graphic interpretation (Tilden 2007).

Researching effective design for graphic interpretation was an important foundation for the creation of the public education poster for Tommy Thompson Park. Topics and goals for the poster as well as the intended audience were discussed with Karen McDonald. She also informed draft editing. The poster was presented at the annual meeting for the Tommy Thompson Park double-crested cormorant advisory committee. Final edits were made based on feedback from the advisory committee. Through this project I have had the opportunity and

challenge to relay information about a controversial species in a way that is both engaging and illuminating.

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Interpretive Poster: Double-Crested Cormorants...Did you Know?

Double-Crested Cormorants...Did You Know?

Too Many Cormorants?

Cormorants are a conservation success story! Native to North America, cormorants eat near the top of the food web where pollutants become most concentrated. In the 1950s, when DDT and other toxins contaminated the environment, cormorant populations drastically declined. The banning and continued clean-up of these pollutants has enabled cormorant populations to rebound.

Today cormorants continue to re-populate their natural habitat range. Since 1990, cormorants have nested at the human-made peninsula of Tommy Thompson Park. In other areas of Ontario, human development and expansion into natural areas has increased cormorant encounters. As more people come into contact with these birds, negativity has been the popular attitude. Though there is often a discrepancy between real and perceived impacts, cormorants are typically associated with tree death and viewed as competitors for fish. Their positive traits including their adaptability and resiliency are often overlooked.

Fishy Breath: An Appetizing Defence

Like loons, these heavy birds sit low in the water and dive to catch their prey. Cormorants eat fish and here, at Tommy Thompson Park, they mainly eat the invasive Alewife.

Eager to protect themselves and their chicks, cormorants intentionally regurgitate or vomit when they feel threatened. Their vomit becomes a smelly, often irresistible dinner option for their predators.



Alewife
↑



Double crests



Cormorants nesting on the ground at Peninsula B.



Hours old, this newly hatched cormorant chick is extremely vulnerable and relies on its parents for food, water, and temperature regulation. It's eyes stay closed for the first few days and initially it will do nothing but eat and sleep.

Spring Beauty

Shortly after the cormorants' spring migration to Canada, the excitement of courting and nesting begins. From behind bird blinds the brilliant colours, feather tufts, and comical wing-waving display of the cormorants can be viewed. The cormorants' heads are adorned with two rows of feather tufts for which the double-crested cormorant is named. Male cormorants can be identified by their unique advertising behaviour which includes rhythmic wing flapping and the uttering of a series of deep, guttural GOO-ou's.



During breeding season, cormorants are eager to show off their brilliant, turquoise mouth and throat.

What About the Trees?

Dead trees = new opportunities. Like beavers, cormorants are landscape transformers. After a few years in a tree-nesting colony, the cormorants' nest building activities and acidic guano or poop kills the trees. Ecosystems are inherently dynamic and change is normal, healthy, and expected.

- Dead and dying trees are hospitable habitats for insects which are later enjoyed by woodpeckers.
- Fallen trees open up habitat for ground nesting birds like gulls and terns.
- Ground nesting birds provide seasonal food for predators like coyotes.

Did you know that cormorants also nest on the ground? As of 2014, more than half of the cormorants at Tommy Thompson Park were nesting on the ground. Park staff encourage cormorants to nest on the ground because this helps ensure that cormorants will not run out of nesting habitat. Also, it keeps some of the trees for other wildlife and for us.

Prepared by: Meagan Mc Rae, FES
↑ Alewife (Alosa pseudoharengus). Courtesy of New York State Department of Environmental Conservation.



Text for Interpretive Poster: Double-Crested Cormorants...Did you Know?

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