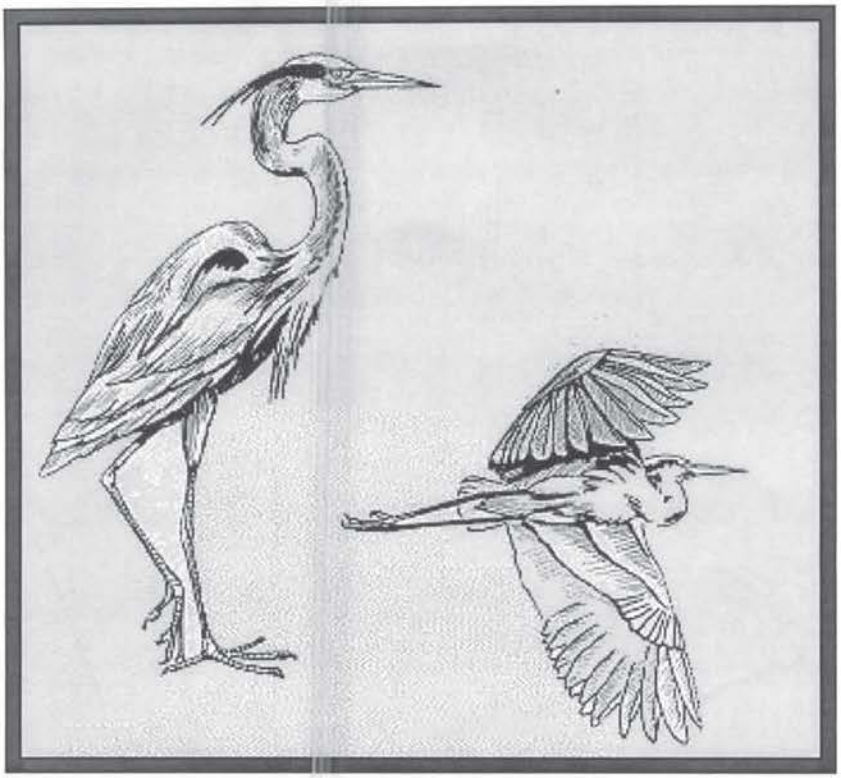
An Assessment of Breeding Great Blue Herons (*Ardea herodias*) and the Impact of Double-Crested Cormorants (*Phalacrocorax auritus*) in the Shad Island Rookery, Swanton, VT



Prepared for the Lake Champlain Ecosystem Team
By Zoe Richards and David Capen
Spatial Analysis Lab, School of Natural Resources
University of Vermont
Burlington, VT 05405

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Summary

Concern about the effects of invading Double-crested Cormorants (*Phalacrocorax auritus)* on Lake Champlain has prompted investigations in the Great Blue Heron (*Ardea herodias*) rookery on Shad Island, Vermont for the past 3 years.

On Shad Island, we conducted a behavioral study in 1999 that indicated that herons nesting near cormorants stayed on the nest longer than herons nesting farther from cormorants ($P < 0.0001$). However, the same protocol for observations in 2000 did not verify this result. Other observed behaviors (feeding rate, feeding time, and aggressive encounters) in both years showed no difference between the two groups. We hypothesized that herons and cormorants might compete for nest sites and sticks; however behavioral observations in 2001 showed no such competition. From 1999 to 2001, detailed mapping of heron nests on Shad Island showed dramatic shifts in nest distribution and nesting success. Although the rookery stayed at approximately 580 nesting pairs during the first two years of study, a quarter of the colony migrated to a new area in 2000 where they failed. In 2001 there were only 350 nest attempts; half of the colony nested in the new area and the entire colony failed. Nesting cormorants also failed in all years of the study, probably due to raccoon (*Procyon lotor*) predation. We suspect that raccoons may be a cause of failure for the Great Blue Herons as well. We wrapped 18 nest trees with duct tape, with the sticky side out, to see if we could pick up tracks of potential nest predators. On 13 of 18 trees, we found evidence of raccoon prints and hair stuck to the tape. The trees were taped while nests were active and checked after nests had been abandoned.

We suspect that predation is a more likely cause of abandonment than either limited food or human disturbance. We had no indications that there were higher levels of human disturbance this year than in the past, and studies of the large, successful Great Blue Heron rookery on Valcour Island, suggest that food resources were not limiting.

We have been unable to measure a direct effect of cormorants on nesting herons, but we have seen dramatic shifts and failures in the 60-year-old rookery on Shad Island, which suggests that further study is warranted. In particular, we are concerned that efforts to manage cormorant populations on other Lake Champlain islands may impact herons by forcing cormorants to leave traditional nesting sites and take up residence in heron rookeries. Further, if raccoon predation is indeed the cause of the heron abandonment we saw this year, it may be that cormorants, which are easy prey for raccoons, are drawing more of these predators into the trees and causing herons to ultimately abandon nests.

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Section 1-Early Season Work and Nest Competition.

Previous work conducted in the Shad Island rookery suggested that there is no obvious effect of nesting cormorants on nesting herons (Hill 2000, Richards and Capen 2000). In 1999 and 2000, studies were directed at observing interactions between nesting cormorants and nesting herons. These studies did not attempt to look at what happened when nests were initiated and we wanted to know whether competition in the early season could account for shifts in nesting patterns in the rookery. Would there be competition between late nesting herons and cormorants for nest sites and sticks which can be hard to come by for less agile waterbirds such as herons and cormorants. Stick competition has been documented between herons and cormorants in one case, where there were many thousands of cormorants and less than twenty-five herons (Drapeau et al. 1984).

Based on previous observations, we assumed that herons start nesting earlier than cormorants but we wanted to document when and how both species arrived in the rookery. This year we went out earlier in the season than past years, to uncover some of these patterns.

Methods

Heron and Cormorant Arrivals

Work was started in the rookery as early as we were able to reliably get there. The Missisquoi River was frozen until mid-April and we did not attempt to get to the rookery until the river was navigable. Our first visit to the rookery was on April 14th. We documented nest building activity and number of nests present by using a digital camera. The digital photographs were printed and the locations of new nests were marked on these prints at each visit. We watched from blinds that were set up off of Shad Island as well as off of Metcalfe Island. We also documented what parts of the rookery were inhabited first as it might be an indicator of which parts of the rookery represented better or more desirable habitat for the incoming herons.

Nest Competition

Observations occurred in three-hour blocks and we watched for any signs of interaction between nesting herons and nesting cormorants. We noted which materials were being used and when and where nests were being built. We also estimated whether herons were still in the nest building phase and what proportion of the nesting population seemed to be incubating eggs.

Nest Mapping

Additionally, as in past years, locations of nest trees were mapped. On Shad, we used early season estimates to locate nest trees, because there were many nests that were never occupied and it was difficult to tell last years nests from nests that had been abandoned this year. This

made ground counts unreliable and forced us to rely on the early season estimates. Conversely, we were able to use the post season ground counts in the Eel Creek area as well as the newly colonized area by the west branch of the Missisquoi delta, under the assumption that all nests present in these areas were built this year (this assumption was based on direct observation).

Another factor that complicated accurate nest counts were renest attempts. It is likely that many of the nests that occurred in the West Branch area were second nest attempts by herons that had failed on Shad Island. Our total nest attempt numbers cannot distinguish first nest attempts from renest attempts.

Results

Heron and Cormorant Arrival and Nest Initiation

As expected, we found that Great Blue Herons appeared to be active in the rookery earlier than Double-crested Cormorants. Our first observation days were in mid-April and it was clear that there had been plenty of activity in the rookery before then. Refuge personnel spotted Great Blue Herons out in the refuge as early as the third week of March but whether they were using the rookery or not at that time is unclear.

Herons built nests first on Shad Island and then in the Eel Creek area (Figure 1). The first visit to the rookery was on April 14th and it appeared that the herons there had likely been there for some time. Heron numbers appeared to stay fairly stable through the few weeks we visited that part of the colony, unlike numbers at Eel Creek, which steadily increased over the three-week observation period (Figure 1). A new colony of roughly 50 herons established itself in the middle of May near the west branch of the Missisquoi Delta (Figure 2). This establishment coincided with the abandonment of nests on Shad Island and is likely to be a re-nest attempt by the Shad Island herons.

Cormorants nest building in the rookery was later than heron nest building. We saw a large influx of cormorants on April 23rd and nesting building activity appeared to occur immediately (Figure 1). This year cormorants only built nests in the Eel Creek area (Figure 3), though they examined and sat on unused heron nests on Shad Island in early May.

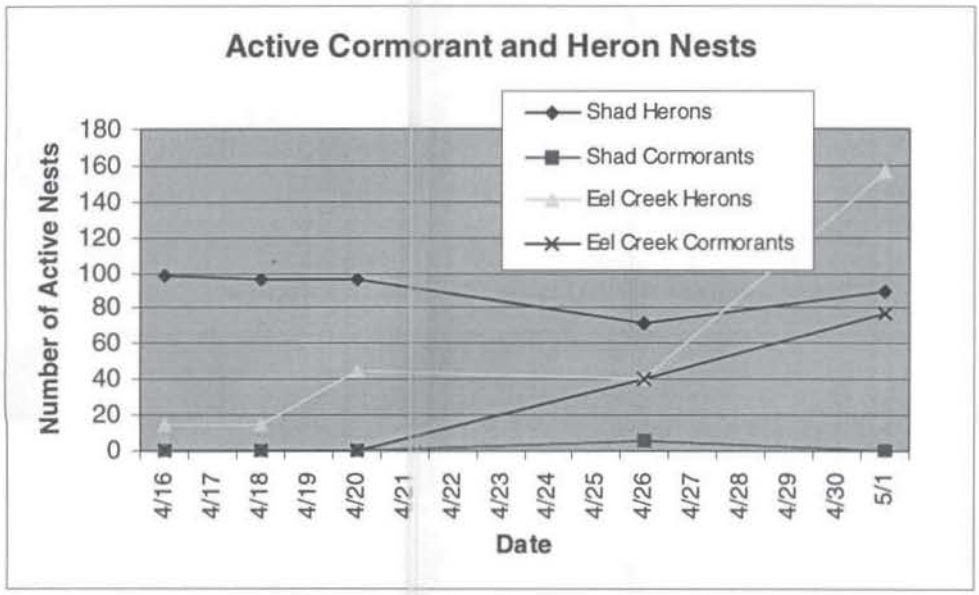

Figure 1. Number of active heron and cormorant nests by date.

Stick Competition and Aggressive Encounters

We found no evidence of aggressive encounters between nesting cormorants and herons. Similar to the studies of the past two years that occurred later in the season, the two species appeared to ignore each other. Further, all aggressive encounters that were seen in over 33 hours of observation time revealed only aggressive encounters between conspecifics. In particular, the herons seemed to be territorial and aggressive towards other herons. We also documented one aggressive encounter between a nesting heron and a family of raccoons moving in the rookery trees.

Herons and cormorants tend to use different nesting material. Herons were observed carrying sticks only and tended to scavenge sticks from last years nest that were still in tact. For example, this year, no herons nested on the spit of Metcalfe between Shad Island and Eel Creek (Figure 2) but many of the nests from last year were still intact in mid-April. Within a few weeks there was no evidence of those nests as herons were observed taking sticks from unused nests and stripping them down to nothing. Cormorants on the other hand, appeared to use shorter sticks and were observed most often carrying marsh grasses which they wove into their nests. Herons and cormorants nested in the same trees and appeared to ignore each other. It also seemed that this year, there was plenty of nesting material available, as a much smaller total population of herons and cormorants inhabited the rookery. There were only 350 nest attempts by herons and 75 by cormorants. Two hundred less herons and 70 less cormorants attempted nests this year leaving plenty of excess nesting material from last year, easily accessible in the trees.

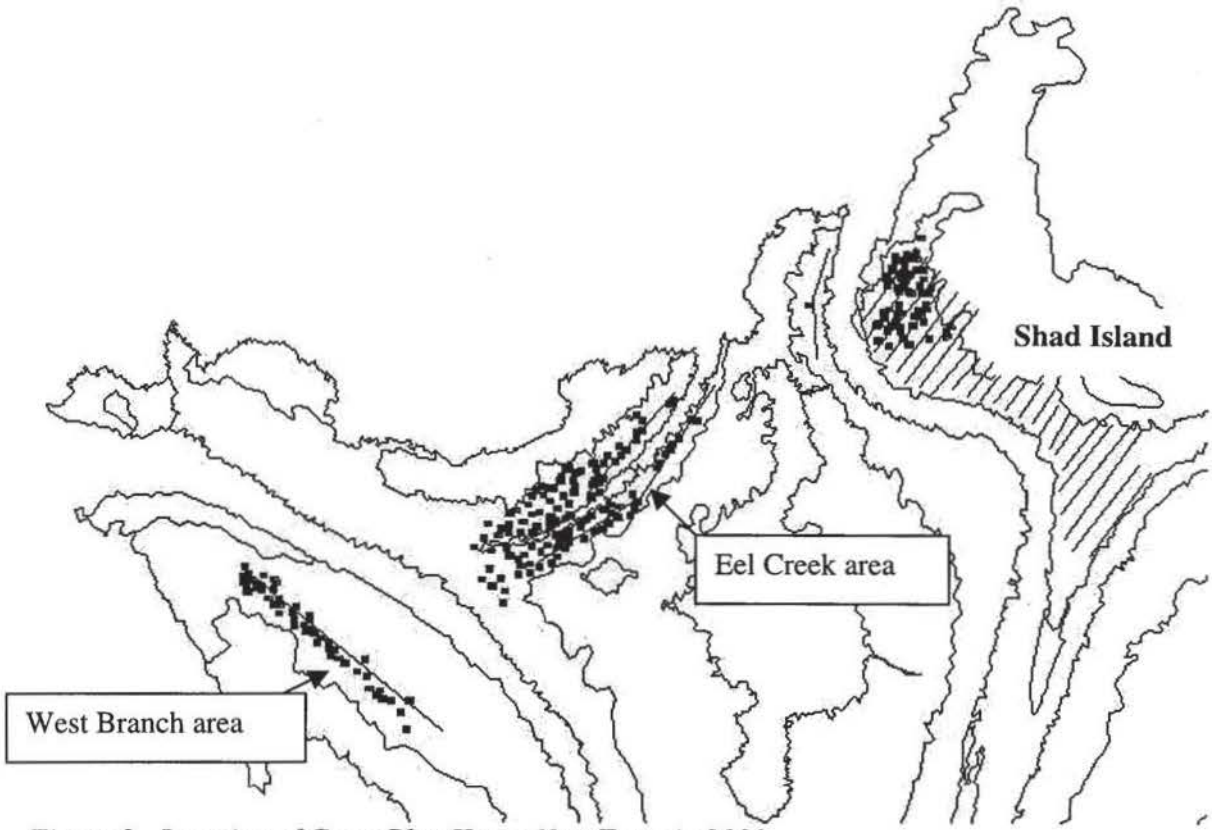

Figure 2. Location of Great Blue Heron Nest Trees in 2001.

Nest Mapping

We mapped locations of nest trees for herons and cormorants. Unlike past years, these numbers more accurately reflect nesting attempts rather than numbers of nesting pairs. Because herons and cormorants did not complete their nesting cylce, we had to use a number of different methods to get the best estimate of nest attempts.

Only herons nested on Shad Island this year and we chose to estimate numbers of nesting attempts through early season observations of active nests (these took place in late April before leaf out). We did this because herons on Shad Island abandoned in mid-May and many of the nests from the year before were unused so a post nesting season count would not give us an accurate picture of which nests were built and used in 2001.

Nests on Metcalfe appeared to have all been built this year as well as nests in the West Branch area. We estimated total nests numbers for herons on Metcalfe and the West Branch from post-season nest counts. For cormorants we used both post-season nest counts and nest counts from the water before leaves were out. In this unusual year, we felt these methods were the most accurate way to discern nesting attempts by herons and cormorants.

We found that 122 heron nests were initiated on Shad Island, 173 were initiated in the Eel Creek area of Metcalfe Island and 49 on the west branch. Cormorant nests were only initiated in the Eel Creek portion of Metcalfe Island and we found a total of 75 nests. Heron and cormorant number were down significantly this year from the past two years. The heron nest attempts were down by at least one third and cormorants by half. It is also worth pointing out that it is likely that the 49 nests in the West Branch area were renest attempts suggesting that less than 300 pairs of herons tried to nest in the rookery.

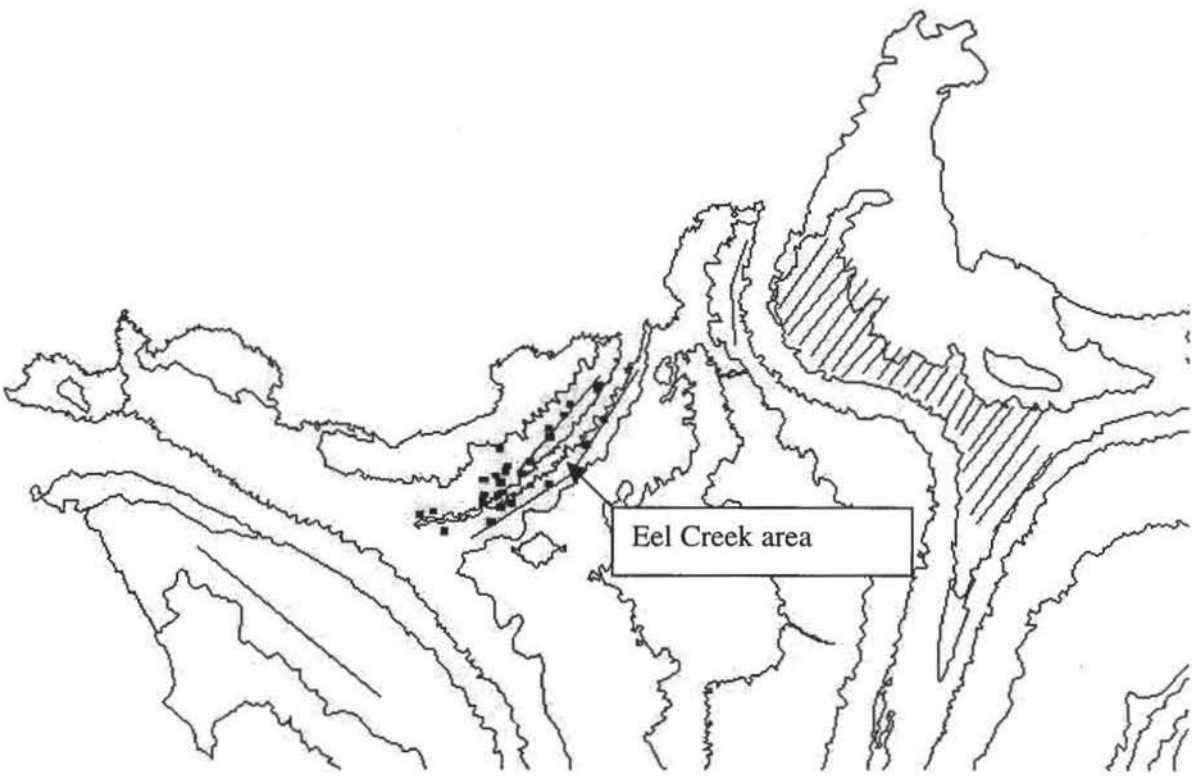

Figure 3. Location of cormorant nest trees in 2001.

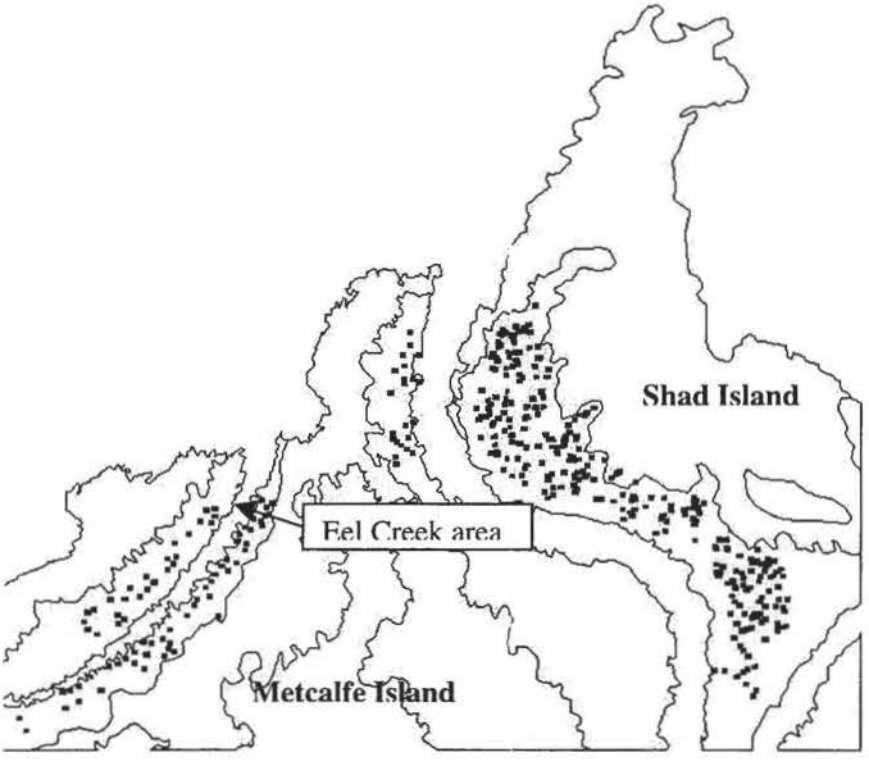

Figure 4. Location of Great Blue Heron nest trees in 2000.

Discussion

Nest Initiation

As expected, from early season work in the rookery, we found that most herons initiate nests well before cormorants. In particular, Shad Island appears to be a focal point for early nesting herons. Male herons called "bachelor males" tend to come into rookeries and settle on nests and court females (Butler 1992). This behavior can complicate interpretation of whether a heron is paired and is standing on a nest it built, or is standing on an old nest. By April 14th, it appeared that most of the birds observed on Shad were building their own nests, courting, copulating and laying eggs. Because the numbers of new nests were relatively stable on Shad and herons were involved in obvious nest building and courtship behavior, we considered most of them to be paired and settled. It did appear that the Eel Creek area was colonized later from the ever increasing nests numbers after April 14th (Figure 1). It is likely that as Shad Island has been used for so many years that this is a common early season gathering place for herons that have probably nested here for years. It is unclear why herons that may have arrived slightly later in the season then started to inhabit the Eel Creek area, rather than the south half of Shad Island which has been used in past years. Last year, herons failed in both areas making neither one apparently advantageous over the other.

Double-crested Cormorants moved into the rookery on April 23, which is roughly a month after the first herons arrive at the rookery. They appeared to start building nests almost straight away. It is unclear why they choose to nest only near Eel Creek, but colonial nesting birds are social creatures. One possibility is that cormorants were stimulated to nest based on the fact that herons in this area were still engaged in nest building while herons on Shad were done with nest building (pers. comm. Trexel 2001).

Great Blue Heron nest initiation dates appear to be very similar between Shad Island, and the large rookery at Valcour Island. We estimated nest initiation dates for Valcour by back dating from when eggs were hatched. As predicted, herons do initiate nests earlier than cormorants, but at least this year, there appears to be a spread in initiation dates among herons in this rookery.

Early Season Competition

We found no evidence of early season nest site or stick competition. We suspected that this sort of competition might occur because for wading and diving birds sticks for nest building can be a valuable commodity. Stick stealing between these two species has been documented (Drapeau et al. 1984). It is hard to fully assess the results of our observations because, though there was no competition this year, it may be an unusual year. Because total number of nest attempts appeared to be lower this year there is more nesting material available, in the trees than there is demand for nest building material. If the rookery were increasing in size, it is more likely that competition would occur (Drapeau et al. 1984). It is clear that herons like to scavenge sticks from old nests rather than going far a field for new nesting material. We observed many herons traveling short distances (100 meters) to an unused nest and removing sticks from it. In fact all stick forays that we observed were short distance trips to old nests.

It appears that this year, early season nest competition did not occur in herons and cormorants. It may be that in other rookeries and other circumstances, for examplewhen a population is growing, resources are likely to be scarcer thus driving competition.

Nest Mapping

This season, nesting attempts decreased significantly for both herons and cormorants. In three seasons of tracking nests, we have watched the rookery shift. In 1999, all nests occurred on Shad Island. In 2000, there was expansion onto Metcalfe Island and also in the Eel Creek area of Metcalfe. In 2001, we continued to see a decrease in nest attempts on Shad and a further westward migration of nest attempts over to the West Branch area of the river (Figure 2&4). It is likely that the 49 nests built in the West Branch area are renest attempts by herons that abandoned Shad Island. We observed these nests being built in late May just after Shad Island was abandoned. We will discuss the abandonment of the rookery in the next section.

Section 2-Rookery Failure and Possible Causes

This year, the entire rookery failed to produce young. It appears that nests were built and adults incubated their eggs. Abandonment occurred roughly around when eggs should have hatched. Because nest initiation dates were not all similar, abandonment occurred in the order that nests were initiated, with Shad abandoning first and the West Branch area last. We are not sure what the cause of the abandonment is and what its implications are for the rookery, but in this section we will explore some of the possibilities. It is worth noting that because the Shad Island rookery was so large, its failure is particularly concerning to local heron populations. Though abandonment is concerning it should also be noted that it is not uncommon in rookeries and causation is often hard to sort out (pers. comm. Butler 2001, Bjorklund 1975).

Methods

We observed the rookery from the water from a distance of at least 100m to keep tabs on how many nests were active. Observation occurred roughly every three days until it was deemed that there were no more active nests.

Before all nests were abandoned, we were curious about the role of mammalian predators, so we wrapped 18 active nests trees with two strips of duct tape with the sticky side out to see if we could pick up tracks or fur of potential nest predators. Because of the large dense canopy we were able to move about under this section of the rookery without disturbing herons from their nests.

After all nests were abandoned, we surveyed all parts of the rookery looking for any obvious clues as to the cause of the abandonment such as predated adults, young or eggs.

Results

Nest Abandonment

Great Blue Herons nesting on Shad Island abandoned their nests early and quickly. On May 18th all nests had been abandoned. According to refuge personnel, only 3 days earlier the rookery appeared to still be active. Observations on May 11 showed no sign of abandonment.

On Metcalfe Island, in the Eel Creek area, the abandonment occurred much more slowly. On May 23rd, we documented a few nest abandonments by cormorants and herons. On May 28th there appeared to be a large drop in active nests of both herons and cormorants and only 30 active herons nests were visible. On June 1st there were 15 active nests. On June 6th there were 5 active heron nests and one active cormorant nest. On June 6th, young were heard but not seen in two heron nests. On June 13th all heron and cormorant nests were abandoned in the Eel Creek area.

In the West Branch area, nests appeared to be abandoned quite quickly. All observation occurred from a boat in long marsh. Most visible nests were active on June 12th, but by June 19th almost all nests, except for 5, were abandoned. By June 25th all nests were abandoned.

Predators

Eighteen trees in the West Branch area of the rookery were wrapped with a double strand of duct tape to see if we could detect potential predators moving in the trees. Tape was put around the base of active nest trees, with the sticky side out, and left alone for a week. When we checked trees a week later we found that all nests had been abandoned and that 11 of 18 trees had either raccoon hair or muddy raccoon prints stuck to the duct tape.

Rookery Observations

All active parts of the rookery were surveyed by foot after the nests had been abandoned looking for clues as to the cause. On Shad Island we could not discern anything. We found no broken eggs or predated young. On Metcalfe, there were plenty of broken eggshells on the ground. Some were shattered and some appeared to look as though they had hatched out normally. We saw no evidence of young. In particular we saw no pinfeathers or dead young on the ground, which are common sites in an active rookery. In the west branch area, we found evidence of hatched eggs and under a few recently abandoned nests saw some evidence of guano from young birds. It appears that all birds that attempted to nest in 2001 laid eggs but did not appear to get much farther than that.

Discussion

The cause of this years (2001) abandonment is unclear. In 2000, we had partial abandonment, which suggested that all was not well with this rookery. Furthermore, we were surprised that areas where herons were not successful raising young in 2000, like on Eel Creek, attracted more nesting herons in 2001. The cause of the failure is opaque but a number of potential causes stand out such as human disturbance, food limitation and predation.

Human Disturbance

Human disturbance is a very common cause of perturbation to nesting herons. Many cases have been documented (Bjorklund 1975, Tremblay and Ellison 1979,Watts and Bradshaw 1994). In particular, nesting Great Blue Herons appear to be particularly sensitive when they are building nests and laying eggs. They will also abandon nests easily when they are incubating eggs. Once the eggs are hatched they are much less likely to abandon young. Although we cannot rule out human disturbance as the cause of this years rookery failure, we have no evidence for it. As the failure occurred over the course of six weeks, there would have to have been repeated disturbance. Generally, personnel at the refuge report that they hear about disturbance events that occur on the refuge. Also, there seems to be no indication that routine use of the refuge by

fisherman has increased dramatically this year. Boat traffic near the rookery has been fairly constant for these nesting herons and tends to be very light early in the season when the birds are most subject to being disturbed.

Food Limitation

Food limitation can cause herons to abandon nests. If food is in short supply, it is not worth it for the herons to invest lots of energy in raising young if they are not likely to make it to fledging. Nonetheless, with a short food supply, herons will still build nests and lay eggs because the energetic investment is low and tend to abandon them just as the eggs are hatching when the energetic investment increases. Though this scenario is consistent with the behavior we observed in breeding herons, we do not believe this is the cause. In particular, work conducted in the Valcour Island rookery this summer suggests otherwise. This large active rookery, which is also on Lake Champlain, was highly successful. It is likely that Shad Island herons and Valcour Island herons do not overlap in their feeding ground but most Valcour Island herons appear to be feeding in the southern Champlain Islands about 15-20 miles south of MNWR. Conditions in the wetlands in both areas are likely to be similar.

Last year there was a copper sulfate spill into the Missisquoi River many miles up stream. An investigation by the State of Vermont into this spill suggested no adverse effects to the river as far down stream as the refuge is located (Hess 2000). Further, anecdotal information from fisherman did not imply that catch was down on the refuge. Similarly, failure and abandonment by cormorants is also unlikely to be due to food limitation. Cormorants nesting on nearby Young Island were very successful.

Predation

We suspect that predation is the main cause of failure in the rookery this year, though we do not fully understand the mechanism. We suspect that either Bald Eagles (*Haliaeetus leucocephalus*) or raccoons are the most likely predators. We do not have a nesting population of Bald Eagles on Lake Champlain but they are common visitors to the area. We sighted a number of eagles on the refuge during the breeding season. In British Columbia, the resurgence of a large nesting population of Bald Eagles has been problematic for nesting herons (pers. comm. Butler 2001). They have found that eagles will come in, kill an adult heron, and then feast on the young. This aggression often scares off all of the other herons and causes them to abandon nests. For a heron, which is long lived, it is probably prudent to abandon young and live to breed for many more years than to risk being killed off by a predator. The speed with which the Shad Island area of the rookery failed is consistent with a dramatic disturbance such as an eagle attack. In the case of the slow abandonment of the cormorant and heron nests by Eel Creek, an eagle attack seems less likely; we would have expected to see a quick abandonment.

Raccoons are another possible predator. This floodplain forest is excellent natural habitat for raccoons, and the muddy forest floor is always full of raccoon tracks. For the past three years we have seen the failure of cormorant nests in this rookery and have suspected that raccoons were

the cause. In past years we have seen direct evidence of raccoon predation on young cormorants though we cannot be sure that that is the entire cause of cormorant nesting failure. Obviously, Great Blue Herons, which have nested in this area close to 60 years, have encountered raccoons before, so the pressing question in why would they be a problem this year.

One possibility is that cormorants are easy prey for raccoons and if cormorants nests are interspersed among heron nests there may be many more raccoons moving in and around the trees than there were previously. We observed herons defending nests against raccoons and they put up a vigorous vocal challenge to any potential nearby threat. In the interaction that we observed, the raccoon never attacked the heron but the heron was in a continued alarmed state for the duration of time that the raccoon was near the nest. It is possible that this type of constant disturbance of the herons was enough to make them abandon. In years where only herons were present in the rookery, raccoons may not have been tempted to head up into the trees because they would get little reward. It has been suggested that as rookeries get larger with diverse species, they can become destinations for predators (Rodgers 1987). Of course, cormorants only occurred this year in the Eel Creek area and not on Shad Island or the newly colonized West Branch area.

Suspecting that raccoons might be the cause of the failure, we were able to document that they are climbing nest trees. We were able to capture raccoon footprints and fur on 11 of 18 active nest trees. All these nest were soon abandoned. It is possible that the nests were abandoned first and then raccoons went up these trees to eat any eggs or young that remained or raccoons could have been the cause of the abandonment.

Conclusions

This years work documented a rookery in distress. Last year (2000) we had concerns that all was not well with the rookery as a portion of it failed and the rookery appeared to be migrating away from Shad Island, its original location. This year we documented the same phenomenon except more extreme. There was further migration from Shad Island and all nests failed (Figures 2&4).

We showed in the past three years that there appears to be no direct competition between herons and cormorants nesting in close proximity. Furthermore, with early season work conducted to look at competition for nest sites between herons and cormorants we found that the two did not tend to compete in the early season. It is likely therefore, that any effect of cormorants on herons is going to be indirect such as drawing more predators into the rookery. Just because the effect may be indirect, it does not mean that it is any less problematic.

Current studies on cormorant populations on Lake Champlain should shed light on whether some of the cormorants that we see in the rookery are from Young Island where they may be being displaced by egg oiling practices. It is important to continue work with this rookery to try and sort out some of its dynamics because such a large conglomeration of nesting herons is important to heron populations in the area. Further, as much of the Lake Champlain Islands and shoreline are built up, relocation of such a large breeding population is unlikely.

Recommendations

1. We recommend continued monitoring of this rookery to assess size and success in the upcoming year.

2. In particular, we recommend that all monitoring happen in the least invasive way possible to give the herons the best chance at nesting success.

3. If cormorants set up in the rookery this year we recommend looking closely at all birds for color bands. Identifying color banded cormorants could give us clues about whether cormorants nesting in the rookery have attempted to nest on young island previously.

4. We suggest that study efforts be directed towards sorting out the role of predators on Great Blue Herons. Setting up footprint and hair traps on nest trees as well as on control trees may help to answer these questions.

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