6-2017

LONG-TERM CHANGES IN CANADA GOOSE NEST SUCCESS AND NEST DENSITIES AT AN IOWA WETLAND COMPLEX

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LONG-TERM CHANGES IN CANADA GOOSE NEST SUCCESS AND NEST DENSITIES AT AN IOWA WETLAND COMPLEX—Giant Canada geese (*Branta canadensis maxima*) were extirpated from Iowa by the early 1900s due to unregulated hunting, egg gathering, and wetland drainage in the nineteenth century (Bishop 1978). Efforts to reintroduce Canada geese in Iowa began in 1964 (Bishop and Howing 1972) and involved releasing flightless adults and goslings at nearly 30 sites across the state (Zenner and LaGrange 1998*a*). In 1972, 13 flightless pairs were released at Rice Lake Wildlife Management Area (WMA; Bishop 1978). By 1989, the breeding population of Canada geese at Rice Lake WMA had increased to 420 nesting adults (G. G. Zenner, Iowa Department of Natural Resources, unpublished data). Canada goose nest success and nest densities were documented from 1989–1991 on extant islands at Rice Lake WMA (Zenner and LaGrange 1998*b*).

Rice Lake WMA (43.379497, –93.472715) is located in north-central Iowa and lies within the southernmost portion of the Prairie Pothole Region. This wetland complex consists of Rice Lake, a 409-ha shallow, natural lake with a maximum depth of 3 m and 20 natural islands ranging in size from 0.04 to 3.9 ha, and Joice Slough, a 73-ha marsh with a maximum depth of 1 m and 15 natural islands ranging in size from 0.02 to 3.19 ha (Zenner and LaGrange 1998*b*). During 1989–1991, potential Canada goose nest sites included islands, elevated structures, and muskrat houses. Over the course of that study, drought conditions left Joice Slough completely dry and dramatically lowered water levels at Rice Lake, exposing islands to increased predator activity. Despite the drought, nest densities were high (68–158 nests/ha) and nest success ranged from 40–58% (Zenner and LaGrange 1998*b*).

In 2013 and 2014, we re-visited Rice Lake WMA to determine Canada goose nest success and nest density on extant islands and compare our findings to those reported by Zenner and LaGrange (1998*b*). In the 25 years since their original study, the number of nesting adults has decreased from 420 to 50, and conditions of the available nesting habitat have changed considerably. Elevated structures have been removed, muskrat houses no longer exist, and many islands have become densely vegetated with shrubs and trees (G. G. Zenner, personal communication). We sought to determine how these changes had affected nesting activity at Rice Lake WMA.

In April 2013, the Iowa Department of Natural Resources (DNR) lowered the water level at Rice Lake by 1 m to expose mudflats which allows shallow water zones to re-vegetate during a managed drawdown. This management action and drought conditions in 2013 and 2014 resulted in water levels similar to conditions observed during 1989–1991 (Zenner and LaGrange 1998*b*, Fig. 1). Only four of Rice Lake's twenty islands were surrounded by water during 2013–2014. Joice Slough water levels were not manipulated but drought conditions left six of the fifteen islands surrounded by water. Joice Slough was completely dry during 1989–1991, but four islands were surrounded by water on Rice Lake during this time, as in our 2013–2014 study (Zenner and LaGrange 1998*b*).

All accessible islands were searched systematically on foot for active, abandoned, and depredated nests by walking transects spaced no more than 5 m apart. We monitored 49 nests on Rice Lake and 48 nests on Joice Slough from 6 April–17 June 2013, and 32 nests on Rice Lake and 55 nests on Joice Slough from 18 April–17 June 2014. Each active nest was assigned a unique identification number and its global positioning system coordinates recorded. We recorded the number of eggs in the nest and their incubation age using a field candling device (Weller 1956, Walter and Rusch 1997, Reiter and Anderson 2008). Egg handling procedures and other study methods were approved by the Iowa State University Institutional Animal Care and Use Committee (protocol #11–12–7460–Q).

We checked nests three times during the nesting period and once post-hatch to determine nest fate. We classified a nest as successful if at least one egg hatched (Mayfield 1961). We identified a successful nest by the presence of eggshell fragments and detached intact membranes in the nest (Girard 1939, Cooper 1978). We classified nests with remains of eaten eggs as depredated.

To make an analogous comparison to the nest success results reported by Zenner and LaGrange (1998*b*), we calculated apparent nest success using only nests located on extant islands. Apparent nest success is the proportion of total nests that hatched at least one egg (Johnson 1979). Generally, this method is considered unreliable for estimating nest success because it can bias estimates high due to the fact that unsuccessful nests are usually not found and nests found later in incubation are more likely to be successful (Mayfield 1961). However, island-nesting geese are an exception to this bias because the search area is confined and most failed nests are located (Johnson and Shaffer 1990). We recorded and incorporated all nests found active, depredated, or abandoned into the total number of initiated nests for both this study and the 1989–1991 study (Zenner and LaGrange 1998*b*). We are confident that all initiated nests found during this study and previous research by Zenner and LaGrange (1998*b*) had equal detection probabilities because goose eggs are conspicuous and the majority of shrubs and trees had not yet produced leaves during nest searches. We used Welch's *t*-test to test for differences in nest densities and nest success within and between the previous study by Zenner and LaGrange (1998*b*) and this study. We evaluated the relationship between water level and predation rate with the Pearson correlation coefficient. Also, we placed camera traps at 29 nests (1–2 m away) to identify potential nest predators.

During 1989–1991, water levels at Rice Lake ranged from 0.43 to 1.22 m below crest (Fig. 1) and Joice Slough was completely dry. During 2013–2014, Rice Lake water levels

ranged from 0.52 to 1.17 m below crest. Water levels at Joice Slough increased from 0.04 m below crest in 2013 to crest in 2014. Although water levels varied throughout both studies, extant island sizes did not drastically change. Due to low water levels, however, islands near the shoreline became connected to the mainland on both Rice Lake and Joice Slough.

Average nest density on Rice Lake islands was 85 nests/ha in 1989 (SD = 50.91) and 153 nests/ha in 1990 (SD = 26.94) (t_4 = –1.75, P = 0.08). Average nest density was 48 nests/ha in 2013 (SD = 9.98) and 25 nests/ha in 2014 (SD = 36.51), but the difference was not significant (t_3 = 1.20, P = 0.153). This is likely because nest densities were highly variable among the 4 islands, ranging from 0 to 78 nests/ha. The average nest density on Joice Slough islands was similar (t_{10} = –0.76, P = 0.232) between 2013 (48 nests/ha, SD = 29.81) and 2014 (62 nests/ha, SD = 33.10). Although water levels were comparable during the two studies (Fig. 1), average nest densities were lower during our 2013–2014 study (t_{14} = –4.42, P < 0.001; 2013–2014: $\bar{x}$ = 48 nests/ha, SD = 29.75; 1989-90: $\bar{x}$ = 129 nests/ha, SD = 59.40).

During 1989–1991, Canada goose nest success on Rice Lake islands ranged from 40–58% (Zenner and LaGrange 1998*b*; Table 1). During 2013–2014, nest success on Rice Lake ranged from 27% to 38%, and nest success on Joice Slough islands ranged from 13–55%. Average nest success during 2013–2014 ($\bar{x}$ = 34%, SD = 17.75) was less than during 1989–1991 ($\bar{x}$ = 50%, SD = 9.45), but not significantly (t_5 = –1.67, P = 0.08). During 1989–1991, predation rates, although modest at ≤ 12%, were highest when Rice Lake water levels were lowest (Zenner and LaGrange 1998*b*, Fig. 1). We observed much higher predation rates (Table 1), which increased as water levels lowered on Rice Lake (40% to 53% from 2013 to 2014), and decreased as water levels increased at Joice Slough (from 78% to 38% from 2013 to 2014). Despite these observations, there was not a strong correlation between water levels and depredation rates (r_5 = 0.58, P = 0.17). Camera traps revealed nests were destroyed by coyotes (*Canis latrans*), raccoons (*Procyon lotor*), American crows (*Corvus brachyrhynchos*), and in 2 instances, local farm dogs (*Canis lupus familiaris*). Additional analysis indicated that camera traps did not negatively impact nest success during this study (Ness and Klaver 2016). However, Iowa harvest records for 2014 indicate that raccoon and coyote harvest rates have increased threefold since 1989 (Iowa DNR 2015). Raccoon harvest averaged 130,000 during 1989–1991 compared to 305,000 during 2013–2014. Coyote harvest averaged 4,500 during 1989–1991 compared to 14,000 during 2013–2014.

Canada goose nest densities on islands and local breeding populations have declined at Rice Lake WMA over the past 25 years. Multiple factors could have contributed to these apparent declines. Although goose hunting is not permitted at Rice Lake WMA, statewide Canada goose harvest during 2013–2014 (60,000) was nearly triple the harvest rate during 1989–1991 (22,000; Iowa DNR 2015). Liberalization of Canada goose harvest regulations throughout the Mississippi Flyway may have reduced the number of breeding pairs at Rice Lake WMA. Another potential cause may be changes

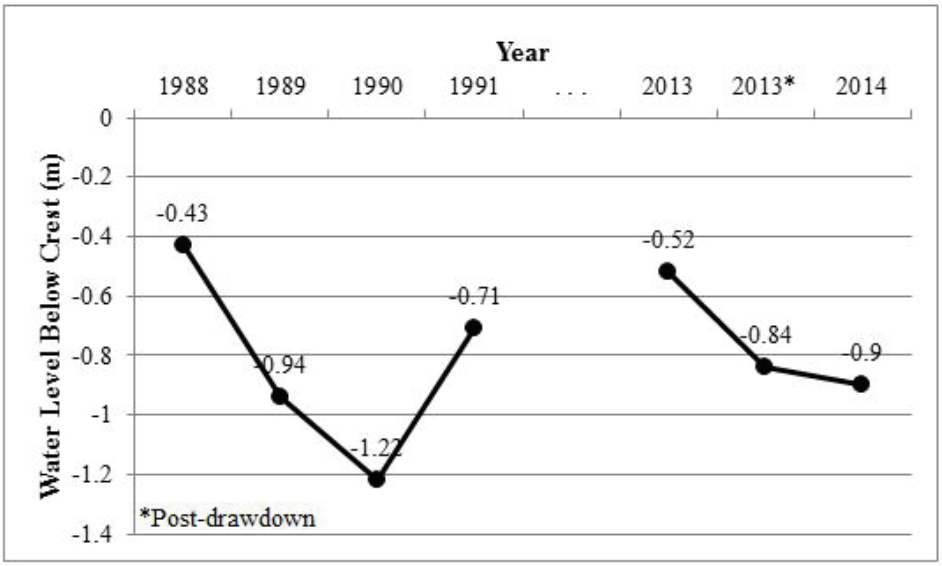

Figure 1. Rice Lake water levels (m) relative to crest during natural drought (1989–1991; Zenner and LaGrange [1998*b*]) and during an Iowa Department of Natural Resource-initiated drawdown (2013–2014). Water levels pre-drawdown and post-drawdown are shown for 2013. Post-drawdown water level was averaged from weekly measurements taken by the Iowa Department of Natural Resources in April and May, 2013–2014.

Table 1. Giant Canada goose production and nest fates at Rice Lake Wildlife Management Area, Iowa during 1989–1991 and 2013–2014.

	Year	Hatched Nests	Initiated Nests	% Hatched	% Depredated	% Abandoned
Rice Lake	1989[Δ]	28	52	54	12	34
	1990[Δ]	81	140	58	11	31
	1991[Δ]	61	150	40	0	60
	2013[†]	13	49	27	40	33
	2014[†]	12	32	38	53	9
Joice Slough	2013[‡]	6	46	13	78	9
	2014[‡]	30	55	55	38	7

[Δ]Data from four Rice Lake islands; originally published by Zenner and LaGrange (1998*b*).
[†]Data from four Rice Lake islands.
[‡]Data from six Joice Slough islands.

to the available nesting sites. In the late 1980s, geese could use nest structures and muskrat houses as alternative nesting sites, neither of which have existed at Rice Lake WMA in recent years. Islands are the only nest sites that currently offer protection from predators; and ecological succession and a lack of habitat management has resulted in more shrubs and trees on these islands (G. G. Zenner, personal communication). Considering the territorial nature of nesting geese, the availability of nest sites is limited by island size (Collias and Jahn 1959,Vermeer 1970, Ewaschuk and Boag 1972, Cooper 1978). Also, nesting geese prefer to use areas with a clear field of vision (Hanson 1997) and typically select islands free of dense vegetation (Kaminski and Prince 1977). It may be that the altered nest site conditions have made these islands less attractive to nesting geese. Nest densities also may have been unnaturally high during 1989–1991 following the reintroduction of the species at this site.

With only two years of data, we cannot make inferences about the trends of nest success at Rice Lake, especially considering the variable habitat conditions created by the renovation activity. Our nest success rates were generally lower (13–55%) than rates reported by other studies of island-nesting Canada geese. Klopman (1958) reported nest success rates of 61% and 35% in Manitoba, Canada. Studies conducted in southeastern Alberta, Canada, reported rates of 27% and 80% (Vermeer 1970), 27–69% (Ewaschuk and Boag 1972), and 43–59% (Giroux 1981). Cline et al. (2004) reported rates of 50% in northeastern Illinois, and, of course, Zenner and LaGrange (1998*b*) reported rates ranging from 40–58% in north-central Iowa.

We can only speculate that the drought conditions at Rice Lake WMA may have had an impact on the accessibility of islands by terrestrial predators. Nest predation rates were considerably higher during our study than during Zenner and LaGrange (1998*b*). We did not find a strong correlation between water levels and depredation rates. However, this result could be due to the possibility that some nests were abandoned prior to being destroyed by predators. Statewide harvest rates for coyote and raccoon have increased threefold over the past 25 years reflecting an increase in these predator populations. A more abundant predator community on the landscape indicates an increase in nest predation pressure.

Rice Lake's renovation project will improve water quality, aquatic vegetation abundance and diversity, fisheries and wildlife habitat, and recreational opportunities. However, our study suggested that the timing of renovation activity may have negative effects on Canada goose nest success. Perhaps the negative effects of the drawdown would be avoided if water levels were lowered earlier, potentially providing a more favorable vegetation response, or later to accommodate nesting waterfowl. Ultimately, it would depend on the management objectives for the drawdown. If improved Canada goose production were desired, it may also be beneficial to implement predator management to reduce nest predation events.

We thank P. Bartelt, J. Godwin, S. Handrigan, and O. Jones for their efforts in nest monitoring, the Iowa DNR for providing field housing, and J. Morris for access to his Jon boat. Partial funding for this project was provided through the Iowa Department of Natural Resources Fish and Wildlife

Trust Fund Contract CRWB0046–8340–WSUCH and Cooperative Agreement Number G12AC20381 from the United States Geological Survey. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.—*Brenna N. Ness[1,4], Robert W. Klaver[2], and Guy G. Zenner[3]. [1]Delaware Wild Lands, P.O. Box 505, Odessa, Delaware 19730, USA, [2]U.S. Geological Survey, Iowa Cooperative Fish and Wildlife Research Unit, 339 Science Hall II, Iowa State University, Ames, Iowa 50011, USA, [3]Iowa Department of Natural Resources, 1203 N. Shore Drive, Clear Lake, Iowa 50428, USA; Corresponding author email address: brennatowery@gmail.com.*

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Submitted 1 Feb 2017. Accepted 19 May 2017. Associate editor was Mark Vrtiska.