BIRDS

LESSER SCAUP AND RACCOONS: ARE THERE LINKS IN SOUTHWESTERN MANITOBA?

Gord Hammell

P.O. Box 37, Erickson, MB, R0J 0P0; E-mail: <hammell@inetlinkwireless.ca>

ABSTRACT

Raccoons (*Procyon lotor*) invaded the southern prairie provinces of Canada during the mid-1990s and became a significant predator of waterfowl nests. Nest predation by this novel predator may alter the reproductive success, and thereby the population size of waterfowl like the lesser scaup (*Aythya affinis*). However, it is difficult to evaluate the effects of raccoon predation relative to other factors that affect scaup populations. To investigate possible links between raccoons and lesser scaup, a species with declining populations, I examined results from studies conducted in southwestern Manitoba before (1950's) and after (1970's) the arrival of the raccoon. Specifically, I attempted to detect possible changes in scaup breeding population size, reproductive success, and hatching chronology that might be related to the arrival of raccoons. I hypothesized that the post-raccoon period would show: (a) decreasing local scaup breeding populations due to lower recruitment as a result of decreased nest success and female survival and (b) a shift in the mean hatching date to later in the season because of increased nest losses and more renesting attempts by female scaup. Local breeding populations appeared unchanged before and after raccoon arrival, providing no strong evidence of an impact on numbers of adult birds. The extent of change to reproductive success was uncertain given available data. However, there was a detectable shift in hatching chronology to later dates in years with wetter summers. It is possible that the shift in hatching chronology could be related to raccoon predation of scaup nests and changes in renesting rates among time periods, but it is impossible to say for sure given the available data. Nevertheless, such a shift may have been detrimental to local populations over the years, as later-hatched ducklings have a lower probability of recruitment into the breeding population.

INTRODUCTION

Lesser scaup (*Aythya affinis*) are medium-sized diving ducks that breed in the boreal forests and parklands from Alaska to Manitoba.[1] In breeding plumage, males are black and white and females are dark chocolate brown with a white face patch (Fig. 1, see inside front cover, bottom). Combined North American breeding populations of lesser scaup and similar-looking greater scaup (*A. marila*) have been declining from highs in the 1970s of 5–7 million birds to lows of 3–4 million in the 2000s (Fig. 2).[2] Lesser scaup comprise ~90% of the combined population;[1] most of the decline has been attributed to this species, especially within the Canadian western boreal forest, where most of these birds breed.[3] Lesser scaup (but not greater scaup) breed in south-western Manitoba parkland, and

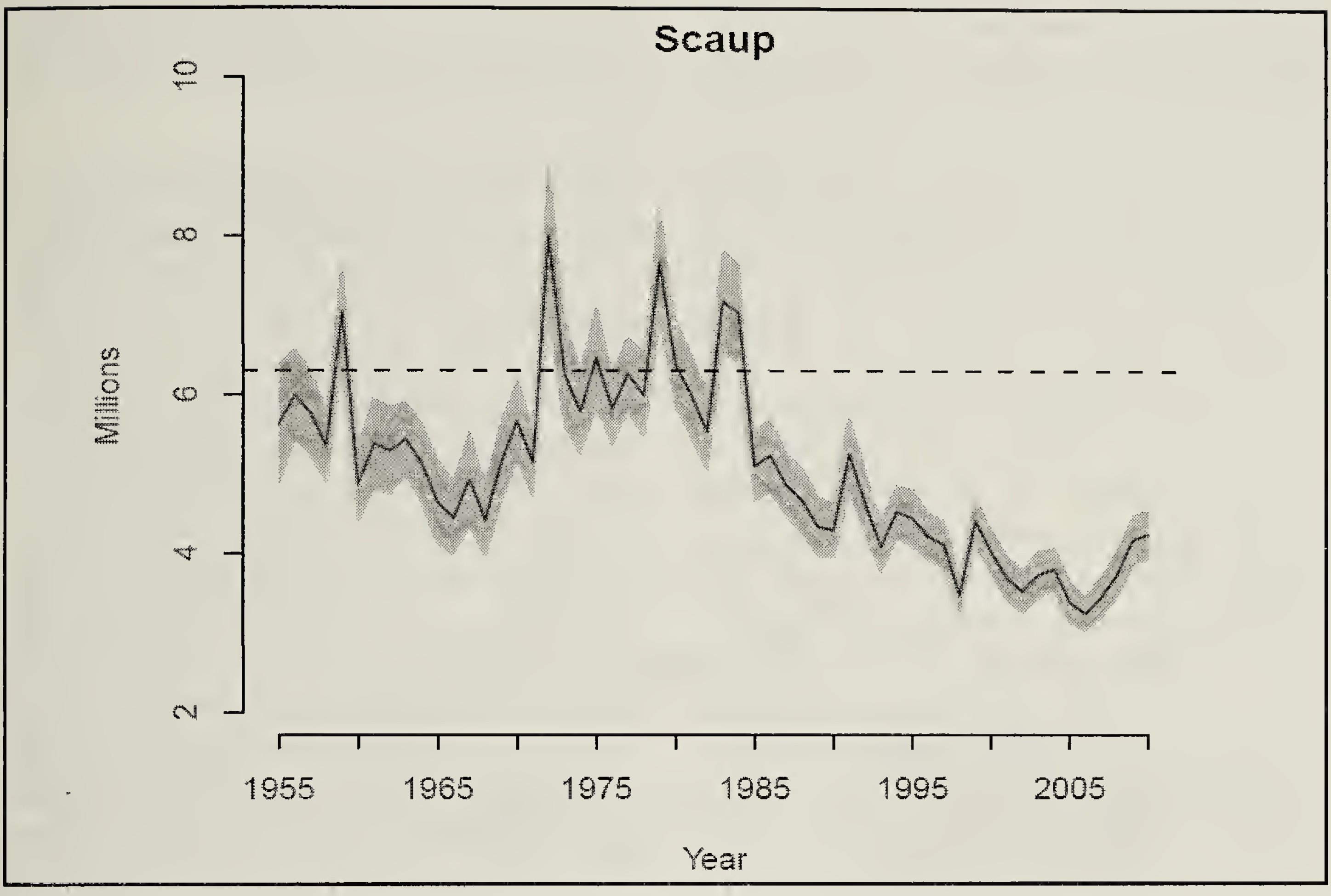

Figure 2. Breeding population estimates, 95% confidence intervals, and North American Waterfowl Plan goal (dashed line) for scaup (lesser and greater) in the traditional survey area (strata 1–18, 20–50, 75–77).

long-term but less consistent declines in breeding pairs have also been noted there.[3,4] Several hypotheses have been presented to explain declining lesser scaup (hereafter scaup) populations, including changes to food resources in wintering and migration habitats,[5-7] chemical contaminant exposure,[1,8-11] climate changes affecting boreal forest wetlands,[3] lower female survival,[3,12] and fewer immature birds relative to adults in human harvests (declining age ratio).[3] However, no clear explanation for the decline has been determined. Declining age ratios in the harvest are suggestive of reduced recruitment, and contributing factors could be any combination of reduced breeding propensity, reduced clutch size and renesting rates among hens, or decreased nest and/or juvenile survival.[3] Reduced nest, juvenile, and female survival have been suggested as proximate causes of decline in local scaup populations in south-western Manitoba and in the boreal forest of the Northwest Territories.[4,13] The major factor responsible for waterfowl nest failure and female and duckling mortality on the breeding grounds is predation,[1,14-16] so predation may be an important factor (but not necessarily the only factor) in explaining reduced recruitment. Therefore, changes to the local predator community (size or composition) might contribute to changes at the local scaup population level.[17,18]

The parkland area of southern Manitoba experienced a change to the predator community with the invasion of the raccoon (*Procyon lotor*) during the mid 1900s.[19] Raccoons have the potential to be a significant predator of scaup nests, but not females,[20] because they search for prey in the upland and emergent vegetation zones adjacent to ponds,[21,22] where most scaup nests are found.[23-27] Previous studies have reported that raccoons are indeed a major predator of scaup nests in south-western Manitoba.[23,28] In this area, more than 50% of scaup nest over water (nest surrounded by water), and more of these nests are successful than are dry-land nests.[23,27] Over-water nests, which may be isolated from dry-land predators for some or all of the incubation period, presumably would be more vulnerable to raccoons because of their nest-searching behaviour. Thus, the arrival of raccoons may have resulted in increased nest losses, reduced productivity and reduced juvenile recruitment. Also, if initial nests are destroyed, some scaup do attempt second nests (renests) depending on female age and habitat conditions.[28] This increased nesting effort resulting from increased initial nest destruction can lead to greater nest-site exposure to predators (e.g., fox [*Vulpes vulpes*] and mink [*Mustela vison*]) and increased female mortality.[14, ,29] Scaup exhibit natal philopatry and breeding-site fidelity,[1,28] so reduced juvenile recruitment and increased female nest-site mortality might result in a smaller local breeding population. Long-term studies of a different species, the canvasback (*A. valisineria*), in southern Manitoba have shown that with increasing raccoon numbers, nest losses increased and productivity decreased.[30] The extent of canvasback renesting was thought to be closely related to predation. Consequently, for scaup I hypothesized that the arrival of raccoons as a novel predator in southern Manitoba affected scaup populations at the local level. Based on this hypothesis, I predicted: (a) a decrease in the size of the breeding population over time due to lower juvenile recruitment as a result of decreased nest success and female survival, and (b) a shift in mean hatching date to later in the season because of increased nest losses and more renesting attempts by female scaup. Importantly, these predictions are not unique to the novel predator hypothesis and could apply to any number of alternatives based on other factors affecting reproduction. However, there is still some merit in testing my predictions to determine whether any of them are substantiated.

The Consensus Report of the Second Scaup Workshop indicated several priority research topics, one of which was the establishment of retrospective analyses to examine patterns over time and space.[31] Analyses of existing data were considered the most immediate research need because results are critical for forming hypotheses, organizing research projects, and securing funding. With this priority in mind, and to evaluate the novel predator hypothesis, I conducted a retrospective analysis of existing scaup breeding pairs, productivity (broods per pair or nest success) and hatching chronology data from studies conducted in south-western Manitoba prior to the 1980s, which was prior to the decline of the continental scaup population. I focused primarily on the area of Erickson, Manitoba (50° 30' N, 99° 55' W). My main objective was to determine whether changes in reproductive parameters occurred after the arrival of the raccoon. Erickson is well-suited to this analysis because several historical studies cover appropriate time periods (Rogers study: 1957–1960;[24,32,33,] Hammell study: 1970–1972,[23] [and unpublished data]; and Afton study: 1977–80[28]). All three studies were conducted at the same locale, and the raccoon arrival time is known and occurred outside of a drought period, eliminating the severe confounding factor of drought on scaup populations and reproduction.[24] In addition, aerial photos and discussions with the local community suggested that agricultural impact (amount of cultivated, hayed, or pastured land) in the study area was similar across the different time periods, thereby controlling for major habitat change as a factor affecting the results. During the 10-year interval between the earlier studies (1960–1970), raccoons

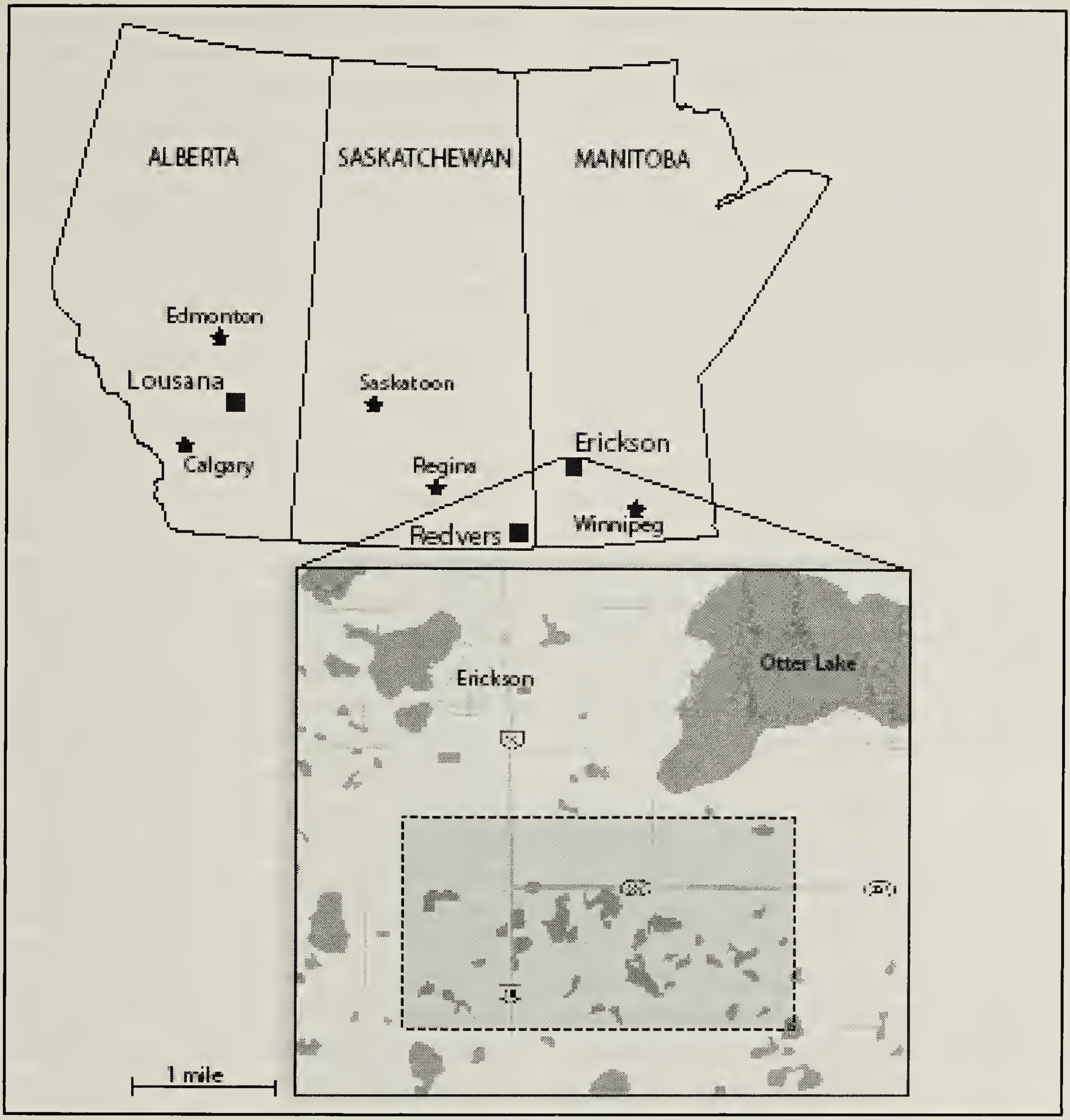

Figure 3. Field study sites (denoted by the small black squares). Shaded area within expanded map represents intensively studied area near Erickson, MB.

were noticed for the first time (mid-1960s) by local residents in the Erickson area. There was no evidence found that raccoons were a predator of scaup during the 1957–60 study (J.P. Rogers, pers. comm.). However, they were a major predator at Erickson by the early 1970s.[23]

METHODS

Study Area

The study area for all three time periods is situated in the parkland pothole region of south-western Manitoba (Fig. 3) and comprises 259 ha for the 1957–60 study, 680 ha for the 1970–72 study, and 777 ha for the 1977–80 study. The two former areas are situated entirely or mostly within the larger area. These block areas were most intensively studied, but additional data were collected from larger lakes and along roadside transects in the Erickson area of approximately 80 km (1957–60) and 71 km (1970–72). The topography is rolling with numerous ponds and lakes. The uplands are a mixture of lands sown to cereal and oilseed crops, hay, pasture, and native woodland. The area is well described in previous studies.[24, 27,28,34]

Field Methods

Scaup were counted weekly by investigators walking on the entire Rogers and Hammell block study areas. Estimates of the breeding lesser scaup population were derived from the average of the two or three counts of pairs seen during the pre-laying period (late May to mid-June). In all studies, scaup nests were located by observing females flying to nests and by conducting systematic foot searches around the margins of all ponds on the study area from early June to early August. Information collected at each site included vegetation characteristics, distances to water and dry land edge, number of eggs, estimated initiation date, and nest success.

Broods of scaup are relatively easily located on rearing ponds, usually swimming to open areas in the pond centre when disturbed.[23,28] For the Rogers and Hammell studies, broods were observed in the main study block and additional numbers were recorded on area lakes and along the roadside transects. Both authors estimated brood ages by juvenile plumage characteristics.[23,24,35,36] Hatching dates were determined by backdating from the brood observation date. For each brood, age class was estimated and a day-of-year hatch date (usually the mid-point of the age class) was assigned for the Hammell data. Rogers[24] conducted weekly surveys on his block area, and additional ones on local lakes and on the roadside just prior to the expected fledging date of the earliest hatched ducklings. Hammell conducted surveys every 3 to 4 days on the block area and weekly on the roadside transect throughout the entire brood period from late July to late September.[23] Afton provided no hatching chronology data.[28] Care was taken by investigators to use duckling number and age to ensure that sightings of individual broods were not duplicated. It was not possible to distinguish which broods were from initial nests and which were from re-nests for the earlier (unmarked bird) studies, but I assumed that later hatching broods were from renesting attempts.[25]

Local Populations and Nest Success

To compare changes in population densities for different sized study areas, I re-examined raw data (1970–72) for the Hammell study (data not available for the Afton study) and determined the number of scaup pairs on the same square mile (259 ha) used by Rogers. This resulted in total pair counts for 1970–72 on the 259-ha block area that were >75% of those numbers recorded on the larger 680-ha area. I also examined raw data from United States Fish and Wildlife Service (USFWS) annual waterfowl surveys for the Erickson area,[37] did regression analysis for the period 1955–80, and compared the results to those from the ground studies. Existing long-term population and productivity data from other authors were available for south-western Manitoba[38] and other Prairie-Parkland Region studies,[39,40] and were compared to Erickson data. To evaluate nest success at Erickson for the periods before and after the raccoon arrival, I examined and compared broods/pair data for the Rogers and Hammell studies and nest success data from Afton's marked bird study. I chose data for author-described non-drought years only (1957 and 1970–72, 1978–80) in an attempt to reduce drought-induced nest success biases,[24] which would most likely mask any raccoon effects. Again, additional support for this decision is provided by the long-term research conducted on canvasbacks in south-western Manitoba.[30] Here, the effect of the raccoon was most noticeable in wet years, and I assumed that a similar pattern might apply to scaup, as most scaup at Erickson nest over-water. Nonetheless, one might expect some raccoon effect in drought years; however, during drought periods, water levels recede drastically and usually all nests become exposed to predators (including those predators normally associated with dry uplands), potentially negating the specific effects of raccoons.

Hatching Chronology

Hammell estimated brood age by juvenile plumage characteristics developed for scaup.[36] Although Rogers aged scaup broods using criteria developed for juvenile redheads (*Athya americana*),[35] he applied an adjustment (6 days for each of the eight age classes) to allow for the fact that scaup reach the flight stage sooner than redheads (J.P. Rogers, pers. comm.). Calculations of possible results obtained using both methods for each age class revealed that different ages could be attributed to a given age class but that these differences were small, averaging less than 2 days (range: +1 to –4, Hammell age minus Rogers age) and depended on brood age at observation. Brood age at observation time is unknown for the Rogers data so the extent and direction of any bias is unclear. I assumed that this bias would not be significant. Consequently, I did not apply any corrections to Rogers' hatching date data and made the assumption that the aging criteria used in the two time periods were similar and the data were comparable. Mean hatch date was not provided for the earlier Erickson data, so in order to make meaningful comparisons, day-of-year of 65% brood hatch (65%HD) was selected as a date for reference.

To conservatively account for possible year effects at Erickson (late versus early, wet versus dry) on first clutch initiation dates (CIDs) and hence the observed 65%HD, I considered author descriptions of spring and summer water conditions, dates of first laying attempts, and meteorological data[41] from Brandon, MB, 63 km south (for 1957–60) and Minnedosa, MB, 25 km south (for 1970–72). Weather data for Minnedosa are incomplete for the years 1957–60. Again, I looked for years with similar climatic conditions and avoided drought years in the analysis because their datasets are very small and drought seriously affects scaup reproduction at Erickson.[24] In addition, to further account for possible differing clutch initiation chronologies, I subtracted from the observed difference in 65%HD the maximum difference (6 days) in mean CIDs for first nests between years recorded for the same area from 1977 to 1980.[28] Recorded CID means could not be compared for the two earlier studies, since these data contained unknown degrees of renesting influence.

RESULTS

Breeding Population, Nest Success, and Productivity

Erickson

Initial analysis produced equivocal results for Erickson population trends for the period before and after raccoon arrival. Scaup breeding populations were lower after the raccoon arrived, but this decrease appears to be drought related and occurred between 1958 and 1959, before the time of arrival (Table 1). Admittedly, the available data are limited and lacking for the years 1961–69, but they do suggest a similar population level of ~7 pairs/km^2 immediately before (1960) and after (1970–72) the raccoon arrival, which occurred in the mid-1960s. This result does not support the expectation of an observed breeding population decrease after raccoon arrival. However, total scaup counted on USFWS annual waterfowl and habitat surveys[37] near Erickson (1955–80; stratum 40: transect 4, segment 4; transect 6, segments 3 and 4) showed a downward trend from 1955 to 1980 (Fig. 4, simple linear regression, $r^2 = 0.199$, 24 df, $p = 0.02$). These data contained very high counts from 1958–62 (the drought years in the Prairie-Parkland Region),[42] and it is suspected that birds from dried-out areas of the prairies immigrated to the relatively wetter parkland areas during this period, especially areas like Erickson with large permanent lakes (some of which are covered by the USFWS survey segments) and that this influx bolstered numbers on the survey segments. This movement of waterfowl to wetter areas in time of drought is well documented,[43-45] and a previous study recorded a similar increase in scaup numbers at Minnedosa during the same drought period.[42] By excluding the drought years from the USFWS data for Erickson, no significant trend in population numbers occurred for the period encompassing the years before and after the raccoon arrival (Fig. 5, $r^2 = 0.003$, 19 df, $p = 0.8$); thus, results from both sources for Erickson local population data concur. Therefore, the expectation that the Erickson population would decline after the raccoon arrival is not supported by the available data.

Erickson scaup reproductive success (nest success and productivity) data show that great variability occurred in years before and also in years after the arrival of the raccoon (Table 1). Reproductive success, evaluated for non-drought years (see METHODS), was high and similar in 1957 and 1971 and lower in 1970,'72,'78,'79, and '80; that is, lower

Table 1. Estimated breeding population (pairs/km²)[a] and production (broods/pair or percent nest success) of lesser scaup at Erickson, MB, 1957–1960, 1970–72, and 1977–80 (see text for data sources). Numbers in parentheses are sample sizes. Raccoons arrived during the mid-1960s.

Year	Population	Production
1957	21	0.50 (27/54)
1958	25	0.05 (3/65)
1959	9	0.08 (2/24)[b]
1960	7	0.18 (3/17)[b]
1970	7	0.23 (5/22)
1971	6	0.58 (11/19)
1972	7	0.13 (3/23)
1977	n/a	18% (17)[c]
1978	n/a	29% (24)[c]
1979	n/a	40% (47)[c]
1980	n/a	27% (41)[c]

[a]On Rogers' block study area (2.6 km²)[24]
[b]Calculated from the number of ducklings/average brood size
[c]Number of marked birds in sample

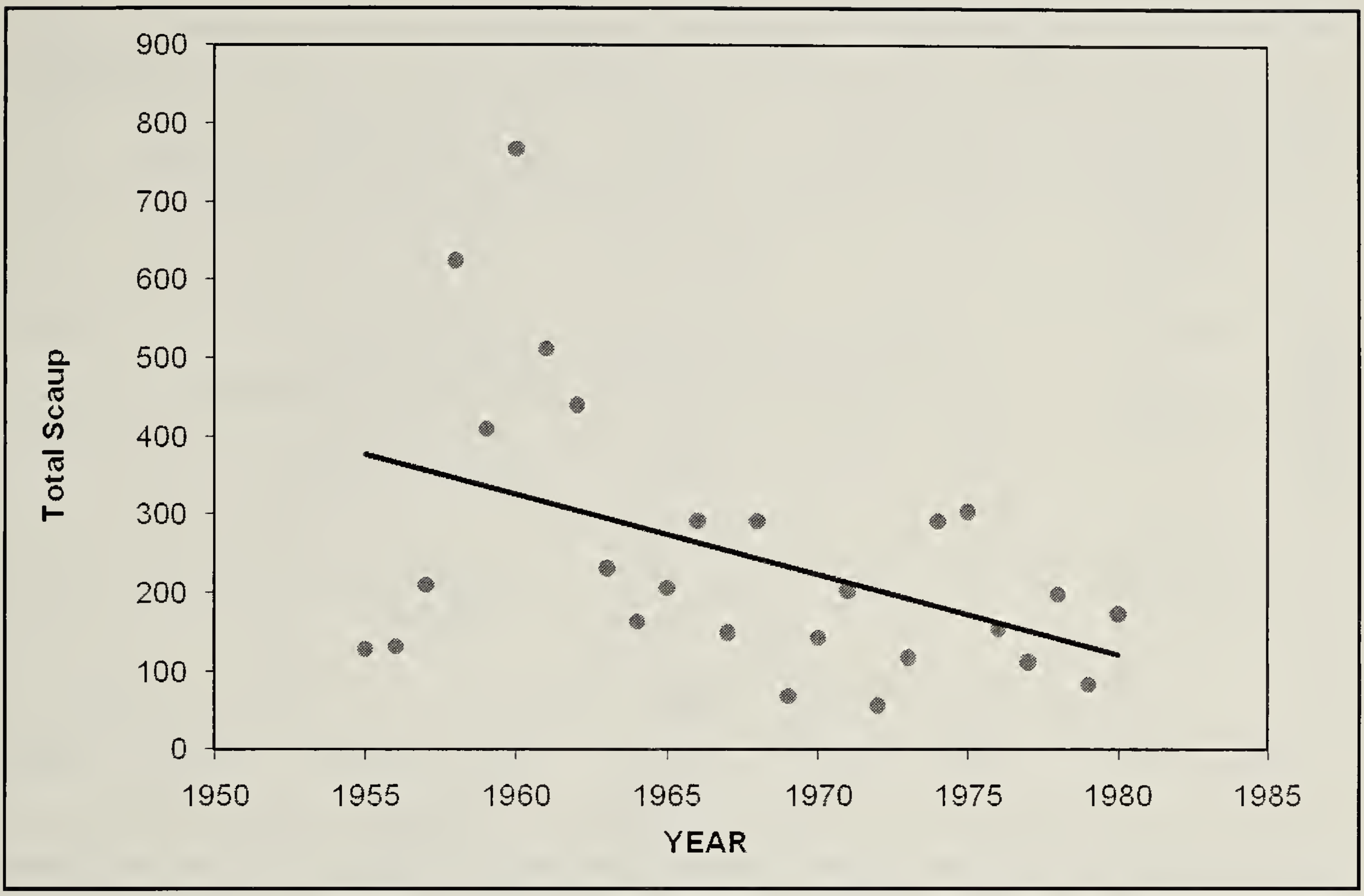

Figure 4. Total scaup (lesser and greater) counted on USFWS annual waterfowl surveys near Erickson, MB, 1955–1980. Raccoons arrived during the mid-1960s.

in five of these six years after the arrival. Therefore, these results (for most years) support the expectation that reproductive success would decline after the arrival of raccoons.

Other Locales

In addition to the Erickson local data, there is some long-term evidence from transects established in a 10,600 km^2 area of south-western Manitoba[36] (Erickson area included) that supports the view that scaup breeding population densities had not changed after the appearance of the raccoon. Trauger and Stoudt summarized the data available from these transects and found that scaup pair densities showed no change from the late 1940s to the late 1970s, despite habitat changes and the arrival of the raccoon in the period ~1955–65.[42] Nest success and productivity data for scaup were not provided. In contrast, in other parkland habitats (Fig. 3) at Redvers, Saskatchewan (49° 34' N, 101° 42' W),[39] and Lousana, Alberta (52° 06' N, 113° 11' W),[40] scaup populations and nest success did decrease after the arrival of the raccoon. This arrival occurred in the late 1950's to early 1960's, a little earlier than at Erickson; however, as in south-western Manitoba, raccoon densities were not recorded at these locales, so it is not possible to compare their relative abundance. After the drought period and into the late 1970's,[42] scaup breeding populations remained lower (50% lower at Redvers, 33% at Lousana), and productivity (broods/pair) was lower at Redvers but showed recovery at Lousana.[39,40]

Hatching Chronology

When comparing April/May pond conditions, 1957 and 1970–72 were wet and similar, and when comparing May to July water regimes, 1970 and 1971 were similar, and 1972 less so to 1957 (Table 2).The years 1957 and 1970–72 with flooded emergent zones were markedly dissimilar to the years 1958–60, which had drier spring conditions. Mean maximum

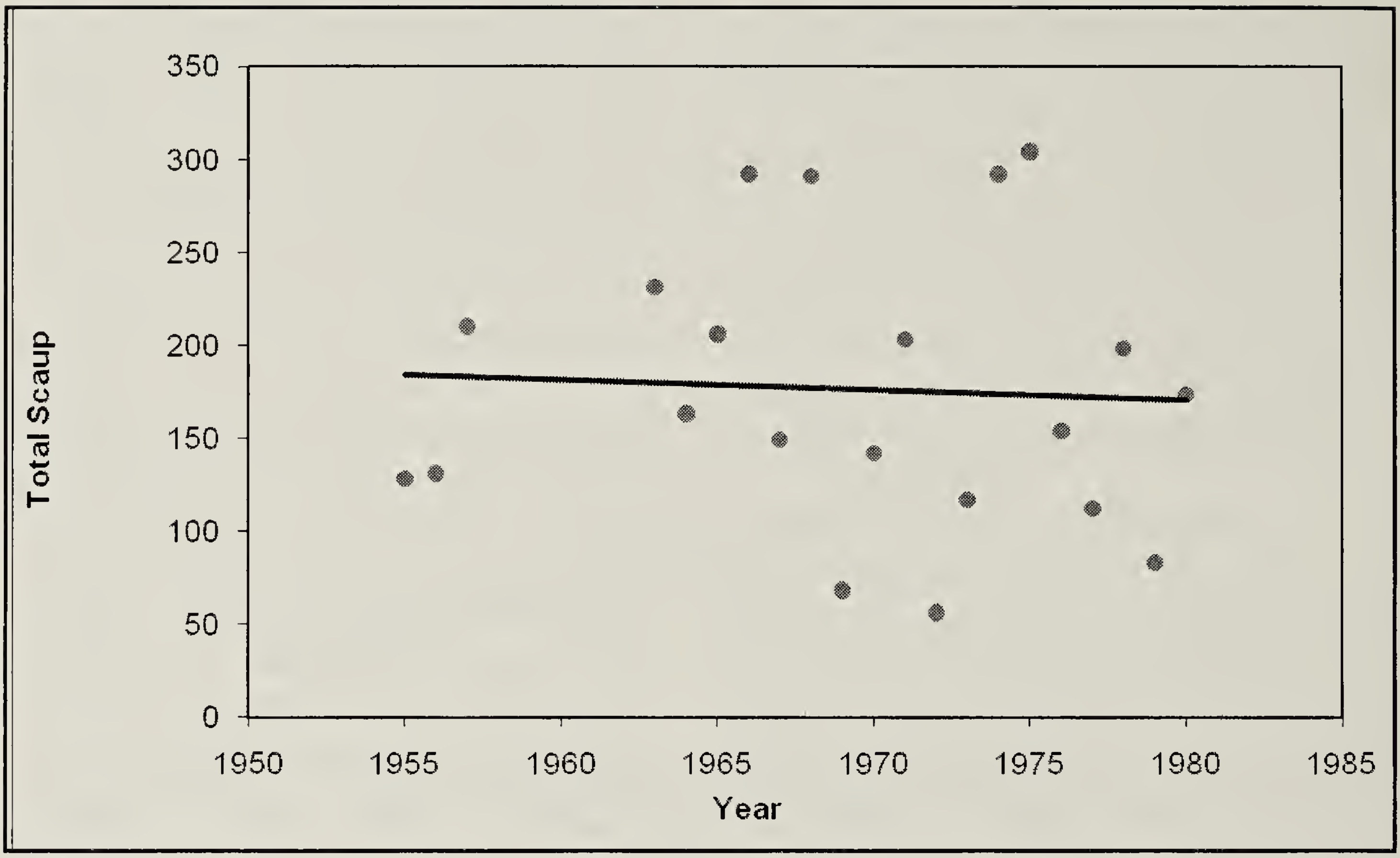

Figure 5. Total scaup (lesser and greater) counted on USFWS annual waterfowl surveys near Erickson, MB, 1955–1957 and 1963–1980 (drought years have been excluded). Raccoons arrived during the mid-1960s.

temperatures for April and May support the observations of the authors that spring 1970 was cooler and later than the other years and that springs 1971, 1972, and 1957 had similar temperature conditions (Table 2). Based on these available data on water regimes and nesting habitat quantity and quality for the years 1957–60 and 1970–72, I restricted my hatching chronology comparison of the two time periods to 1957 and 1970–72 (See METHODS). All of these years presented very good habitat conditions in the spring. Also, all first CIDs are close despite years having early and late springs, except for 1959, the very dry year. These dates support the assumption that at Erickson, all years (except 1959) had similar CIDs. In fact, recent research suggests that scaup are quite inflexible in timing of clutch initiation, resulting in low annual and site variation for this parameter.[46]

Hatching chronology shifted to later dates than those in 1957 in years with severe predation (1958, 1959, 1960) and in all years after the raccoon arrived (Tables 3 & 4). The estimated 65%HDs for 1970–72 (after raccoon arrival) are from 1 to almost 3 weeks later than those for 1957; i.e.,16, 18, and 7 days later, respectively (Table 4). Adjusted estimated hatching date differences (to account for possible year effects: see METHODS) are 10, 12, and 1 day(s). These results for 1970, 1971, and, to a much lesser extent, 1972 support the hypothesis that a shift in hatching chronology would be expected after the arrival of the raccoon at Erickson.

DISCUSSION

Breeding Population, Nest success, and Productivity

The prediction that breeding populations of scaup would decrease after the arrival of the raccoon was not supported by the data available for south-western Manitoba. Interestingly, these results for scaup are similar to those observed for canvasbacks near Erickson, where breeding pair densities of this over-water nester also did not differ after

Table 2. Habitat and meteorological conditions at Erickson, MB, 1957–60[a] and 1970–72[b].

Year	Spring Conditions	Spring to Summer Pond Water Levels	Emergent Zone[c]	April/May Mean Max.	Temp. C°	First Observed Nest Initiation Date[d]
1957	very wet	high and stable	all flooded to mid-July	8.4	19.2	10 June (10)
1958	dry	moderate and falling very rapidly	sedge zone dry by June	12.2	M	12 June (18)
1959	very dry	very low and falling very rapidly	mudflats beyond emergent zone	9.8	15.5	19 June (13)
1960	dry	moderate and falling	sedge zone hayed and grazed, dry by June	6.8	18.7	11 June (5)
1970	wet	high and falling slowly	flooded to mid-July	3.5	13.8	14 June (20)
1971	wet	high and rising	flooded to September	8.4	17.3	9 June (30)
1972	wet	high and falling	flooded in spring; sedge meadows dry mid-July	6.3	19.0	12 June (13)

[a]meteorological data from Brandon, MB
[b]meteorological data from Minnedosa, MB; M = data missing
[c]emergent zone comprises cattail *(Typha latifolia)*, bullrush *(Scirpus acutus)* and sedges *(Carex spp.)*
[d]sample size in parentheses

raccoon arrival, although it was believed that observed decreased productivity (broods/pair) could be attributed to the raccoon.[30] It is unclear what effect the presence of the raccoon had on this local scaup breeding population stability. A potentially larger population could have been depressed by pressure from this predator, through lower recruitment resulting from reduced nest success or productivity, to the observed 1970's levels. Alternatively, the raccoon could have been having no or minimal effect, and the resulting population size was due to other factors. Also, as expected, reproductive success data for Erickson suggest a decline in productivity in most years after raccoon arrival. However, the dataset prior to 1970 is limited to one non-drought-affected year, and scaup reproductive success after 1970 is highly variable even between wetter years. Given such scant comparative data, I am unable to say with any certainty that reproductive success did indeed change after the arrival of raccoons. A larger dataset from non-drought years prior to the mid-1960s might provide more clarity and confidence in the interpretation of the results. Such population and reproductive success results allow for few conclusions regarding possible effects of a novel predator at Erickson. However, they do suggest no obvious links between scaup breeding population size and the arrival of raccoons.

Table 3. Estimated time of hatching of lesser scaup broods near Erickson, MB. Data from 1957–60 from Rogers;[24] 1970–72 from Hammell[23] (and unpublished data). Raccoons arrived during the mid-1960s.

Year	July 1-7	July 8-14	July 15-21	July 22-28	July 29-Aug 4	Aug 5-11	Aug 12-18	Aug 19-25	Total
1957	6	27	38	18	7	2	8	3	109
1958	1	0	0	3	1	4	0	0	9
1959	0	0	0	0	0	1	3	0	4
1960	0	0	0	3	2	5	0	0	10
1970	0	1	4	7	15	10	6	0	43
1971	0	1	5	13	5	15	13	1	53
1972	1	2	7	8	1	3	0	0	22

In contrast, at other parkland areas (Redvers and Lousana) for a similar time frame, populations and nest success did decline and productivity was variable after raccoon arrival. Again, it is unclear what effect raccoons were having at these locales, since their arrival was coincident with severe drought and deteriorated habitat, but the authors concluded that the only condition affecting wide fluctuations in waterfowl breeding populations was drought and the size of the continental population, not variations in local production. More subtle effects (raccoon) were beyond the scope of their investigations. It is not known whether the novel predator hypothesis as proposed for Erickson scaup would be applicable to these other areas, and since any hypothesis applying to a wider spatial effect would need more data for evaluation than was available to me, further examination has not been attempted here. In summary, I am only able to say with certainty that between the late 1950's and the late 1970's and coincident with the arrival of raccoons, breeding populations of scaup appeared to remain stable in south-western Manitoba, contrary to expectations, but declined in south-eastern Saskatchewan (Redvers) and in south-central Alberta (Lousana).

Hatching Chronology

I restricted my hatching chronology comparison of the two time periods to 1957 and 1970–72 to control for year effects (see METHODS). Since the dataset is limited in years not suffering from drought before the arrival of the raccoon at Erickson (1957 only), there is the possibility that this year was an anomaly. I cannot substantiate the assumption that it was not. Also, there is a possibility of a bias in comparing observed chronologies resulting from different methods of aging broods (see METHODS). Given that this bias appears to be small and could increase or decrease observed differences in hatching chronologies depending on brood age at observation time, I assumed that both sets of data were comparable. Accordingly, caution is advised when considering the interpretations discussed here.

Despite applying additional year effect adjustments (total = –6 days) to the Erickson data, a shift in hatching

Table 4. Scaup hatching chronology data for the period before (1957–60) and after (1970–72) the arrival of raccoons[a] in Erickson, MB.

Year	% of broods hatched by day 202 (July 21)	Day of 65% brood hatch	
		Actual	Difference from 1957 value (days)
1957	65 (109)[b]	202	~
1958	11 (9)	>217-<223	n/a
1959	0 (4)	>224-<230	"
1960	0 (10)	>217-<223	"
1970	12 (43)	218	16 (10)[c]
1971	11 (53)	220	18 (12)
1972	45 (22)	209	7 (1)

[a]racoons arrived during mid-1960's
[b]no. of broods in sample
[c]adjusted difference from 1957 value

chronology of 10 and 12 days later than that observed in 1957 occurred for the two years (1970, 1971) with water regimes closest to those of 1957 (Table 4). In contrast, the adjusted estimate for 1972 indicates little change from 1957 despite heavy depredation losses in 1972. This result may have been caused by very little renesting effort and/or success of renests due to rapidly falling water levels during the summer (Hammell, unpubl. data). Over-water nests were isolated on drier ground and exposed to the full complement of predators, including those dryland predators not usually associated with over-water nest predation (pers. obs.) Very few broods hatched after 28 July 1972 compared to the two other years (Table 3), and therefore 65%HD occurred earlier.

The full clutch initiation adjustment could apply to 1970 as it was a late year (Table 2) and the first nesting attempt was later. A smaller clutch initiation adjustment (<6 days) may be more appropriate for 1971 and 1972 since these years appear to have had very similar spring temperatures to those of 1957. This reduced adjustment would produce a shift in hatching chronology to later dates for 1971 (>12 days) and for 1972 (>1 day). The years 1958–60 were drought-affected years and suffer from small datasets but do show delayed hatching chronology even without the raccoon being present. These results were thought to be due to gonadal inhibition of nesting effort and/or deteriorated spring nesting habitat leading to delayed CID and/or very low early-season nest success.[24] These Rogers study data suggest that a shift in scaup hatching chronology to later dates can also be expected in years with drought-induced deteriorated habitat.

The 1970–72 Erickson data suggest that a similar shift occurred in non-drought years as well, years when water levels were stable and adequate. This shift coincides with the arrival of the raccoon, a significant predator of scaup nests, and according to my hypothesis, one might expect such a shift to a later period after the arrival of the raccoon. The available data provide one explanation of the possible relationship between this predator and scaup hatching chronology. Prior to the appearance of the raccoon, over-water nests (representing ~60% of nests[4,23]) may have had an advantage through isolation from dryland, as most predation of scaup nests at that time was attributed to skunk (*Mephitis mephitis*;[24] J.P. Rogers, pers. comm.), a predator usually associated with dryland habitats.[20] In years with wet summers, over-water nests are more successful than dryland ones even with raccoons present[23,27] and may have been even more so prior to the 1960s. The arrival of a novel predator of over-water nests would be expected to have some new influence on these previously less vulnerable nests, possibly causing increased losses and subsequent increased renesting. These new nests, if successful, would hatch later, resulting in an advanced hatching chronology.

Undoubtedly, other factors responsible for changes in scaup hatching chronology exist and may be many (e.g., female age and breeding condition affecting CID[5-7,28] and factors affecting nest success, including propensity to renest and predator community, their behaviour, and prey[13]) and may co-vary and make difficult any attempt to determine the importance of each. My analysis does not control for the possibility of these other factors influencing the results, although I have tried to control for year effects. A causal relationship between raccoons and hatching chronology could exist at Erickson, but that relationship has not been proven here. I have only provided indirect evidence of a link to raccoons during wet years. Further research into possible predator-related links to changes in hatching chronology involving scaup or other avian species might help determine the extent of this effect.

Water conditions are variable in the parklands of Canada, and years with good production potential for scaup are limited, so it is imperative that any additional downward pressure on that reproductive potential be avoided in years with favourable breeding habitat if populations are to be maintained. Later hatching dates during wet years, as observed at Erickson, could be such a pressure, and later hatching dates for scaup and other *Aythya* species have been associated with reduced size of ducklings and adults, and a lower probability of recruitment to the breeding population.[47,48] Those authors believe that late-hatched juveniles have a smaller probability of recruitment because they may have less time to acquire the resources necessary to mitigate the costs of migration. Females staying with these later broods spend little time feeding[49] and have shorter times to regain body condition in preparation for migration.[50] In addition, egg-laying and incubation are dangerous periods for female scaup (increased exposure to predation), and female annual survival appears to be lower in years when breeding propensity is high; i.e., there is a survival cost in attempting to reproduce.[29] Therefore, if the observed shift in hatching chronology was the result of increased renesting, then by doing so, females may experience increased exposure to predators, possibly resulting in increased female mortality. Furthermore, total juvenile production would be reduced if renests (which generally have fewer eggs per nest than initial nests) comprised a greater proportion of total successful nests. Accordingly, over the years, the later hatching chronology could prove detrimental to the local Erickson population and may have contributed to the regional decline observed today[4] (Hammell, unpublished data).

Acknowledgements

Dr. E. D. Bailey, and the other members of my committee, Drs. R. J. Brooks, D.

H. Pengelly, and R. E. Walker, offered guidance and advice. Their assistance during my student years was much appreciated. I thank the landowners and others around Erickson for their hospitality and permission to access their lands. I also thank those who provided help in the field, especially G. Curry, R. Beaver, and J. Jefferson. Funds for the 1970s study were provided by the National Research Council of Canada, Delta Waterfowl Research Station, University of Guelph, and Canadian National Sportsman's Show. More recently, I acknowledge the help provided by J. Fisher (Delta Waterfowl), I. Glass (Ducks Unlimited librarian, Oak Hammock Marsh, MB) and the library staff at Brandon University (Brandon, MB) for allowing me to conduct a literature review using their resources. Thanks to S. Frith for technical assistance with maps and figures. A. Rogosin, M. Hammell, *Blue Jay* editors, and an anonymous reviewer provided helpful comments to improve earlier drafts of this manuscript. Most importantly, I thank Marg for being there for me throughout the years.

1. Austin JE, Custer CM, Afton AD (1998) Lesser scaup (*Aythya affinis*). In: Poole AA, Gill F (eds) The Birds of North America, Number 338. The American Ornithologists' Union, Washington, D.C.

2. Zimpher NL, Rhodes WE, Silverman ED, Zimmerman GS, Koneff MD (2010) Trends in Duck Breeding Populations, 1955–2010. United States Fish and Wildlife Service, Laurel, MD.

3. Afton AD, Anderson MG (2001) Declining scaup populations: a retrospective analysis of long-term population and harvest survey data. *Journal of Wildlife Management* 65:781-796.

4. Koons DN, Rotella JJ (2003b) Have lesser scaup, *Aythya affinis,* reproductive rates declined in parkland Manitoba? *Canadian Field Naturalist* 117(4):582-588.

5. Anteau MJ, Afton AD (2006) Diet shifts of lesser scaup are consistent with the spring condition hypothesis. *Canadian Journal of Zoology* 84:779-786.

6. Anteau MJ, Afton AD (2008) Diets of Lesser Scaup during spring migration throughout the Upper-Midwest are consistent with the Spring Condition Hypothesis. *Waterbirds* 31(1):97-106.

7. Anteau MJ, Afton AD (2009) Lipid reserves of lesser scaup (*Aythya affinis*) migrating across a large landscape are consistent with the "spring condition" hypothesis. *The Auk* 126(4):873-883.

8. Custer CM, Custer TW, Anteau MJ, Afton AD, Wooton DE (2003) Trace elements in lesser scaup (*Aythya affinis)* from the Mississippi flyway. *Ecotoxicology* 12:47-5

9. Anteau MJ, Afton AD, Custer CM, Custer TW (2007) Relationships of cadmium, mercury, and selenium with nutrient reserves of female lesser scaup (*Aythya affinis*) during winter and spring migration. *Environmental Toxicology and Chemistry* 26:515-520.

10. DeVink JM, Clark RG, Slattery SM, Scheuhammer TM (2008a) Effects of dietary selenium on reproduction and body mass of captive lesser scaup. *Environmental Toxicology and Chemistry* 27:471-477.

11. DeVink JM, Clark RG, Slattery SM, Wayland M (2008b) Is selenium affecting body condition and reproduction in boreal breeding scaup, scoters, and ring-necked ducks? *Environmental Pollution* 152:116-122.

12. Koons DN, Rotella JJ, Willey DW, Taper M, Clark RG, Slattery S, Brook RW, Corcoran RW, Lovvorn JR (2006) Lesser Scaup population dynamics: What can be learned from available data? *Avian Conservation and Ecology- Ecologie et conservation des oiseaux* 1(3):6. Available at <http://www.ace-eco.org/vol1/iss3/art6/>

13. Brook RW (2002). Breeding ecology and local population dynamics of Lesser Scaup (*Aythya affinis*) in boreal forest of western Canada. M.Sc. Thesis, University of Saskatchewan, Saskatoon.

14. Johnson DH, Sargeant AB (1977). Impact of red fox predation on the sex ratio of prairie mallards. United States Fish and Wildlife Service Wildlife Research Report 6. Northern Prairie Wildlife Research Center, Jamestown, ND.

15. Klett AT, Shaffer TL, Johnson DH (1988) Duck nest success in the prairie pothole region. *Journal of Wildlife Management* 52:431-440.

16. Greenwood RJ, Sargeant AB, Johnson DH, Cowardin LM, Shaffer TL (1995) Factors associated with duck nest success in the prairie pothole region of Canada. *Wildlife Monographs* No. 128.

17. Johnson DH, Sargeant AB, Greenwood RJ (1989) Importance of individual species of predators on nesting success of ducks in the Canadian prairie pothole region. *Canadian Journal of Zoology* 67:291-297.

18. Savoda MA, Sargeant AB, Grier JW (1995) Differential effects of coyotes and red foxes on duck nest success. *Journal of Wildlife Management* 59:1-9.

19. Lynch GW (1971) Raccoons increasing in Manitoba. *Journal of Mammalogy* 52: 621-622.

20. Sargeant AB, Savoda MA, Greenwood RJ (1998) Interpreting evidence of depredation of duck nests in the prairie pothole region. United States Geological Survey, Northern Prairie Wildlife Research Center, Jamestown, ND and Ducks Unlimited, Inc., Memphis, TN.

21. Fritzell EK (1978) Habitat use by prairie raccoons during the waterfowl breeding season. *Journal of Wildlife Management* 42:118-127.

22. Greenwood RJ (1981) Foods of prairie raccoons during the waterfowl nesting season. *Journal of Wildlife Management* 45:754-760.

23. Hammell GS (1973) The ecology of the lesser scaup (*Aythya affinis* Eyton) in southwestern Manitoba. M.S. Thesis, University of Guelph, Guelph, ON

24. Rogers JP (1964) Effect of drought on reproduction of the Lesser Scaup. *Journal of Wildlife Management* 28:213-222.

25. Keith LB (1961) A study of waterfowl ecology on small impoundments in southeastern Alberta. *Wildlife Monographs* 6

26. Hines JE (1977) Nesting and brood ecology of lesser scaup at Waterhen Marsh, Saskatchewan. *Canadian Field Naturalist* 91:248-255.

27. Koons DN, Rotella JJ (2003a) Comparative nesting success of sympatric lesser scaup and ring-necked ducks. *Journal of Field Ornithology* 74:222-229.

28. Afton AD (1984) Influence of age and time on reproductive performance of female lesser scaup. *Auk* 101:255-265.

29. Rotella JJ, Clark RG, Afton AD (2003) Survival of female lesser scaup: effects of body size, age, and reproductive effort. *Condor* 105: 336-347.

30. Stoudt JH (1982) Habitat use and productivity of Canvasbacks in southwestern Manitoba, 1961–72. United States Fish and Wildlife Service Special Scientific Report Wildlife No 248. Washington, DC

31. Austin JE, Anteau MJ, Barclay JS, Boomer GS, Rohwer FC, Slattery SM (2006) Declining scaup populations: reassessment of the issues, hypotheses, and research directions. Consensus report from the Second Scaup Workshop, 17-19 January 2006, Bismarck, ND

32. Rogers JP (1959) Low water and lesser scaup reproduction near Erickson, Manitoba. *Transactions North American Wildlife Conference* 24: 216-223.

33. Rogers JP (1962) The ecological effects of drought on reproduction of the Lesser Scaup, *Aythya affinis* (Eyton). Ph.D. dissertation, University of Missouri, Columbia, MO

34. Sunde LA, Barica J (1975) Geography and lake morphometry of the aquatic study area in the Erickson-Elphinstone district of southwestern Manitoba. Environment Canada Fisheries Marine Service Technical Report No. 510, Winnipeg, MB.

35. Weller MW (1957) Growth, weights, and plumages of the redhead, *Aythya americana*. *Wilson Bulletin* 69(1):5-38.

36. Gollop JB, Marshall WH (1954) A guide for aging duck broods in the field. Mississippi Flyway Council Technical Section.

37. United States Fish and Wildlife Service. Waterfowl Breeding Populations and Habitat Survey Segment Count Data. Available at <http://mbdcapps.fws.gov/mbdc/databases/mas/dispr_segcnt.asp>

38. Kiel WH (1949) Waterfowl productivity in the Newdale-Erickson District of Manitoba. In: Waterfowl populations and breeding conditions – summer 1949. United States Fish and Wildlife Service Special Scientific Report Wildlife No 2. Washington, DC, p 76-81.

39. Stoudt JH (1971) Ecological factors affecting waterfowl production in the Saskatchewan parklands. United States Fish and Wildlife Service Resource Publication 99.

40. Smith AG (1971) Ecological factors affecting waterfowl production in the Alberta parklands. United States Fish and Wildlife Service Resource Publication 98.

41. Canada's National Climate Archive. Available at <http://www.climate.weatheroffice.ec.gc.ca >

42. Trauger DL, Stoudt JH (1978) Trends in waterfowl populations and habitats on study areas in Canadian parklands. *Transactions North American Wildlife and Natural Resources Conference* 43:187-205.

43. Dzubin A (1969) Assessing breeding populations of ducks by ground counts. In: Saskatoon Wetland Seminar. Canadian Wildlife Service Report Series 6, p 178-230.

44. Sugden LG (1978) Canvasback habitat use and production in Saskatchewan parklands. Canadian Wildlife Service Occasional Papers 34.

45. Giroux JF (1981) Ducks nesting on artificial islands during drought. *Journal of Wildlife Management* 45(3):783-786.

46. Gurney KEB, Clark RG, Slattery SM, Smith-Downey NV and 13 others (2010) Time constraints in temperate-breeding species: influence of growing season length on reproductive strategies. *Ecography* Published on-line doi: 10.1111/j.1600-0587.2010.06622.

47. Dawson RD, Clark RG (2000) Effects of hatching date and egg size on growth, recruitment, and adult size of Lesser Scaup. *Condor* 102:930-935.

48. Blums P, Clark RG, Mednis A (2002) Patterns of reproductive effort and success in birds: path analysis of long-term data from European ducks. *Journal of Animal Ecology* 71 (2):280-295.

49. Afton AD (1983) Male and female strategies for reproduction in lesser scaup. Ph.D. dissertation, University of North Dakota, Grand Forks, ND.

50. Austin JE, Fredrickson LH (1987) Body and organ mass and body composition of postbreeding lesser scaup. *Auk* 104:694-699.

Ryan McCulloch took this photo of a fox pup, one of a litter of six, south of Morse, SK, on 6 June 2011. Ryan is only five years old !