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Waterfowl and Habitat Changes After 40 Years on the Waubay Study Area

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Waterfowl and Habitat

CHANGES

after 40 years on the

WAUBAY

STUDY AREA

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by

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Cover photo:
Aerial photo taken in May 1964 of the Waubay study area. The photo was shot from the southwest corner of section 23 on the far west side of the study area and shows a view looking northeast across sections 23, 24, 13, and 14.

CHANGES on the WAUBAY STUDY AREA

Abstract. From 1950 to 1953, Evans and Black (1956) conducted the Waubay Study, one of the first comprehensive studies of waterfowl and wetlands on private lands in the Prairie Pothole Region. In 1992 and 1993, we repeated their work to assess changes in waterfowl populations, wetland characteristics, land use, and landowner demographics after 40 years. Our findings:

- Annually cropped land decreased substantially and was largely replaced by Conservation Reserve Program grasslands.
- Wetland drainage since 1985 has been less than in earlier years; 28 wetlands have been restored.
- More class IV wetlands were dominated by dense, monotypic stands of cattail (*Typha*) in 1992-93 than in 1950-53.
- Pairs per km^2 averaged 34.5 during 1992-93 and 25.0 during 1950-53.
- Pair densities were significantly higher in 1992 and 1993 than in 1951 or 1953.
- Over-water nest searches of 40 class IV and 15 class III wetlands revealed 66 nests in 1992 and 64 in 1993.
- Mayfield clutch success of over-water nesting species combined was 14.2% in 1992 and 23.6% in 1993.
- Redheads (*Aythya americana*) were the most abundant over-water nesting duck during 1992 and 1993.
- Forty upland nests were found; the blue-wing teal (*Anas discors*) was the most common nester.
- Mayfield clutch success of upland species combined was 8.2% in 1992 and 5.7% in 1993.
- Mammalian predation was the leading cause of all clutch losses.
- Broods per km^2 averaged 4.9 in 1992-93 and 9.1 during 1950-53.
- Mean brood densities were significantly lower in 1992-93 than in 1950-53.
- Dabbling duck broods were more abundant than diving duck broods in all years.

Key Words: Waubay study, waterfowl, ducks, wetlands, pair densities, brood densities, nests, predation, South Dakota.

The many, diverse wetlands of the Waubay study area attract large numbers of nesting waterfowl. Left, a researcher candles an egg at the nest to determine incubation stage. Since the previous study, cropland acreage decreased substantially, drainage slowed, and 28 wetlands were restored. Most of the area is in private ownership.

CHANGES on the WAUBAY STUDY AREA

Until recently, waterfowl populations had steadily declined (CWS/USFWS 1986). Because ducks provide recreational, aesthetic, and economic benefits, resource managers in South Dakota and other states continually search for new ways to increase duck recruitment (total number of surviving ducklings generated by a single species or by the entire population during one breeding season).

However, little is known about the environmental changes that have taken place on private and public lands over a period of years. Have waterfowl management techniques changed with evolving environmental conditions?

From 1950 to 1953, Evans and Black (1956) examined waterfowl and wetland relationships on the Waubay study area, a tract of mostly private land in Day County, South Dakota. Theirs was one of the first comprehensive studies of ducks in which detailed records were made of land use, wetland classification and location, wetland vegetation and its relationship to water permanency, and numbers of waterfowl pairs and broods. This information was used to determine the value of typical prairie pothole country to ducks and to determine the relative importance of various pothole types and the effects of their drainage on ducks.

Data from this study led to development of the Small Wetlands Acquisition Program and the purchase of Waterfowl Production Areas (WPAs) in the prairie pothole region. The first WPA, the McCarlson WPA, is on the western edge of the study area and was purchased by the U.S. Fish and Wildlife Service (USFWS) on January 19, 1959.

Subsequent long-term studies in other parts of the prairie pothole region have also provided valuable information about the importance of prairie pothole habitat to breeding waterfowl (Smith 1971; Stoudt 1971, 1982; Kiel *et al.* 1972; Leitch and Kaminski 1985; Higgins *et al.* 1992).

Of particular value to our study are the surveys that were continued at Waubay, either on the entire original study area or portions of it, by Jenni (1956) in 1954, by USFWS personnel during 1955-64 (except in 1956), and by Drewien (1968). Because of this extensive historical data, the Waubay study area offered a unique opportunity to repeat the study 40 years after the original project.

We collected data on upland and aquatic habitats, waterfowl populations, and landowner demographics in the Waubay study area to document habitat, land use, demographic, and ownership changes and to determine temporal and spatial changes in the physical and vegetative characteristics of wetlands since 1950-53. We also compared current waterfowl abundances and reproductive indices with those of the earlier study.

Results from our study will provide waterfowl managers in the prairie pothole region a comprehensive evaluation of landscape changes and their relationships to waterfowl abundances over a 40-year time period.

STUDY AREA

The study area is in T124N, R54W (latitude 45° 30' N, longitude 97° 20' W) in Day County in northeastern South Dakota, 9.7 km east of Roslyn, S.D., and 5.6 km north of Grenville, S.D. (Fig 1). Altitude above sea level is 579 m.

The area covers approximately 29 km² of the Coteau des Prairies physiogeographic region (Van Bruggen 1985), most of which is privately owned and which supports a large diversity of birds, mammals, reptiles, and amphibians (Appendices A-C).

The study area is in the tallgrass prairie region of South Dakota (Johnson and Nichols 1982). Dominant grasses that formerly occupied this region include big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), and indiangrass (*Sorghastrum nutans*). Untilled native prairie still exists on 24% of the study area, mostly as pasture or annually hayed grasslands.

Climate

Past and present weather data were obtained from records maintained at the Waubay National Wildlife Refuge. The climate of eastern South Dakota is typically mid-continental with great annual and seasonal variation. Summers are short and warm, and winters are long and cold. The highest recorded temperature at Waubay National Wildlife Refuge was 40.6° C on June 30, 1963. The coldest recorded temperature was -37.2° C on January 15, 1972. The mean high temperature extreme during 1954-93 was 36.4° C, and the mean low temperature extreme during 1954-93 was -33.2° C.

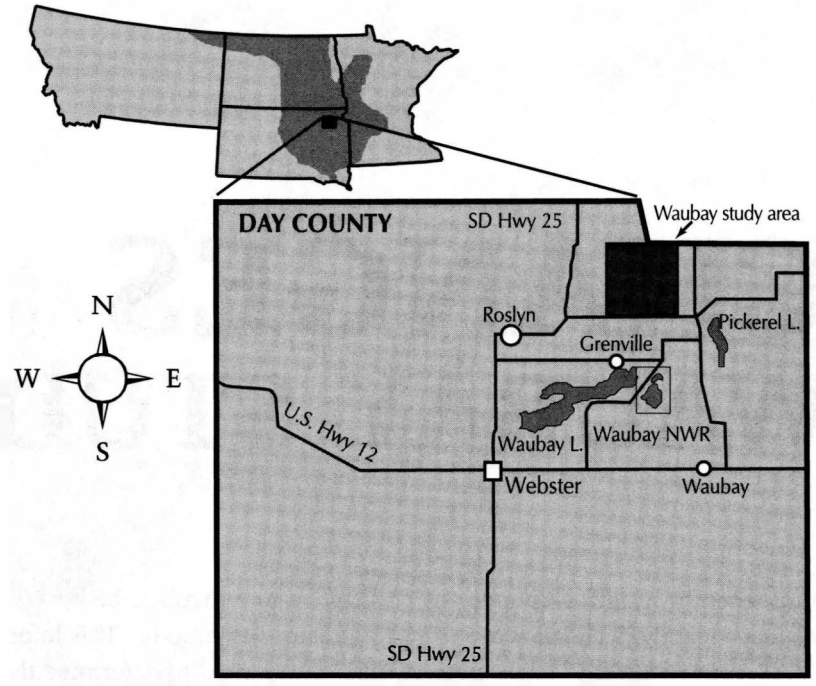

Figure 1. The Waubay study area, Day County, South Dakota, 1950-1953 and 1992-1993.

Annual precipitation from 1954 to 1993 ranged from 17.8 cm in 1976 to 81.8 cm in 1962 (Fig 2), primarily in the form of rain and most abundantly during April-August (Table 1). Snow accumulates in most years, and the wetlands are dependent upon runoff received from snowmelt.

METHODS

Demographics

Plat books were used to determine changes in the number of occupied farmsteads, number of different landowners, and average farm size since the early-1950s. In December 1991 and January 1992, we visited landowners on or near the study area to obtain permission to conduct research on their lands. Landowners living some distance from the study area were contacted by telephone.

Habitat Types

Each quarter section of land was given an identification number from 1 to 42 (Fig 3). Upland habitats on the study area were mapped during 1992-93 to show current land use practices and were compared with land use during the early 1950s. Land use on each quarter section was verified and delineated on field maps. Landowners were contacted to verify certain practices and habitat components.

Annually tilled land consisted of corn (*Zea mays*), soybeans (*Glycine max*), wheat (*Triticum*), barley (*Hordeum*), oats (*Avena sativa*), rye (*Secale cereale*), buckwheat (*Fagopyrum esculentum*), alfalfa (*Medicago sativa*), and fallowed land. Scientific names of domestic grains follow Scott and Wasser (1980).

Other habitat types included Conservation Reserve Program (CRP)

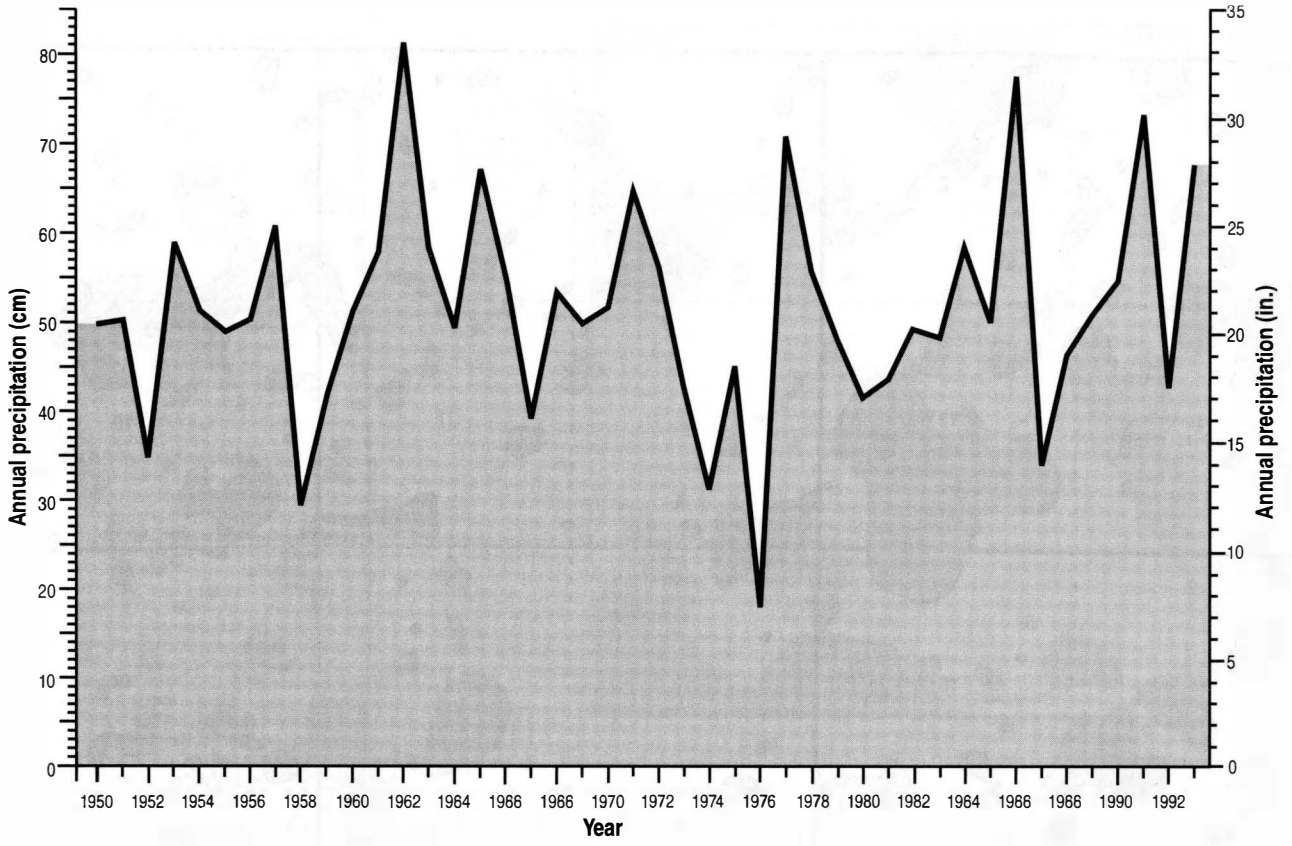

Figure 2. Annual precipition (cm, in.) in the Waubay study area, Day County, South Dakota, 1950-1993.

Table 1. Average monthly precipitation (cm, inches) at Waubay National Wildlife Refuge, Day County, South Dakota, 1954-1993.

	PRECIPITATION	
	cm	*inches*
January	1.17	0.46
February	1.30	0.51
March	2.31	0.91
April	4.72	1.86
May	7.09	2.79
June	9.42	3.71
July	8.03	3.16
August	6.96	2.74
September	4.37	1.72
October	3.28	1.29
November	1.85	0.73
December	1.12	0.44
April-August	**36.22**	**14.26**
Total	**51.62**	**20.32**

grasslands (highly erodible land taken out of crop production for 10 years and planted to native grasses), pastures, annually hayed grasslands, trees and shrubs, miscellaneous rock piles, junk piles, abandoned buildings, and wetlands. Field sizes were measured with a digitizing planimeter.

Wetland Surveys

Wetlands in the study area were classified in 1992 according to Stewart and Kantrud (1971). Individual wetlands were identified and referred to by the same wetland numbering system that Evans and Black (1956) used (Fig 4).

Wetland vegetation was mapped according to emergent plant species that occupied 5% or more of a wetland basin. Species lists of aquatic macrophytes that occupied 5% or more of a basin were made for each wetland. Cover types (Stewart and Kantrud 1971) were also assigned to each wetland.

Wetlands were categorized as completely drained, partially drained, undrained, restored, or tilled.

Total drained area in each wetland class was measured from total original wetland area. Records of drainage dates were available for all basins drained on or before 1968 from earlier studies and surveys (Evans and Black 1956; USFWS files, Waubay National Wildlife Refuge, Waubay, S.D.). These data were used to analyze wetland losses over time.

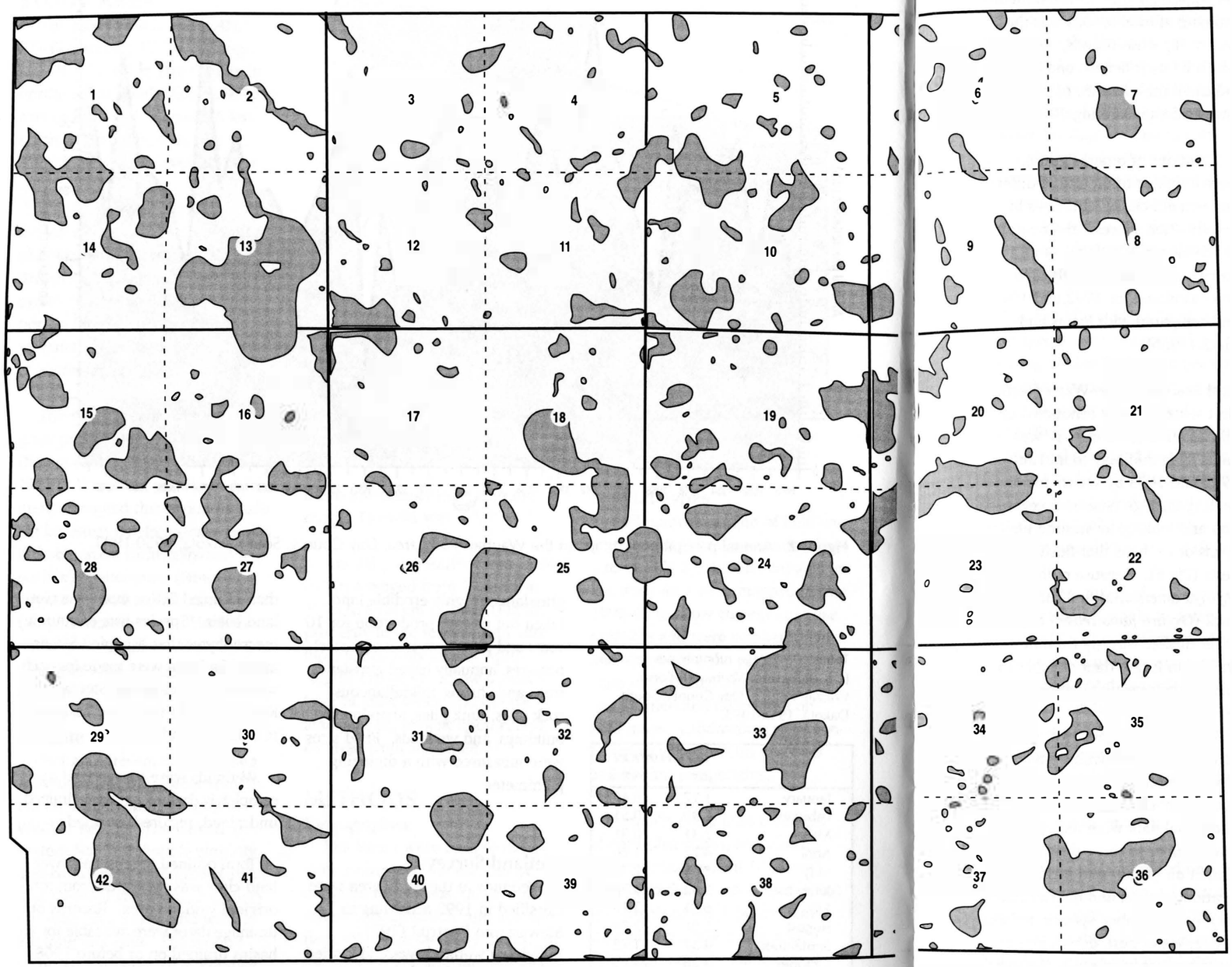

Figure 3. The Waubay study area, Day County, South Dakota, divided into 42 quarter sections, 1992-1993.

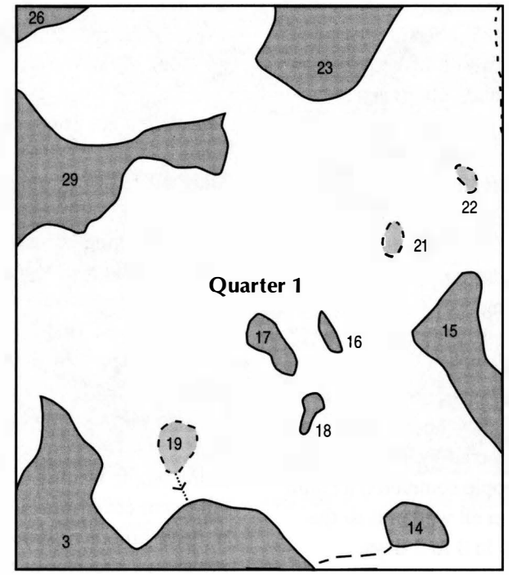

Figure 4. Wetland numbering system, section 14, quarter 1, Waubay study area, Day County, South Dakota, 1992-1993. For details of Figures 3 and 4, see Evans and Black (1956).

We also noted wetland-basin condition (wet or dry), location, and size (hectares). Wetlands were considered wet if 10% or more of the basin contained standing water at least 2.5 cm deep.

Four surveys of wetland-basin condition were conducted annually —in early May, late May, late June, and late July. Wetland size was measured with a digitizing planimeter on aerial photographs and field maps, and different sizes were grouped according to Evans and Black (1956). Frequency histograms were made of wetland classes and drainage histories.

Waterfowl Surveys

Breeding Pair Counts. Two counts of breeding waterfowl pairs were made in May of each field season to provide an index of the number of ducks nesting on and around the study area. If properly timed, pair densities can be accurately estimated from only two counts (Higgins *et al.* 1992).

The first pair count was timed to coincide with onset of nesting by blue-winged teal (*Anas discors*), and the second pair count was timed to coincide with onset of nesting by gadwalls (*A. strepera*).

Breeding pairs, hereafter called pairs, were counted by a person walking around the perimeter of each wetland. Pairs in large wetlands choked with vegetation were counted by two people walking on opposite sides of the wetland until they met at the far end, where they compared notes and eliminated duplicate counts. Pairs on large, open-water wetlands were surveyed from a distant vantage point.

We attempted to avoid duplicate counts later in the survey by noting the flights of flushed ducks to other wetlands. In quarter sections with large wetlands and large numbers of ducks, smaller wetlands were counted first.

Only ducks flushed from counted wetlands were tabulated. Ducks flying over or landing in a wetland were not counted.

Pairs were counted between 0630 and 1800 hours. All counts were conducted by walking. Two to four people completed a count of ducks on all wetlands in the study area in 3 to 5 days.

During pair counts, all ducks were recorded on maps by specific location, species, and sex. At final tabulation, groups were segregated from pairs. Pairs, lone drakes, and lone hens of all species were tabulated for comparison with data from Evans and Black (1956). Groups of males and mixed groups of males and females were each tabulated as pairs when occurring in groups of "five or fewer males" except American wigeon (*Anas americana*) and northern shovelers (*A. clypeata*) for which only pairs and lone drakes were tabulated. Pairs were tabulated according to Hammond (1969).

An average of the two annual pair counts was used for analyses of pair densities by species. Relative use of different wetland classes and basin sizes by pairs was only calculated with data from 1993, which also were compared with similar data obtained by Evans and Black (1956).

Brood Counts. Two brood counts were conducted annually to obtain an index of duck production.

The first count was initiated when the first class IIa (Gollop and Marshall 1954) ducklings were seen in the immediate area, on approximately 25 June in both years. The second brood count was initiated approximately 24 July in both years.

All wetlands classified as wet were searched for broods. Broods in large wetlands choked with vegetation were counted by two or more people wading through the emergent cover in a zigzag pattern to drive broods or brood hens toward an observer at the opposite side of the wetland (Evans and Black 1956). Smaller wetlands were searched by one person. Broods in large, open-water wetlands were counted from a distant vantage point with binoculars and spotting scopes during early morning and evening hours.

Recorded data included species, number of ducklings, duckling age class (Gollop and Marshall 1954), the presence or absence of a hen, and the section, quarter, and wetland in which the brood was seen.

All broods were recorded during each count; however, only broods that hatched since the completion of the first brood count were used for tabulation of the second count. Incidental sightings of broods known to have hatched since the completion of the second count were added to the final number of broods each year.

Estimates of brood densities are reported as the number of broods per square kilometer. The annual estimate of total broods was the sum of flightless broods, hens which by their actions and calling indicated the presence of a brood, and incidental sightings.

Locations of brood sightings were an index of the use of different wetland classes and sizes by broods. Hen success (the number of broods per 100 pairs) of all species found in the study area was calculated for 1992 and 1993 and compared with Evans and Black (1956).

Nest Searches: Over-Water Nests. Nest searches were conducted on 15 class-III and 40 class-IV wetlands from mid May to mid July 1992 and 1993 by systematically wading through emergent vegetation and looking for nesting platforms or for hens that flushed from nests (Fig 5). Because redhead (*Aythya americana*) and ruddy duck (*Oxyura jamaicensis*) hens never flushed directly from nests, we had to locate their clutches by finding their nesting platforms.

When found, a nest was numbered and marked with a small strip of white cloth tied to emergent vegetation 4.6 m north of the nest. Additional data were recorded on cards similar to those described by Klett *et al.* (1986) and included location (section and quarter number), pond number, species, upland or over-water nest, dominant nest site vegetation, nest status (occupied by hen or terminated), date, time, number of eggs from the host and from parasitic hens, the age of a clutch of eggs, nest initiation date (determined by summing the number of host eggs and their age

when the nest was found and counting backward on the calendar to the date the first egg was laid), estimated hatch date (determined by estimating age of the host eggs and counting forward the number of calendar days needed to complete incubation), water depth, and distance to nearest shoreline. Distances to nearest shorelines were estimated to avoid creating paths through emergent vegetation that predators could follow.

The age of a clutch of eggs of most species was determined by candling (Weller 1956), but because of eggshell thickness, the ages of ruddy duck and giant Canada goose (*Branta canadensis maxima*) eggs were determined by flotation (Westerskov 1950). The length of the incubation period needed to hatch a clutch of eggs of each species followed Klett *et al.* (1986).

Nests were revisited at 2-week intervals when possible to determine the fate of each clutch and to estimate the number of exposure days (number of days each clutch of eggs was under observation and vulnerable to loss to predators and other decimating factors). A different path was taken to nests on subsequent visits to avoid establishment of permanent trails.

Additional data recorded on subsequent nest site visits included date, time, number of host eggs, age of eggs, clutch fate (whether one or more eggs in a nest hatched or whether the eggs were destroyed and the nest terminated), cause of nest loss (predation, flooding, machinery, investigator disturbance, etc.), evidence of hen mortality, number of unhatched host eggs and condition of eggs, and evidence of nest parasitism.

Figure 5. Over-water canvasback nest in a seasonal wetland in the Waubay study area, Day County, South Dakota, 1993.

A successful clutch was defined as a clutch in which one or more eggs hatched. A clutch was considered unsuccessful if destroyed by predators, abandoned, or flooded.

A clutch destroyed by predators was characterized by missing eggs, eggshell fragments (other than from hatching), and visible nest disturbance. Clutches were considered abandoned if on subsequent visits all eggs were cold and the embryos were dead. A flooded nest was characterized by fully or partially submerged eggs or by nest platforms and clutches that had been completely washed away.

Clutch success rates were calculated by the Mayfield 40% method (Miller and Johnson 1978, Johnson 1979). Only nests that were occupied by a hen during egg laying or incubation were used in clutch success calculations. The ages of clutches at hatching that were used for Mayfield calculations were adjusted for the average clutch sizes in the study area.

Nest Searches: Upland Nests. Incidentally found upland nests were marked, recorded, and monitored until they were terminated. Predators which destroyed upland nests were identified according to Rearden (1951).

Statistical Analysis

Most data that we collected from surveys and inventories were descriptive in nature. Our use of inferential statistical analyses had to be limited because only summary data (mean, %) from the final publication by Evans and Black (1956) were available for statistical comparison. Consequently, statistical inference was used to evaluate differences in pair and brood densities between 1950-53 and 1992-93.

We used a two-sample t-test in which a single observation is com-

pared with a mean of a sample (Sokal and Rohlf 1981) to compare pair densities of species between years with similar weather patterns and wetland conditions. Means from the early 1950s were treated as densities taken from only one breeding pair count because variances could not be calculated without the raw data. Data from 1951 were compared with data from 1992, and data from 1953 were compared with data from 1993.

Comparisons of total pair densities and brood densities between 1950-53 and 1992-93, 1951 and 1992, and 1953 and 1993 were made with a two-sample paired differences t-test (McClave and Dietrich 1988). Differences were deemed significant at $\alpha=0.10$ for all statistical tests. Differences were deemed marginally significant at $\alpha=0.20$ to minimize the chance of making a Type II error.

RESULTS

Demographics

The number of occupied farms on the study area decreased from 21 in 1951 to 8 in 1992-93, and the number of landowners decreased from 38 to 22 during the same time period. Average farm size increased from 76 to 132 ha. Fourteen of 22 landowners in 1992-93 were either present as tenants or as offspring of tenants present during the original study.

Study Area Landowners

Access was granted to 2,850 ha (97.8%) of the study area. Two landowners of small tracts did not allow access, but we were able to view these areas from adjacent properties.

Land Use Practices and Habitat Types

The amount of land used for annual cropping decreased from 63.0% in 1950-53 to 29.7% in 1992-93 (Table 2), a 52.9% drop.

Much (27.5%) of the land that was annually cropped in 1950-53 was classified as highly erodible and enrolled in the CRP (Johnson and Schwartz 1993) for 10-year contracts beginning in 1986. Once enrolled, the land was seeded to mixtures of cool-season grasses and legumes. This is the main reason for the large decrease in annually cropped land on the study area since 1953.

Agricultural crops in the study area in the early 1950s were limited to spring wheat, flax (*Linum*), barley, and oats. Crops in 1992-93 also included winter wheat, rye, buckwheat, corn, soybeans, and alfalfa (Table 2). Flax is still grown in the area but was not planted in the study area during 1992-93. Sunflowers (*Helianthus*) are a commonly grown row crop in the region but were not planted in the study area during 1992-93. Overall, fewer hectares of row crops were planted in 1993 than in 1992 because of the wet growing season.

Table 2. Comparison of land use practices in the Waubay study area, Day County, South Dakota, 1992-1993 and 1950-1953.

	Percent (%) Use of Total		
Type of Use	*1950-53*	*1992-93*	*% change*
Row crops	0.0[a]	10.9	+ 10.9
corn	0.0	4.7	+ 4.7
soybeans	0.0	6.2	+ 6.2
Small grain[b]	63.0	13.3	- 78.9
Alfalfa	0.0	3.4	+ 3.4
Summer fallow	0.0	2.1	+ 2.1
Total Cropped	**63.0**	**29.7**	**- 52.9**
CRP[c]	0.0	27.5	+ 27.5
Pasture	22.0[d]	12.4	—
Hayed grassland[e]	—	9.6	—
Hayland	—	2.3	—
Trees/shrubs	0.7	2.3	+ 1.6
Miscellaneous[f]	—	0.2	—
Wetlands	15.0	16.1	+ 1.1
Total Uncropped	**37.7**	**70.4**	**+ 86.7**

[a] C. Evans and K. Black (pers comm) explained that row crops and alfalfa were nonexistent during the early 1950s.

[b] Cultivated small grains include spring and winter wheat, barley, oats, rye, and some buckwheat during 1992-93.

[c] Land enrolled in the Conservation Reserve Program and planted to grassland.

[d] This figure represents a combination of pasture and hay during the early 1950s.

[e] Hayed grasslands include road ditches, idle hay fields, idle pastures and other areas containing volunteer grasses and forbs, mainly smooth brome (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*).

[f] Miscellaneous during 1992-93 included rock piles, junk piles and all building sites.

Wetland Habitats

Wetland Classification. Eight different classes of wetlands (Stewart and Kantrud 1971) were found in the study area in 1992-93 (Fig 6). Of 504 wetlands, 43.5% were categorized as class III seasonals and 24.3% were in tillage classes III^t, T-2, T-3, and T-4 during 1992-93 (Fig 6).

Wetland Drainage. Drainage on the study area is extensive, with evidence of some type of drainage on 180 of 504 (35.7%) wetlands (Table 3).

On the basis of wetland class, proportionately more drainage occurred in class I ephemeral (45.6%) and class II temporary (56.8%) basins and in tillage classes T-2, T-3, T-4, and III^t (Table 3). All drainage in the study area was by open ditches.

Drainage records from previous studies in the Waubay study area were only available for 173 of 180 wetlands that have at least been partially drained since the 1950s. The number of drained basins in each wetland class was greatest after 1968 and smallest between 1954-68 (Table 4). Although fewer basins were drained before 1954 than after 1968, more wetland area was drained before 1954 than after 1968 (Table 4).

The USFWS restored three of five (60.0%) previously drained class IV wetlands in the study area and smaller percentages of temporary (32.0%) and seasonal (22.1%) wetlands (Tom Wickstrom, Waubay National Wildlife Refuge, pers comm) (Fig 7).

Breeding Pairs of Ducks

More total ducks and breeding pairs were present in the study area in 1993 than in 1992 (Table 5). Eight species of dabbling ducks, or surface-feeding ducks, [blue-winged teal, gadwall, mallard (*Anas platyrynchos*), northern pintail (*A. acuta*), northern shoveler, American wigeon, green-winged teal (*A. crecca*), wood duck (*Aix sponsa*)]; five species of diving ducks [redhead, canvasback (*Aythya valisineria*), ruddy duck, lesser scaup (*A. affinis*), ring-necked duck (*A. collaris*)]; and giant Canada geese were observed during 1992-93.

The same species occurred in the study area in 1950-53 (Table 6). However, only two pairs of Canada geese were seen in this period (Evans and Black 1956).

Species Composition. Dabbling ducks made up 83.8% and diving ducks 16.2% of total pairs during 1992-93 (Table 6). Pairs of blue-winged teal were the most common (39.3%) dabbling ducks during 1992-93 and 1950-53 (47.3%) (Table 6). Pairs of mallards were the second most common (22.0%) dabbling ducks during 1992-93 and third most common (13.4%) during 1950-53 (Table 6).

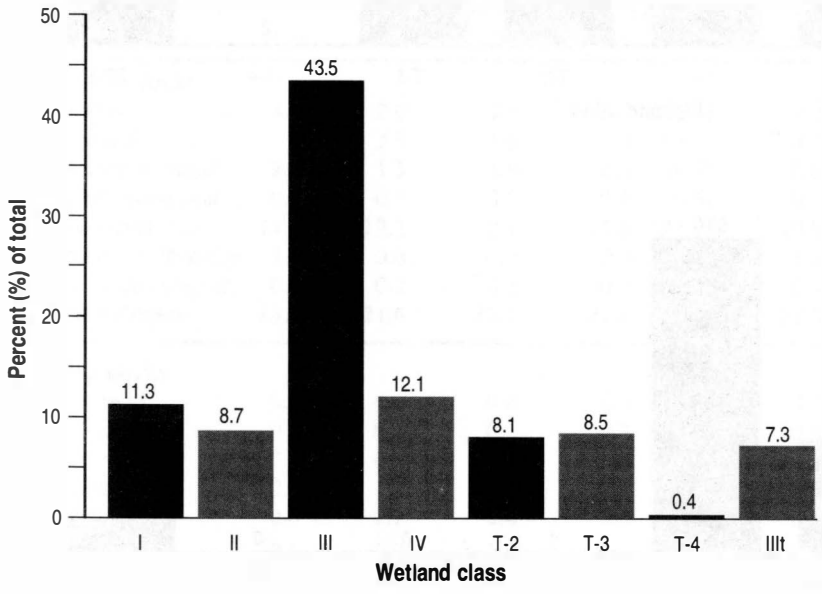

Figure 6. Percent of wetlands in different wetland classes (Stewart and Kantrud 1971) in the Waubay study area, Day County, South Dakota, 1992.

Table 3. Percent composition of wetland basins by class (Stewart and Kantrud 1971) and percent drainage of 504 wetlands in the Waubay study area, Day County, South Dakota, 1992.

Wetlands		Comp	Drained	
Class	No.	%	No.	%
I	57	11.3	26	45.6
II	44	8.7	25	56.8
III	219	43.5	68	31.1
IV	61	12.1	5	8.2
III^t	37	7.3	15	40.5
T-2	41	8.1	11	26.8
T-3	43	8.5	30	69.8
T-4	2	0.4	0	0.0
Total	**504**	**99.9**	**180**	**35.7**

Table 4. Chronology of drainage by wetland class (Stewart and Kantrud 1971) for 173 drained wetlands in the Waubay study area, Day County, South Dakota, 1954-1993.

	Before 1954				*Between 1954-1968*				*1968-93*			
Wetland Class	*No. Drained*	*(%)*[a]	*Hectares Drained*	*(%)*[b]	*No. Drained*	*(%)*	*Hectares Drained*	*(%)*	*No. Drained*	*(%)*	*Hectares Drained*	*(%)*
I	6	25.0	1.28	45.9	3	12.5	0.25	9.1	15	62.5	1.26	45.0
II	8	33.3	3.60	66.1	2	8.3	0.32	5.9	14	58.3	1.53	28.0
III	17	26.2	12.44	47.1	7	10.8	1.40	5.3	41	63.1	12.60	47.6
IV	2	40.0	3.48	61.8	1	20.0	0.13	2.2	2	40.0	2.03	36.0
III[t]	3	20.0	1.33	32.3	2	13.3	0.36	8.7	10	66.7	2.44	59.0
T-2	3	27.3	1.23	54.0	4	36.4	0.43	19.0	4	36.4	0.62	27.0
T-3	11	37.9	6.70	56.4	5	17.2	1.62	13.6	13	44.8	3.56	30.0
T-4	0	0.0	0.00	0.0	0	0.0	0.00	0.0	0	0.0	0.00	0.0
Total	**50**	**28.9**	**30.07**	**51.3**	**24**	**13.9**	**4.51**	**7.7**	**99**	**57.2**	**24.02**	**41.0**

[a] Percentage of the total number of drained wetland basins in each class that have been drained during each time period.

[b] Percentage of the total hectares that have been drained in each wetland class during each time period.

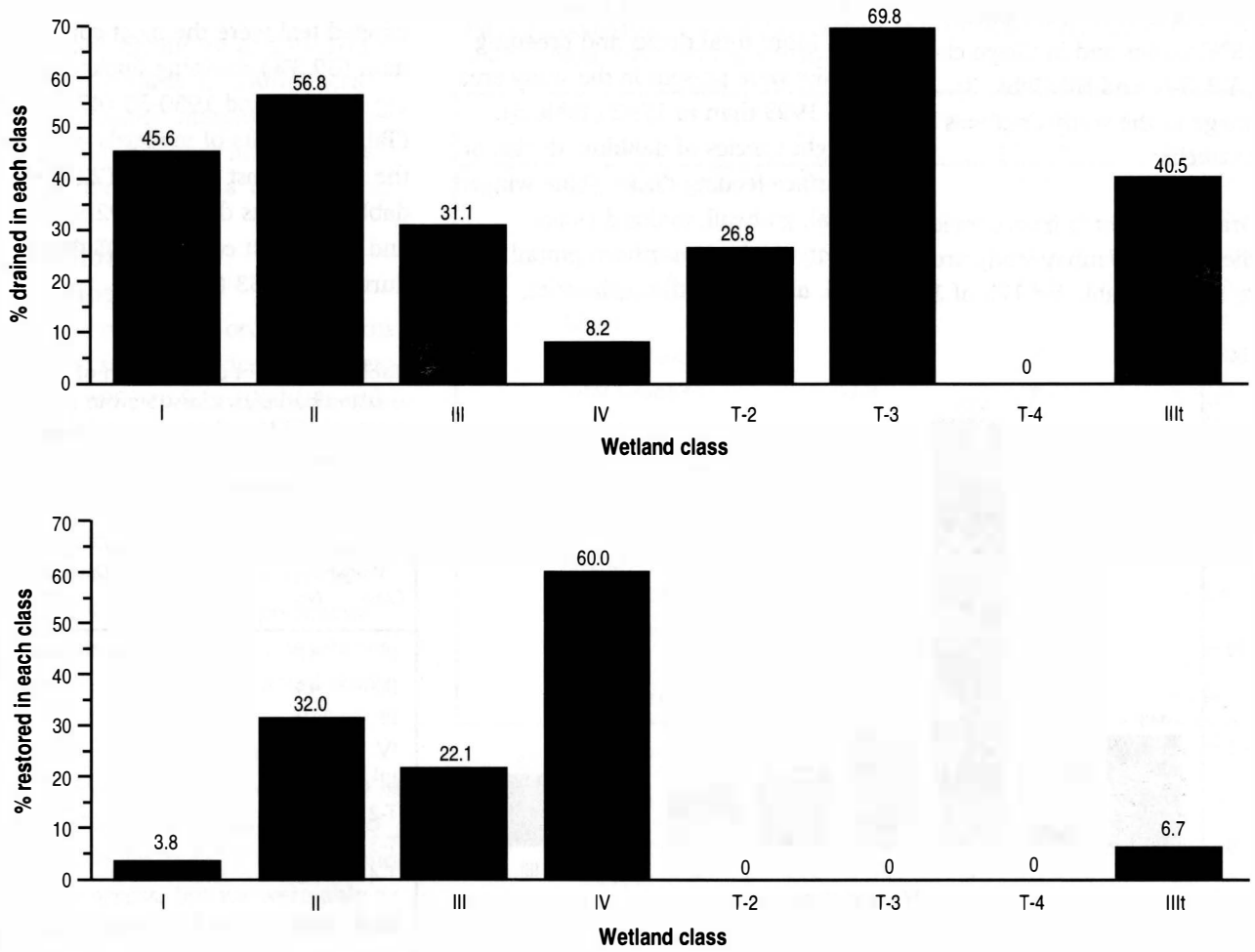

Figure 7. Percent of 173 wetland basins by wetland class (Stewart and Kantrud 1971) that have been drained or restored in the Waubay study area, Day County, South Dakota, as of 1992-1993.

Table 5. Total ducks and indicated breeding pairs tabulated during four pair counts in the Waubay study area, Day County, South Dakota, 1992-1993.

	Total Ducks		*Individual Pairs*		*Total Ducks*		*Individual Pairs*	
	1992		*1992*		*1993*		*1993*	
	5/11-5/15	*5/26-5/29*	*5/11-5/15*	*5/26-5/29*	*5/10-5/14*	*5/24-5/27*	*5/10-5/14*	*5/24-5/27*
Dabbling ducks								
Mallard	254	286	206	218	308	353	227	220
Gadwall	268	207	155	119	202	222	109	132
Northern pintail	43	16	28	13	62	58	47	39
Green-wing teal	7	10	5	9	18	4	12	3
Blue-wing teal	578	408	335	294	794	702	463	497
Northern shoveler	95	73	55	49	92	84	54	56
American wigeon	4	1	3	1	0	0	0	0
Wood duck	10	1	9	1	2	4	1	4
Total Dabblers	**1,259**	**1,002**	**796**	**704**	**1,478**	**1,427**	**913**	**951**
Diving ducks								
Redhead	145	184	94	120	223	163	138	110
Canvasback	10	9	9	7	18	6	12	4
Lesser scaup	29	2	16	1	0	3	0	2
Ring-necked duck	4	0	2	0	0	0	0	0
Ruddy duck	35	32	23	25	53	55	39	37
Total Divers	**223**	**227**	**144**	**153**	**294**	**227**	**189**	**153**
Total	**1,482**	**1,229**	**940**	**857**	**1,772**	**1,654**	**1,102**	**1,104**
Canada geese	70	—	47	—	40	—	109	—

Table 6. Density (pairs/km^2) and percent composition (%) of duck breeding pairs in the Waubay study area, Day County, South Dakota, 1992-1993, 1951, 1953, and 1950-1953.

	Indicated Pair Densities (Percent composition)											
			1951 & 1953	*1950-53*						*1992-93*	
Species	*1951*[a]	*1953*[b]	*Avg.*	*Avg.*	*(%)*	*1992*	*(%)*	*1993*	*(%)*	*Avg.*	*(%)*
Dabbling ducks											
Mallard	3.3	2.8	3.1	3.4	(13.4)	7.3	(23.7)	7.7	(20.3)	7.5	(22.0)
Gadwall	3.9	3.9	3.9	3.9	(15.5)	4.7	(15.2)	4.1	(11.0)	4.4	(13.1)
Northern pintail	2.5	1.5	1.9	2.4	(9.7)	0.6	(2.3)	1.5	(3.9)	1.1	(3.1)
Green-wing teal	0.2	0.1	0.1	0.1	(0.5)	0.2	(0.8)	0.3	(0.7)	0.3	(0.8)
Blue-wing teal	11.9	12.3	12.1	11.8	(47.3)	10.8	(35.0)	16.5	(43.5)	13.7	(39.3)
Northern shoveler	1.1	0.8	0.9	0.9	(3.6)	1.8	(5.8)	1.9	(5.0)	1.9	(5.4)
American wigeon	0.2	0.2	0.2	0.2	(0.9)	0.1	(0.2)	tr.	(0.0)	tr.	(0.1)
Total dabblers	**23.1**	**21.6**	**22.2**	**22.7**	**(90.8)**	**25.5**	**(82.3)**	**32.0**	**(84.2)**	**28.9**	**(83.8)**
Diving ducks											
Redhead	0.8	0.8	0.8	0.8	(3.2)	3.7	(12.0)	4.3	(11.3)	4.0	(11.7)
Canvasback	0.2	tr.	0.1	0.2	(0.6)	0.3	(0.9)	0.3	(0.8)	0.3	(0.9)
Lesser scaup	0.4	0.5	0.5	0.4	(1.6)	0.3	(0.9)	tr.	(0.1)	0.2	(0.5)
Ruddy duck	0.6	1.4	1.0	0.9	(3.6)	0.8	(2.7)	1.3	(3.5)	1.1	(3.1)
Total divers	**2.0**	**2.7**	**2.4**	**2.3**	**(9.2)**	**5.1**	**(16.5)**	**5.9**	**(15.5)**	**5.6**	**(16.2)**
Others[c]	0.1	0.2	0.1	tr.		0.2	(0.6)	0.1	(0.2)	0.2	(0.6)
Total	**25.2**	**24.4**	**24.8**	**25.0**		**31.0**		**38.0**		**34.5**	

[a] Similar to 1992 in precipitation and basin wetness.

[b] Similar to 1993 in precipitation and basin wetness.

[c] Includes traces of ring-necked ducks and wood ducks.

Table 7. Percent change of breeding pairs/km^2 in the Waubay study area, Day County, South Dakota, 1992-1993, 1950-1953.

Species	Pairs/km^2 1992	1993	% change from 1992 to 1993	Pairs/km^2 Mean 1990s[a]	Mean 1950s[b]	% change from 1950s to 1990s
Dabbling ducks						
Mallard	7.3	7.7	+ 5.5	7.5	3.4	+ 120.6
Gadwall	4.7	4.1	- 12.8	4.4	3.9	+ 12.8
Northern pintail	0.6	1.5	+ 150.0	1.1	2.4	- 54.2
Green-wing teal	0.2	0.3	—	0.3	0.1	—
Blue-wing teal	10.8	16.5	+ 52.8	13.7	11.8	+ 16.1
Northern shoveler	1.8	1.9	+ 5.6	1.9	0.9	+ 111.0
American wigeon	0.1	tr.	—	tr.	0.2	—
Wood duck	0.2	0.1	—	0.1	tr.	—
Total dabblers	**25.7**	**32.1**	**+ 24.9**	**28.9**	**22.7**	**+ 41.4**
Diving ducks						
Redhead	3.7	4.3	+ 16.2	4.0	0.8	+ 400.0
Canvasback	0.3	0.3	+ 14.3	0.3	0.2	+ 50.5
Lesser scaup	0.3	tr.	- 62.5	0.2	0.4	- 50.0
Ruddy duck	0.8	1.3	+ 15.7	1.1	0.9	+ 22.2
Total divers	**5.1**	**5.9**	**+ 15.7**	**5.5**	**2.3**	**+ 156.5**
Total	**30.8**	**38.0**	**+ 23.4**	**34.4**	**25.0**	**+ 52.0**

[a] Pooled 1992,1993.

[b] Pooled 1950,1951,1952,1953.

Redhead pairs were the most common (11.7%) diving ducks during 1992-93, but ruddy duck pairs were the most common (3.6%) in 1950-53 (Table 6). Redhead pairs were the second most common (3.2%) diving duck during 1950-53 (Table 6).

Breeding Pair Densities. Total pair densities (pairs per km^2) were larger in 1992 ($t=2.59$, $df=13$, $P<0.05$) than in 1951 and were larger in 1993 ($t=2.33$, $df=13$, $P<0.05$) than in 1953. In fact, the total pair density in 1993 was the second largest ever recorded in the Waubay study area.

Density of all species increased from 1950-53 to 1992-93 except for northern pintails and lesser scaup. Density of all species except gadwalls, wood ducks, and

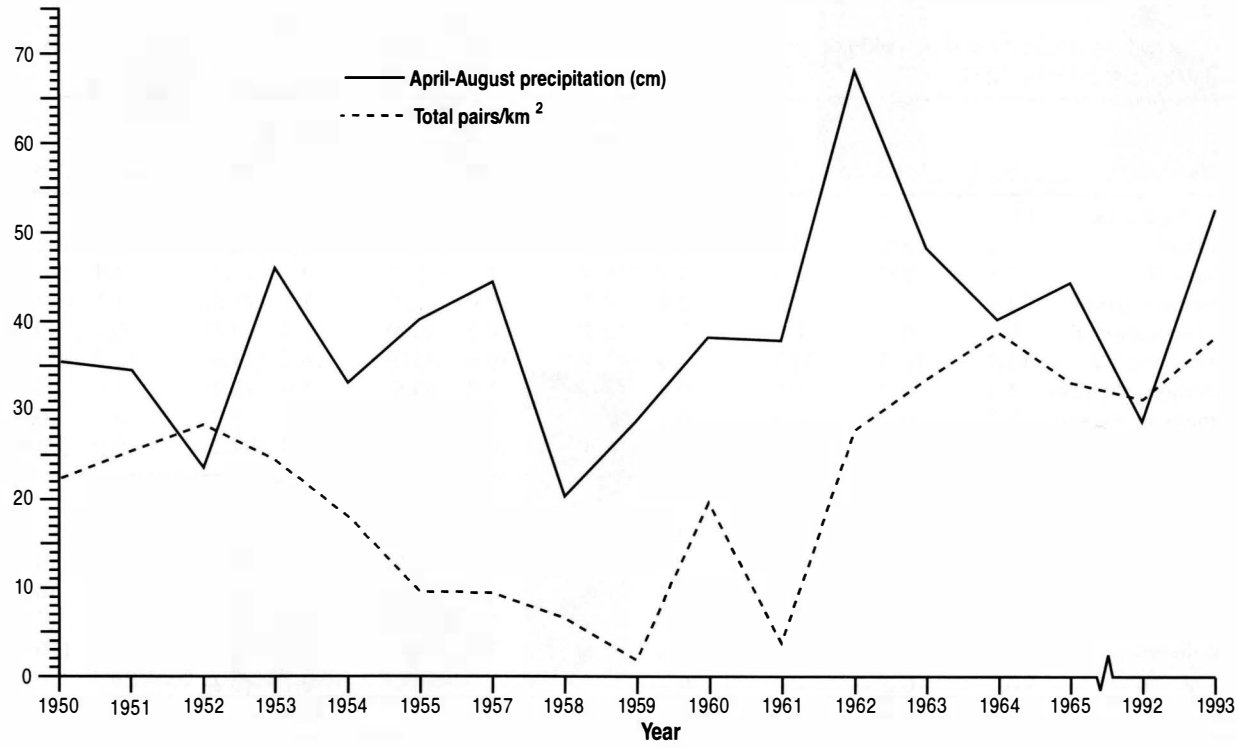

Figure 8. Total pairs densities (pairs/km^2) in relation to April-August precipitation (cm) in the Waubay study area, Day County, South Dakota, 1950-1965, 1992-1993.

lesser scaup also increased from 1992 to 1993 (Table 7).

The large annual variations in pair densities of waterfowl are strongly related to precipitation during the growing season (April-August; Fig 8). Annual patterns of local precipitation paralleled annual patterns of the local breeding population (Fig 8).

Wetland Conditions. More than twice as many ponds (54.7%) contained water in early May in 1993 than in 1992 (24.9%; Fig 9). Water conditions followed similar patterns during 1992 and 1993.

The number of wet basins was smallest in late May 1992 and 1993, but abundant June and July precipitation (Table 1) filled a large percentage of the wetlands by late July (Fig 10). The number of wet basins was largest in late July of 1992 and 1993 (Fig 9).

Use of Different Wetland Classes and Sizes by Pairs. In 1993, pairs of dabbling ducks were seen most frequently in class III and class IV wetlands (Table 8).

Northern pintails, northern shovelers, and blue-winged teal were seen most frequently in class III wetlands. Most (84%) pairs of diving ducks were seen in class IV wetlands (Table 8). However, redhead pairs (15.4%) were also quite common in class III wetlands.

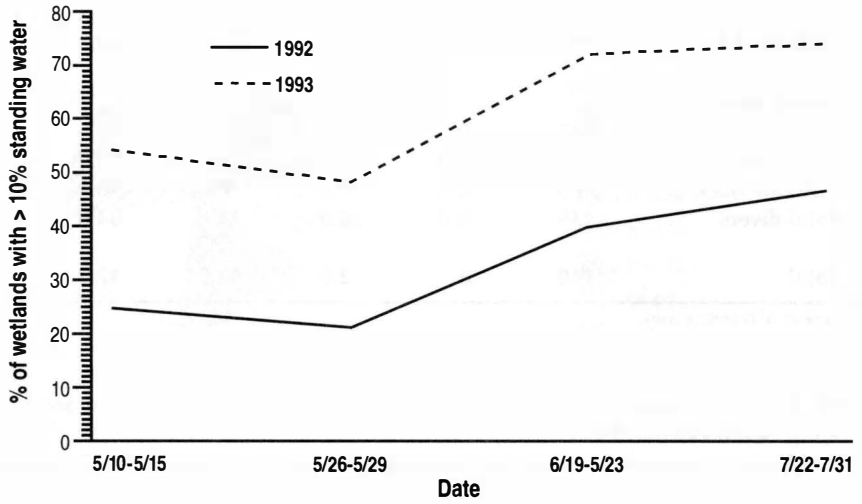

Figure 9. Percent of basins in the Waubay study area, Day County, South Dakota, containing >10% standing water at four time periods from May-August, 1992-1993.

Figure 10. Road on east side of the Waubay study area, Day County, South Dakota, flooded from abundant summer rain fall in 1993.

Table 8. Use (%) of different wetland classes (Stewart and Kantrud 1971) by breeding pairs in the Waubay study area, Day County, South Dakota, 1993.

		Wetland Class (Stewart and Kantrud 1971)							
Species	*n*[a]	*I*	*II*	*III*	*IV*	*IIIt*	*T-2*	*T-3*	*T-4*
Dabbling ducks									
Mallard	429	0.0	1.4	42.0	45.7	3.7	5.8	0.2	1.2
Gadwall	230	0.0	1.7	44.8	40.4	6.1	3.5	1.3	2.2
Northern pintail	85	0.0	4.7	44.7	30.6	8.2	9.4	1.2	1.2
Blue-wing teal	948	0.1	2.7	54.5	39.8	1.8	0.8	0.0	0.2
Northern shoveler	109	0.0	2.8	58.7	30.3	4.6	1.8	0.0	1.8
Total dabblers	**1,801**	**tr.**	**2.4**	**50.1**	**40.3**	**3.3**	**2.8**	**0.3**	**0.8**
Diving ducks									
Redhead	247	0.0	0.0	15.4	79.4	1.6	0.4	0.0	3.2
Canvasback	16	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Ruddy duck	76	0.0	0.0	0.0	96.1	3.9	0.0	0.0	0.0
Total divers	**339**	**0.0**	**0.0**	**11.2**	**84.0**	**2.1**	**0.3**	**0.0**	**2.4**
Total	**2,140**	**tr.**	**2.0**	**43.9**	**47.2**	**3.1**	**2.4**	**0.2**	**1.1**

[a] Number of breeding pairs.

Table 9. Breeding pairs/ha[a] of undrained wetland by wetland class (Stewart and Kantrud 1971) in the Waubay study area, Day County, South Dakota, 1993.

	Wetland Class							
Species	*I*	*II*	*III*	*IV*	*III*[t]	*T-2*	*T-3*	*T-4*
Dabbling ducks								
Mallard	0.00	1.65	1.11	0.78	2.68	9.58	1.49	5.68
Gadwall	0.00	1.10	0.63	0.37	2.35	3.07	4.48	5.68
Northern pintail	0.00	1.10	0.23	0.10	1.17	3.07	1.49	1.14
Blue-wing teal	0.34	7.16	3.19	1.50	2.85	3.07	0.00	2.27
Northern shoveler	0.00	0.83	0.39	0.13	0.84	0.77	0.00	2.27
Total dabblers	**0.34**	**11.84**	**5.55**	**2.88**	**9.89**	**19.56**	**7.46**	**17.04**
Diving ducks								
Redhead	0.00	0.00	0.23	0.78	0.67	0.38	0.00	9.09
Canvasback	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00
Ruddy duck	0.00	0.00	0.00	0.29	0.50	0.00	0.00	0.00
Total divers	**0.00**	**0.00**	**0.23**	**1.13**	**1.17**	**0.38**	**0.00**	**9.09**
Total	**0.34**	**11.84**	**5.78**	**4.01**	**11.06**	**19.94**	**7.46**	**26.13**

[a] Not calculated for lesser scaup, ring-necked duck, and wood duck because of low pair numbers.

Ruddy duck and canvasback pairs were seen almost exclusively in class IV wetlands (Table 8).

Of the tilled wetland classes, pairs of dabbling ducks were seen most frequently in class III[t] (3.3%) and class T-2 (2.8%) basins (Table 8). Few diving duck pairs were found on tilled wetlands.

The greatest density of dabbling duck pairs per hectare of wetland area in each class were seen in class II (11.84) natural basin wetlands and class T-2 (19.56) tillage wetlands (Table 9). The greatest density of diving duck pairs per hectare of wetland area in each class were seen in class IV (1.13) natural basin wetlands and class T-4 (9.09) tillage wetlands (Table 9). However, only two class T-4 wetlands were in the study area in 1992-93.

The largest percentages of pairs of all species in 1993 were in wetlands larger than 4.81 ha (Figs 11, 12). Pairs of dabbling ducks were also well represented on all wet-

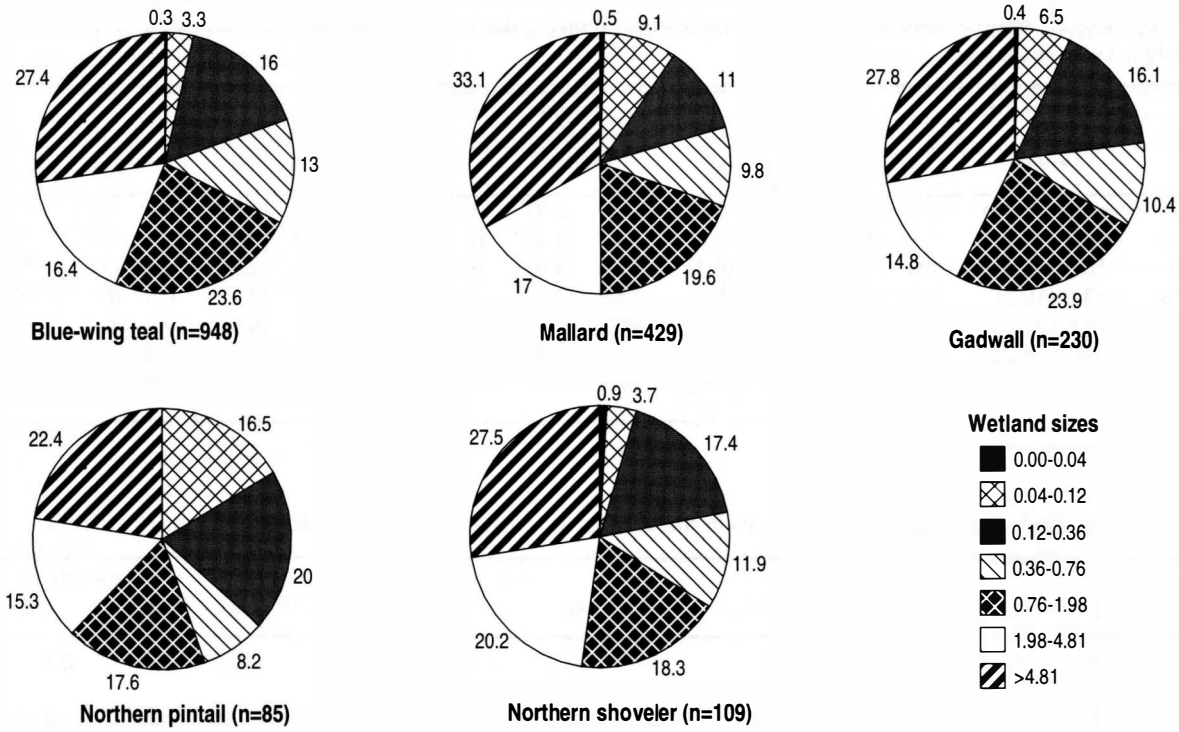

Figure 11. Use (%) of different wetland sizes (ha) by dabbling duck pairs in the Waubay study area, Day County, South Dakota, 1993.

lands larger than 0.12 ha (Fig 11). Diving duck pairs were seen almost exclusively in wetlands larger than 4.81 ha (Fig 12). Redhead pairs were observed on more wetlands of different sizes than other diving duck species.

Pair observations of each species on wetlands of different sizes varied annually in 1992-93 and reflected the available wetland habitat (Table 10).

Observations of pairs of dabbling ducks in wetlands smaller than 0.36 ha were considerably fewer during the early 1950s than in 1993, whereas observations of pairs of dabbling ducks in wetlands larger than 1.98 ha were greater during the early 1950s than in 1993 (Table 10). Pairs of dabbling ducks used wetlands smaller than 0.76 ha during the extremely wet conditions of 1993.

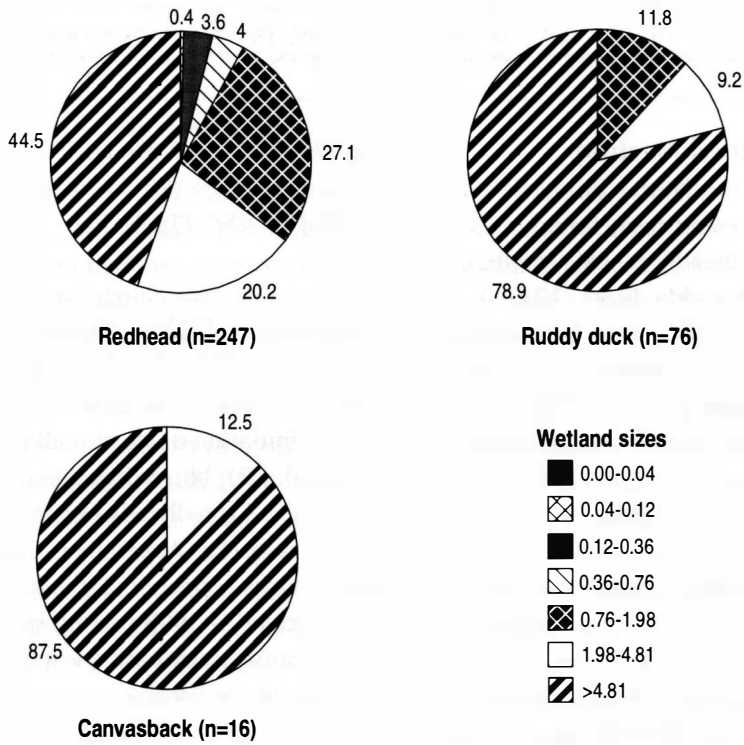

Figure 12. Use (%) of different wetland sizes (ha) by diving duck pairs in the Waubay study area, Day County, South Dakota, 1993.

Table 10. Use (%) of different wetland sizes (ha) by dabbling and diving duck pairs in the Waubay study area, Day County, South Dakota, 1993, 1950-1953.

Wetland Size (ha)	Blue-wing teal (n=948)	Mallard (n=429)	Gadwall (n=230)	Northern Shoveler (n=109)	Northern Pintail (n=85)	Redhead (n=247)	Ruddy duck (n=76)	Canvasback (n=16)
0.00 - 0.04	0.3 (0.3)a	0.5 (0.5)	0.4 (0.6)	0.9 (0.9)	0.0 (0.3)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
0.04 - 0.12	3.3 (2.8)	9.1 (3.9)	6.5 (3.8)	3.7 (2.2)	16.5 (5.0)	0.4 (0.0)	0.0 (0.0)	0.0 (0.0)
0.12 - 0.36	16.0 (5.8)	11.0 (7.5)	16.1 (6.1)	17.4 (4.9)	20.0 (10.1)	3.6 (2.2)	0.0 (0.0)	0.0 (0.0)
0.36 - 0.76	13.0 (10.2)	9.8 (9.7)	10.4 (8.7)	11.9 (7.6)	8.2 (9.1)	4.0 (2.7)	0.0 (0.0)	0.0 (5.0)
0.76 - 1.98	23.6 (20.7)	19.6 (18.2)	23.9 (19.5)	18.3 (21.1)	17.6 (17.4)	27.1 (6.5)	11.8 (10.2)	12.5 (10.0)
1.98 - 4.81	16.4 (25.3)	17.0 (25.3)	14.8 (25.4)	20.2 (24.7)	15.3 (23.2)	20.2 (26.1)	9.2 (29.9)	0.0 (25.0)
size > 4.81	27.4 (34.8)	33.1 (34.8)	27.8 (36.0)	27.5 (38.6)	22.4 (34.9)	44.5 (62.5)	78.9 (59.9)	87.5 (60.0)

[a] Values in ( ) are average % use of wetland sizes for 1950-53.

Table 11. Percent clutch success of over-water nests in the Waubay study area, Day County, South Dakota, 1992-1993.

	1992			1993			1992-93		
Species	n	App.[a]	Mayfield	n	App.	Mayfield	n	App.	Mayfield
Mallard	21	28.6	9.8 (2.6-34.6)[b]	5	20.0	2.6 (0.1-84.1)	26	26.9	8.1 (2.3-26.8)
Northern pintail	2	0.0	1.2 (0.0-100.0)	0	0.0	0.0	2	0.0	1.2 (0.0-100.0)
Redhead	33	51.5	24.8 (12.3-49.7)	30	36.7	16.6 (7.2-37.5)	63	44.4	20.0 (11.6-34.3)
Canvasback	1	100.0	100.0	16	56.3	38.9 (18.9-78.8)	17	58.8	39.1 (19.0-79.0)
Ruddy duck	9	11.1	4.0 (0.4-36.3)	13	46.2	38.1 (18.2-78.2)	22	31.8	21.2 (9.4-46.7)
Total	**66**	**37.9**	**14.2 (7.6-26.3)**	**64**	**42.2**	**23.6 (14.6-37.8)**	**130**	**40.0**	**18.9 (12.9-27.6)**

[a] Apparent clutch success = the number of successful nesting attempts/the total number of nesting attempts.

[b] Values in ( ) are 95% CI's for Mayfield estimates (Klett *et al.* 1986). The variance of the estimate is greatly affected by sample size and number of exposure days. Thus, smaller sample sizes and/or fewer exposure days lead to larger variances and wider confidence intervals.

Waterfowl Nesting

Over-Water Nests. Proportions of 66 over-water nests found in 1992 were redheads (50.0%), mallards (31.8%), ruddy ducks (13.6%), pintails (3.0%), and canvasbacks (1.5%). Proportions of 64 over-water nests found in 1993 were redheads (46.9%), canvasbacks (25.0%), ruddy ducks (19.7%), and mallards (7.8%).

The average clutch sizes of over-water nests were 10.6 (redheads), 7.9 (mallards), 8.1 (ruddy ducks), 8.0 (pintails), and 8.8 (canvasbacks) eggs. Overall clutch success of over-water nests calculated using the Mayfield technique was 14.2% (95% CI=7.6%-26.3%) in 1992 and 23.6% (95% CI=14.6%-37.8%) in 1993 (Table 11).

Species specific clutch success varied between years. However, our sample of northern pintail nests was small. The distribution of nest initiation dates of mallards (Appendix D), blue-winged teal (Appendix E), redheads (Appendix F), canvasbacks (Appendix G), and ruddy ducks (Appendix H) indicated an extended 1993 nesting season, because many basins were wet throughout the breeding season.

Nine giant Canada goose nests were found in 1993, and seven clutches (36.5% Mayfield) hatched. Average clutch size of giant Canada goose nests was 6.1 eggs.

Destruction of over-water nests in 1992-93 was caused by mammalian predation, flooding, and abandonment (Table 12).

Predation (36.2%), mainly by raccoons (*Procyon lotor*), was the leading cause of nest destruction in over-water nests. However, losses from mammalian predation decreased as nest initiation dates became later (Fig 13). Flooding was the second leading cause of nest destruction in over-water nests in 1992 (n=9, 13.6%) and

Table 12. Fates of 130 over water and 40 upland nests in the Waubay study area, Day County, South Dakota, 1992-1993.

Species	*n*	*Successful*	*Predated*	*Flooded*	*Abandoned*	*Unknown*
Over-water nests						
Mallard	25	7	16	0	0	2
Northern pintail	2	0	2	0	0	0
Redhead	63	28	17	9	9	0
Canvasback	17	10	4	3	0	0
Ruddy duck	22	7	7	8	0	0
Total (%)	**129**	**52 (40.0)**	**47 (36.2)**	**20 (15.4)**	**9 (6.9)**	**2 (1.5)**
						Machinery
Upland nests						
Mallard	10	1	8		0	1
Gadwall	3	1	2		0	0
Northern pintail	2	0	1		0	1
Blue-wing teal	22	7	13		2	0
Northern shoveler	3	0	3		0	0
Total (%)	**40**	**9 (22.5)**	**27 (67.5)**		**2 (5.0)**	**2 (5.0)**

Table 13. Percent of over-water nests for five waterfowl species found in different wetland classes (Stewart and Kantrud 1971) in the Waubay study area, Day County, South Dakota, 1992-1993.

Species	*n*[a]	*Class III*	*Class IV*
Mallard	27	14.8	85.2
Northern pintail	2	100.0	0.0
Redhead	72	6.9	93.1
Canvasback	20	0.0	100.0
Ruddy duck	24	12.5	87.5
Total	**145**	**9.7**	**90.3**

[a] Includes some nests already terminated when found.

1993 (n=11, 17.2%). Evidence of a hen being killed was apparent in only one over-water nest.

Nest parasitism was highest in 1993. Twenty-five of 64 (39.1%; 10 canvasbacks, 12 redheads, three ruddy ducks) over-water nests were parasitized in that year, with 60.0% of the parasitized clutches hatching. Six of 66 (9.1%; four redheads, one mallard, one ruddy duck) were parasitized in 1992, with 16.7% hatching. Redheads were the parasitic layers in 30 of 31 (96.8%) parasitized nests.

In 1993, 62.5% of the canvasback nests, 40.0% of the redhead nests, and 23.1% of the ruddy duck nests that we found and monitored were parasitized.

Most (90.3%) over-water nests during 1992-93 were in class IV wetlands (Table 13), and most (72.2%) were in dense, monotypic stands of residual-growth cattail (*Typha*). Most redhead (77.8%), ruddy duck (57.1%), canvasback (76.5%), and mallard (65.4%) nests were in dense, monotypic stands of residual growth cattail. Ruddy ducks frequently constructed nests in new growth cattail.

Hardstem bulrush (*Scirpus acutus*), softstem bulrush (*S. tabernaemontani*), and river bulrush (*S. fluviatilis*) occupied greater than 5% of the basin in 65.6% of class IV wetlands, but only 11.9% of the nests were in these habitats.

Only 9.7% of over-water nests were in seasonal wetlands (class III; Table 13). Nests in seasonal wetlands were in whitetop (*Scolochloa festucacea*), slough sedge (*Carex atherodes*), river bulrush, or giant burreed (*Sparganium eurycarpum*).

Table 14. Mean water depths (cm) and distances (m) from nearest shoreline of 127 over water nests in the Waubay study area, Day County, South Dakota, 1992-1993.

Species	*n*	*Depth*	*Min.- Max.*	*Distance*	*Min.- Max.*
Mallard	26	37.8 (3.3)[a]	7.6-61.0	25.3 (2.9)	0.0-54.9
Redhead	62	56.4 (1.8)	25.4-101.6	38.1 (3.0)	6.4-137.2
Canvasback	17	61.2 (2.6)	40.6-81.3	41.6 (5.6)	22.9-114.3
Ruddy duck	22	62.5 (3.4)	40.6-96.5	26.0 (3.1)	9.1-73.2

[a] Values in ( ) are SE for mean depths and distances.

Mean water depth and mean distance to the nearest shoreline from nest sites varied by species (Table 14). Mallards nested over considerably shallower water than did other over-water nesting ducks Table 14).

Water depths at nest sites of all species varied, but no nests were found where water was deeper than 101.6 cm. Only 7 of 127

Table 15. Percent clutch success of upland nests in the Waubay study area, Day County, South Dakota, 1992-1993.

	1992			1993			1992-93		
Species	*n*	*App.*[a]	*Mayfield*	*n*	*App.*	*Mayfield*	*n*	*App.*	*Mayfield*
Mallard	6	16.7	5.0 (0.4-66.8)[b]	4	0.0	0.0	10	10.0	1.5 (0.1-22.4)
Gadwall	1	0.0	17.8 (0.5-100.0)	2	50.0	35.7 (4.3-100.0)	3	33.3	27.7 (4.3-100.0)
Northern pintail	2	0.0	0.0	0	0.0	0.0	2	0.0	0.0
Blue-wing teal	13	30.7	13.3 (3.4-49.6)	9	33.3	12.9 (2.3-66.1)	22	31.8	13.1 (4.5-36.8)
Northern shoveler	1	0.0	9.6 (0.0-100.0)	2	0.0	0.2 (0.0-100.0)	3	0.0	1.6 (0.0-100.0)
Total	**23**	**21.7**	**8.2 (2.5-26.2)**	**17**	**23.5**	**5.7 (1.1-26.9)**	**40**	**22.5**	**7.1 (2.7-18.2)**

[a] Apparent clutch success = the number of successful nesting attempts/the total number of nesting attempts.

[b] Values in ( ) are 95% CIs for Mayfield estimates (Klett *et al.* 1986). The variance of the estimate is greatly affected by sample size and number of exposure days. Thus, smaller sample sizes and/or fewer exposure days lead to larger variances and wider confidence intervals.

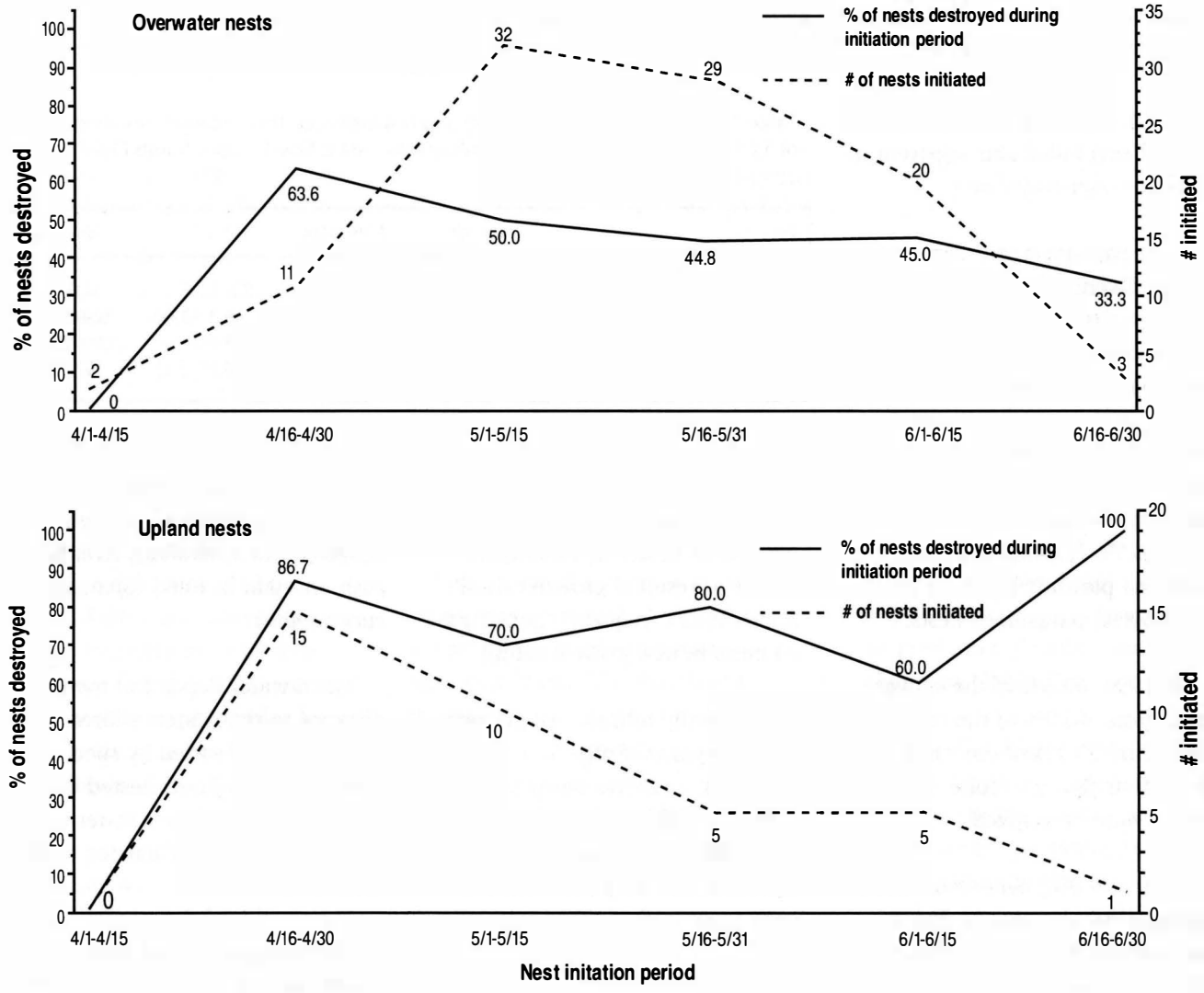

Figure 13. Percent of nests destroyed by mammalian predators during 6 different nest initiation periods in the Waubay study area, Day County, South Dakota, 1992-1993.

(5.5%) nests were over depths greater than 76.2 cm, even though wetlands with good emergent cover in water deeper than 77 cm were searched. Nests of ruddy ducks and mallards were closest to shoreline, and nests of redheads and canvasbacks were farthest from shoreline (Table 14).

Upland Nests. Twenty-three duck nests in 1992 and 17 nests in 1993 were found in upland habitats (Table 15). Largest percentages were on wetland edges (25.0%), grasslands enrolled in CRP (22.5%), and pastures (20.0%).

Smooth brome (*Bromus inermis*) (62.5%), Kentucky bluegrass (*Poa pratensis*) (35.0%), and alfalfa (27.5%) were the most common plant species at nest sites. The proportions of upland nests found in 1992 were blue-winged teal (56.5%), mallards (26.1%), northern shovelers (4.3%), gadwalls (4.3%), and northern pintails (8.7%). In 1993 the proportions were blue-winged teal (52.9%), mallards (23.5%), northern shovelers (11.8%), and gadwalls (11.8%). Average clutch sizes for upland nests by species were 10.1 eggs (blue-winged teal), 10.5 (northern shoveler), and 8.7 eggs (gadwall). Overall clutch success for upland nests calculated using the Mayfield technique was 8.2% (95% CI = 2.5%-26.2%) in 1992 and 5.7% (95% CI = 1.1%-26.9%) in 1993 (Table 15).

Destruction of most (67.5%) upland nests was caused by mammalian predation (Table 12), and predation continued at a high rate throughout the nesting season (Fig 13). A total of 238 ducklings hatched from monitored nests in 1992; 188 ducklings hatched in 1993 (Table 16).

Table 16. Ducklings and goslings produced from monitored nests in the Waubay study area, Day County, South Dakota, 1992-1993.

Species	Avg. Clutch Size	(min-max)[a]	1992 n	1992 No. eggs hatched	1993 n	1993 No. eggs hatched	1992-93 n	1992-93 No. eggs hatched
Over water								
Mallard	7.9	(05-11)	6	47	1	10	7	57
Redhead	10.6	(06-14)	17	132	11	68	28	200
Canvasback	8.8	(06-11)	1	6	9	29	10	35
Ruddy duck	8.1	(05-13)	1	7	6	42	7	49
Subtotal			**25**	**192**	**27**	**149**	**52**	**341**
Upland								
Mallard	7.9	(04-13)	1	6	0	0	1	6
Gadwall	8.7	(08-09)	0	0	1	8	1	8
Blue-wing teal	10.1	(08-12)	4	40	3	31	7	71
Subtotal			**5**	**46**	**4**	**39**	**9**	**85**
Total			**30**	**238**	**31**	**188**	**61**	**426**
Others								
Canada goose[b]	6.1	(06-07)			7	36	7	36

[a] Minimum and maximum clutch sizes observed.
[b] Nests were only recorded and monitored during 1993.

Diving ducks accounted for 80.6% of the total ducklings hatched from monitored nests in 1992 and for 79.3% in 1993. Redhead ducklings were the most numerous diving duck hatched from monitored over-water nests while blue-winged teal ducklings were the most numerous dabbling duck hatched from monitored upland nests (Table 16).

Recruitment of Ducks. One hundred broods were counted in 1992 and 183 in 1993 (Table 17). Dabbling-duck broods accounted for 66.0% of all broods in 1992, 74.3% in 1993, and 87.8% during 1950-53 (Table 17).

Counted on wetlands from distant observation points with binoculars or telescopes were 66% of all broods in 1992, 60.7% in 1993, and 75.0% in 1950-53.

Because many wetlands in 1992 were completely choked with emergents, brood counting was difficult. For example, only 20 of 505 (4.0%) wetlands had enough open water in 1992 for the survey of broods with binoculars or telescopes; whereas in 1953, broods could be surveyed by this technique in a minimum of 79 of 505 (16.0%) wetlands. In 1993, abundant rainfall allowed additional wetlands to be surveyed for broods with binoculars or telescopes.

In 1992, 25.0% of the counted broods were mallards, 19.0% were blue-winged teal, 16.0% were gadwalls, 5.0% were northern shovelers, 1.0% were wood ducks; 19.0% were redheads, 7.0% were ruddy ducks, and 4.0% were canvasbacks (Table 17).

Table 17. Brood densities (broods/km^2) and species composition (%) of counted broods in the Waubay study area, Day County, South Dakota, 1950-1953, 1992-1993.

	# of Broods		Production (Broods/km^2)		1950-53 Production (Broods/km^2)					Percent of Total Broods		
Species	1992	1993	1992	1993	1950	1951	1952	1953	4-yr. Avg.	1992	1993	1950-53
Dabbling ducks												
Mallard	25	24	0.9	0.8	0.7	0.9	0.8	1.0	0.8	25.0	13.1	9.3
Gadwall	16	26	0.5	0.9	1.2	1.0	2.0	1.4	1.4	16.0	14.2	15.3
Northern pintail	0	4	0.0	0.2	0.4	0.8	1.0	0.7	0.7	0.0	2.2	8.1
Green-wing teal	0	1	0.0	tr.	0.0	0.0	0.1	tr.	tr.	0.0	0.5	0.4
Blue-wing teal	19	69	0.7	2.4	3.7	4.6	5.3	5.4	4.7	19.0	37.7	52.2
Northern shoveler	5	12	0.2	0.4	0.2	0.2	0.2	0.2	0.2	5.0	6.6	2.1
Americanwigeon	0	0	0.0	0.0	0.0	0.0	tr.	0.1	tr.	0.0	0.0	0.4
Wood duck	1	0	tr.	0.0	—	—	—	—	—	1.0	0.0	—
Total dabblers	**66**	**136**	**2.3**	**4.7**	**6.2**	**7.5**	**9.4**	**8.8**	**7.8**	**66.0**	**74.3**	**87.8**
Diving ducks												
Redhead	19	9	0.7	0.3	0.2	0.1	0.5	0.2	0.2	19.0	4.9	2.5
Canvasback	4	9	0.2	0.3	0.0	0.1	0.1	0.0	tr.	4.0	4.9	0.4
Lesser scaup	0	1	0.0	tr.	tr.	0.1	0.1	0.1	0.1	0.0	0.5	0.9
Ruddy duck	7	17	0.2	0.6	0.1	0.8	1.2	0.9	0.8	7.0	9.3	8.5
Total divers	**30**	**36**	**1.1**	**1.2**	**0.3**	**1.1**	**1.9**	**1.2**	**1.1**	**30.0**	**19.6**	**12.3**
Unidentified	4	11	0.2	0.4	0.0	tr.	0.0	0.0	tr.	4.0	6.0	—
Total	**100**	**183**	**3.4**	**6.3**	**6.4**	**8.6**	**11.3**	**10.0**	**9.1**	**100.0**	**99.9**	**100.0**

In 1993, 37.7% of the counted broods were blue-winged teal, 14.2% were gadwalls, 13.1% were mallards, 6.6% were northern shovelers, 2.2% were northern pintails, 0.5% were green-winged teal; 9.3% were ruddy ducks, 4.9% were redheads, 4.9% were canvasbacks, and 0.5% were lesser scaup (Table 17).

During 1950-53, 52.2% of counted broods were blue-winged teal, 15.3% were gadwalls, 9.3% of the counted broods were mallards, 8.1% were northern pintails, 2.1% were northern shovelers, 0.4% were green-winged teal, 0.4% were American wigeon; 8.5% were ruddy ducks, 2.5% were redheads, 0.9% were lesser scaup, and 0.4% were canvasbacks (Table 17).

Brood Densities. Total brood densities did not differ statistically between 1992 and 1951. However, in 1993, total brood densities ($t=2.11$, $df=12$, $P<0.10$) were significantly less than in 1953. In 1992-93, total brood densities ($t=1.94$, $df=12$, $P<0.10$) were significantly less than during 1950-53 (Table 18).

The density of broods of all species decreased since the early 1950s except for northern shovelers, redheads, and canvasbacks (Table 19). Northern pintails showed the highest percentage decrease in brood densities since the early 1950s, and canvasbacks had the largest percentage increase (Table 19).

All species had percentage increases in brood densities from 1992 to 1993 except for redheads and mallards (Table 19).

Total brood densities during 1992 and 1993 were lower on average than during 1950-63 (Fig 14). For example, total brood density was 9.7/km^2 in 1963 and 3.4/km^2 in 1992 (Fig 14).

Indices of hen success in 1992-93 and 1950-53 follow the same pattern. Overall hen success was 14.2 in 1992-93 and 36.4 in 1950-53 (Table 20). Hen success in all species declined since 1950-53 (Table 20).

Table 18. Comparisons of brood densities (broods/km^2) of ducks (Anatinae) in the Waubay study area, Day County, South Dakota, 1951 vs. 1992, 1953 vs. 1993, and 1950-1953 mean vs. 1992-1993 mean with a 2-sample paired differences t-test.

Years Compared	*Broods/km^2*
1951[a] vs. 1992	
1951	8.57
1992	3.44*
1953[b] vs. 1993	
1953	9.96
1993	6.29**
1950-53 vs. 1992-93	
1950-53 Mean	9.11
1992-93 Mean	4.86**

[a] Weather patterns similar to 1992.

[b] Weather patterns similar to 1993.

* Marginally significant at α=0.20, df=12 (shown to minimize the chance of making a Type II error).

** Significant at α=0.10, df=12.

Table 19. Percent change of broods/km^2 in the Waubay study area, Day County, South Dakota, 1992-1993, 1950-1953.

Species	*Broods/km^2 1992*	*Broods/km^2 1993*	*% change from 1992 to 1993*	*Broods/km^2 Mean 1990s[a]*	*Broods/km^2 Mean 1950s[b]*	*% change from1950s to 1990s*
Dabbling ducks						
Mallard	0.9	0.8	- 4.5	0.9	0.9	- 2.3
Gadwall	0.5	0.9	+ 64.5	0.7	1.4	- 48.6
Northern pintail	0.0	0.2	+ 100.0	0.1	0.7	- 89.5
Blue-wing teal	0.7	2.4	+ 258.8	1.6	4.7	- 68.3
Northern shoveler	0.2	0.4	+ 100.0	0.3	0.2	+ 50.0
Total dabblers	**2.3**	**4.7**	**+ 104.3**	**3.5**	**7.9**	**- 55.7**
Diving ducks						
Redhead	0.7	0.3	- 52.9	0.5	0.2	+ 108.3
Canvasback	0.2	0.3	+ 50.0	0.3	tr.	+ 500.0
Ruddy duck	0.2	0.6	+ 200.0	0.4	0.8	- 47.5
Total divers	**1.1**	**1.2**	**+ 9.1**	**1.2**	**1.0**	**+ 15.0**
Total	**3.4**	**6.3**	**+ 79.8**	**4.9**	**9.0**	**- 49.4**

[a] Pooled 1992,1993.

[b] Pooled 1950,1951,1952,1953.

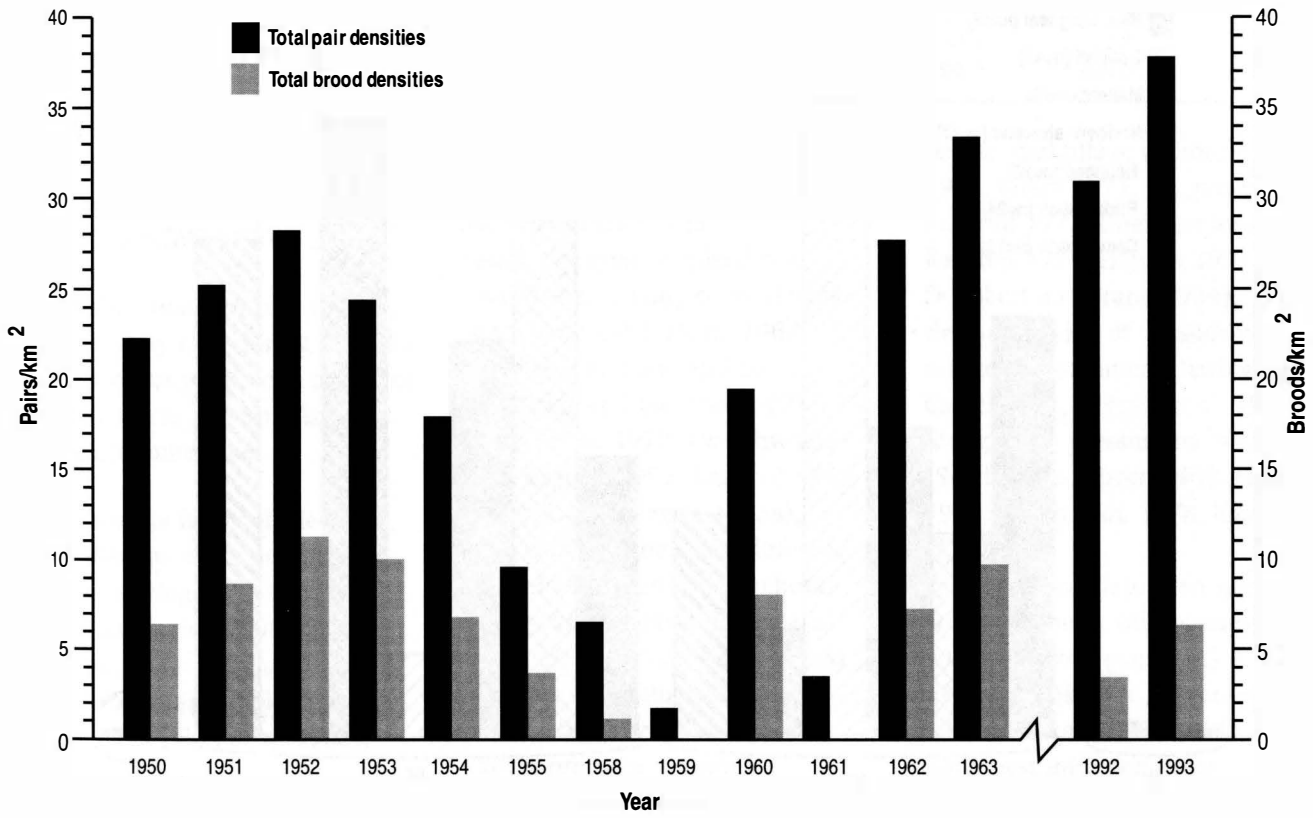

Figure 14. Annual pair densities (pairs/km^2) compared to annual brood densities (broods/km^2) in the Waubay study area, Day County, South Dakota, 1950-1955, 1958-1963, 1992-1993.

Table 20. Comparison of pair/brood ratio and hen success (broods/100 pairs) in the Waubay study area, Day County, South Dakota, 1950-1953, 1992-1993.

	Pair/Brood Ratio				Hen Success[a]			
Species	*1950s Mean*	*1992*	*1993*	*1990s Mean*	*1950s Mean*	*1992*	*1993*	*1990s Mean*
Dabbling ducks								
Mallard	4.3	8.1	9.6	8.3	23.5	12.3	10.4	12.0
Gadwall	2.8	9.4	4.6	6.3	35.9	10.6	22.0	15.9
Northern pintail	3.4	0.0	7.5	11.0	29.2	0.0	13.3	9.1
Green-wing teal	2.5	0.0	5.0	10.0				
Blue-wing teal	2.5	15.4	6.9	8.9	39.8	6.5	14.5	11.3
Northern shoveler	4.5	9.0	4.8	6.3	22.2	11.1	21.1	15.8
Total dabblers	**2.9**	**11.5**	**6.8**	**8.4**	**34.7**	**8.7**	**14.7**	**11.9**
Diving ducks								
Redhead	4.0	5.3	14.3	8.0	25.0	18.9	7.0	12.5
Canvasback	5.0	1.5	1.0	1.0				
Lesser scaup	4.0	0.0	1.0	1.0				
Ruddy duck[b]	1.1	4.0	2.2	2.8				
Total divers	**2.1**	**4.6**	**4.9**	**4.6**	**47.8**	**21.6**	**20.3**	**21.8**
Total	**2.7**	**9.1**	**6.0**	**7.0**	**36.4**	**11.0**	**16.6**	**14.2**

[a] Not calculated for species with pair densities < 0.7 pairs/km^2 because they were not calculated by Evans and Black (1956).

[b] Hen success not calculated for ruddy duck because of difficulty in accurately censusing the breeding population.

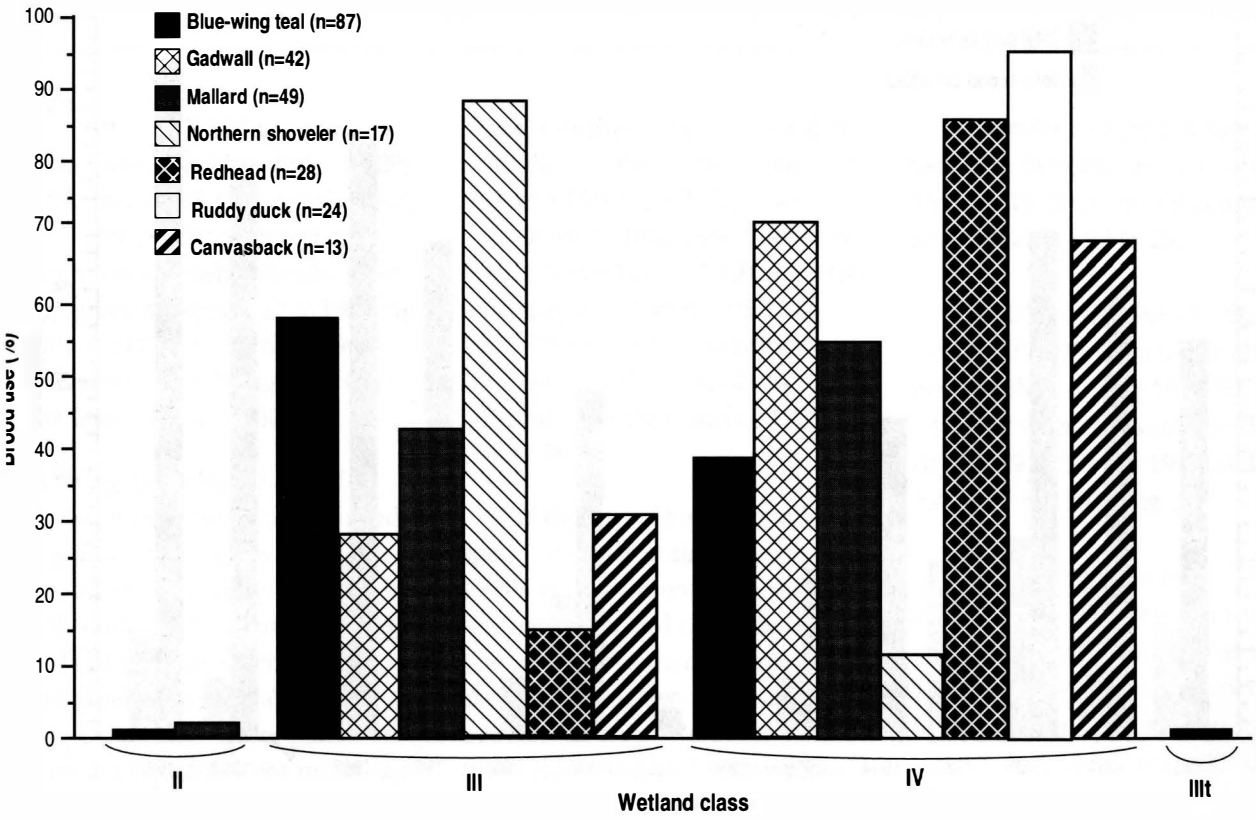

Figure 15. Use (%) of different wetland classes (Stewart and Kantrud 1971) by broods in the Waubay study area, Day County, South Dakota, 1992-1993.

Use of Different Wetland Classes and Sizes by Broods. Broods of blue-winged teal (58.6%) and northern shovelers (88.2%) were seen most frequently in class III wetlands. Broods of mallards (55.1%) and gadwalls (71.4%) were seen most often in class IV wetlands (Fig 15). Canvasback (69.2%) and redhead (85.7%) broods were seen most often in class IV wetlands (Fig 15). Ruddy duck broods were seen exclusively in class IV wetlands (Fig 15).

Broods of blue-winged teal, mallards, gadwalls, and northern shovelers were seen most frequently in wetlands larger than 0.81 ha in 1992 and 1993, whereas broods of redheads, canvasbacks, and ruddy ducks were seen most often on wetlands larger than 6.07 ha (Table 21). Broods of northern shovelers and canvasbacks were found in wetlands of various sizes.

Table 21. Use (%) of different wetland sizes (ha) by broods in the Waubay study area, Day County, South Dakota, 1992-1993.

	Dabbling Duck Species			
Wetland size (Hectares)	*Blue-wing teal (n=87)*	*Mallard (n=49)*	*Gadwall (n=42)*	*Northern shoveler (n=17)*
< 0.20	9.2	6.1	2.4	17.6
0.20 - 0.40	6.9	6.1	2.4	17.6
0.40 - 0.81	18.4	6.1	2.4	5.9
0.81 - 1.21	8.0	6.1	4.8	17.6
1.21 - 1.61	6.9	2.0	4.8	5.9
1.61 - 2.02	6.9	12.2	11.9	5.9
2.02 - 4.05	4.6	8.2	11.9	11.8
> 4.05	39.1	53.1	59.5	17.6
Total	**100.0**	**99.9**	**100.1**	**99.9**

	Diving Duck Species		
	Redhead (n=28)	*Ruddy duck (n=24)*	*Canvasback (n=13)*
< 0.20	0.0	0.0	7.7
0.20 - 0.40	0.0	0.0	0.0
0.40 - 0.81	3.6	0.0	0.0
0.81 - 1.21	3.6	0.0	15.4
1.21 - 1.61	0.0	0.0	0.0
1.61 - 2.02	7.1	4.2	7.7
2.02 - 4.05	3.6	4.2	0.0
4.04 - 6.07	3.6	0.0	7.7
6.07 - 8.09	21.4	33.3	7.7
> 8.09	57.1	58.3	53.8
Total	**100.0**	**100.0**	**100.0**

DISCUSSION

Abundances of North American duck species have been declining since 1955 (CWS/USFWS 1986).

Breeding pair densities in the Waubay study area during 1992-93 did not mirror population trends of breeding ducks in North America during the same time.

Yet, despite high pair densities in the Waubay study area, brood densities during 1992-93 were lower than during 1950-53, and clutch success was below levels needed to sustain stable duck population sizes (Klett *et al.* 1988).

Many landscape and biological factors affect clutch success and the recruitment rate of ducks.

Factors reported to increase clutch success and recruitment include but are not limited to

- adequate quality upland and over-water nesting cover (Evans and Black 1956, Martz 1967, Duebbert and Kantrud 1974, Duebbert and Lokemoen 1976, Krapu *et al.* 1979, Luttschwager and Higgins 1992, Kantrud 1993, Solberg and Higgins 1993a),
- adequate numbers and different classes of wetlands throughout spring and summer (Evans *et al.* 1952, Stoudt 1971, Kantrud and Stewart 1977, Ruwaldt *et al.* 1979, Higgins *et al.* 1992),
- lower predator densities (Duebbert and Kantrud 1974, Duebbert and Lokemoen 1980, Sovada 1993),
- less annual tillage (Milonski 1958, Miller 1971, Higgins and Kantrud 1973, Duebbert and Kantrud 1974, Higgins 1977, Duebbert and Frank 1984),
- delayed haying of uplands until mid to late summer (Oetting and Cassel 1971, Higgins *et al.* 1992),
- less grazing pressure by livestock (Sowls 1955, Kirsch 1969, Miller 1971, Kirsch *et al.* 1978, Kaiser *et al.* 1979),
- removal of predator den sites created by humans (old buildings, junk piles, rock piles, etc.) (Cowan 1973, Fritzell 1978, Greenwood 1981, Sargeant *et al.* 1993),
- early nest initiation dates (Higgins *et al.* 1992),
- low intra- and interspecific brood parasitism in over-water nests

(Weller 1959, Sayler 1985),
- adequate food for breeding hens and their ducklings (Bartonek and Hickey 1969, Krapu 1974, Swanson *et al.* 1979),
- reduced usage of agricultural pesticides (Sheehan *et al.* 1987, Grue *et al.*1988, Dieter 1993),
- lower mortality from disease (Smith *et al* .1990), and
- smaller hunter harvest rates (Anderson and Burnham 1976, Conroy and Krementz 1990, Smith and Reynolds 1992).

The landscape in the Waubay study area has undergone numerous changes since 1950-53, and these changes may explain the observed changes in duck abundances in the study area.

Major Changes Since 1950-53

Brood Densities and Hen Success. Brood densities of all duck species, except those of redheads and canvasbacks, were lower in 1992-93 than in the early 1950s, even though pair densities of most species in 1992-93 were similar or larger than those during 1950-53.

Redheads had been federally protected from hunting in the Central Flyway, at least in some areas, for 7 years and canvasbacks for 12 years since 1969 (Spencer Vaa, State Waterfowl Biologist, SDGFP, Brookings, pers comm). This may help explain their higher breeding populations.

During the 1950-53 period, many wetlands were in the open-water phase and over-water nesting habitat was limited. However, a sufficient amount of quality over-water nesting habitat has been present in or near the Waubay study area for the past 20 years. These factors may partially explain the apparent increase in the abundances of redheads and canvasbacks in the Waubay study area.

Hen success of all duck species was lower in 1992-93 than during 1950-53. Possible factors contributing to lower brood densities and hen success will be addressed in the rest of this section.

Annual Tillage. Much of the prairie pothole region was settled in the 1880s. Drainage of wetlands, conversion of grasslands to croplands, intensive cultivation, and excessive grazing all followed (Duebbert and Frank 1984). These factors are detrimental to waterfowl productivity (Milonski 1958, Miller 1971, Higgins and Kantrud 1973, Higgins 1977; Kirsch *et al.* 1978, Klett *et al.* 1988). Several studies show that converting grasslands to croplands contributes greatly to waterfowl declines.

Annually tilled acreage decreased substantially since the early 1950s, mostly because of conversion of cropland to idle grasslands enrolled in the CRP. The conversion of annually tilled land to CRP grasslands since 1950-53 should have increased the clutch success and brood density of upland nesting duck species in the Waubay study area in 1992-93 over those in 1950-53. Instead, clutch success was poorer and brood densities were lower in 1992 and 1993, suggesting that other factors were depressing the reproductive potential of ducks.

Conservation Reserve Program Grasslands. The importance of large, undisturbed fields of grassland to ducks that nest in upland habitats has been well documented. The number of ducklings hatched from nests located in large blocks of cool-season grasses mixed with legumes can be as much as six times greater than the number hatched from lands containing less suitable nesting cover (Duebbert and Kantrud 1974).

Upland nesting ducks recently have had high clutch success on blocks of CRP grasslands in eastern South Dakota (Luttschwager and Higgins 1992) and in south-central North Dakota and west-central Minnesota (Kantrud 1993). CRP grasslands provide dense residual cover that is important for nest sites of early nesting species (Sowls 1955, Martz 1967, Duebbert and Lokemoen 1976, Krapu *et al.*1979).

CRP grasslands replaced a large percentage of the annually tilled land on the study area since 1950-53. However, 10.9% of the remaining cropland is now planted to row crops (corn and soybeans). Row crops are poor nesting habitats for ducks (Moyle 1964), and the negative effects of row cropping may offset the positive benefits of CRP grasslands.

The remaining cropland is planted to small grain. Small grain fields are better habitat for upland nesting ducks than other types of annually tilled land (Higgins 1977, Duebbert and Kantrud 1987).

The kind, quality, and amount of upland nesting cover in the Waubay study area has changed substantially since 1950-53, but

the different habitats may be compensatory in relation to the potential recruitment of ducks.

Predator Community. High clutch success, especially in wet years, is needed by all species of ducks to increase population sizes, but predators can severely depress clutch success.

Mammalian predation has been the leading cause of nest destruction in several studies (Duebbert and Lokemoen 1976, Stoudt 1982, Higgins *et al.* 1992, Kantrud 1993, Solberg and Higgins 1993a).

Predation primarily by raccoons was the leading cause of destruction of over-water nests in the study area in 1992-93. On upland sites, red fox (*Vulpes vulpes*) and striped skunks (*Mephitis mephitis*) were the primary cause of nest destruction.

Raccoons are relatively recent inhabitants of the prairie pothole region (Sargeant *et al.* 1993). Historically, they occupied wooded hills and river valleys in the southeastern portion of the region until the 1940s and 1950s when they expanded their range because humans had altered the landscape (summarized by Sargeant *et al.* 1993).

The expansion of raccoons into formerly unoccupied areas has had an impact on the clutch success of ducks that nest over water. Olson (1964) found that the average clutch success by canvasbacks was 77% in southern Manitoba in 1953 when raccoons were absent but only 21% during 1959-61 when raccoons were common.

Raccoon survival is enhanced during harsh winters because the animals can use many unnatural den sites (old buildings, rock piles, junk piles, shelterbelts; Fritzell 1978) for shelter and cereal grains for food (Cowan 1973, Greenwood 1981), and both were abundant in the Waubay study area in 1992-93. Raccoons also use dense patches of cattails as winter den sites.

The number of coyotes (*Canis latrans*) has recently increased because of bans on 1080 poisoning and hunting from airplanes and snowmobiles, plus less hunting and trapping in response to low fur values (USFWS 1978, Sargeant 1982). Coyotes are common in and around the study area, and coyote numbers in northeastern South Dakota have nearly tripled since 1983 (SDGF&P Animal Damage Control, Pierre, unpub data).

Demographics. The number of occupied farms and landowners in the Waubay study area decreased since 1950-53. Buildings are still present on most of the abandoned farms and may provide possible den sites for predators.

At the same time, the average farm size in the Waubay study area has nearly doubled. These changes could have indirect effects on breeding waterfowl. Fewer residents in the study area may reduce hunting and trapping of predators. Furthermore, without an economic incentive for hunting or trapping predators, most people choose not to spend much time pursuing these activities (Sargeant 1982, Sovada 1993). These changes may be increasing predator populations in the study area and contributing to lower clutch success.

Wetland Vegetation. Cattails dominated many of the semi-permanent wetlands in the Waubay study area in 1992-93, whereas hardstem bulrush dominated during the early 1950s (Evans and Black 1956).

This is a major habitat change. However, cattails seem to be adequate nesting cover for ducks that nest over water because the largest percentage of nests over water in 1992-93 were in wetlands with dense, monotypic stands of cattail (residual and new growth).

Because data on clutch success from the 1950s were unavailable, we can only speculate that over-water clutch success was higher during 1950-53.

Many of the cattail-dominated wetlands in the study area have several smaller wetlands nearby that drain into them. Thus, these wetlands remain in the degenerating and lake marsh stages of the wet-dry cycle described by van der Valk and Davis (1978b) for long periods of time. Many of these wetlands no longer return to the important dry and regenerating marsh phases (van der Valk and Davis 1978b) except during extreme drought conditions.

Static water levels are optimum for cattail growth and result in dense, monotypic stands. Once established, either during an extreme drought or partial summer drawdown, cattails spread vigorously by vegetative means. Clones from a single plant of *Typha latifolia* can spread over an area as large as 58 m^2 within 2 years of establishment (Grace and Wetzel 1981).

Wetlands with a 50-50 interspersion of open-water and emergent vegetation (hemi-marsh) provide better food and cover resources for waterfowl (Weller and Spatcher 1965).

Solberg and Higgins (1993b) used Rodeo herbicide in an attempt to create a hemi-marsh environment in cattail-dominated wetlands of northeastern South Dakota. Most class IV wetlands in the Waubay study area in 1992 were completely choked with cattails and contained few open-water areas. However, in aerial photographs from the early 1950s, many of these wetlands were hemi-marshes, suggesting that they were more beneficial to breeding ducks because they were enhanced by better wetland vegetation and associated invertebrate populations (Voigts 1976, Nelson and Kadlec 1984) during 1950-53.

Minor Changes Since 1950-53

Introduction of Row Crops. Corn, soybeans, and sunflowers were not planted in the study area during the early 1950s (C. Evans, Lumni Island, Wash., and K. Black, Panama City, Fla., pers comm), but they were planted on 10.9% of the annually tilled land in 1992-93.

Several other studies also showed higher row crop acreages. Nomsen (1969) in Iowa, Vance (1976) in southeastern Illinois, and Taylor *et al.* (1978) in Nebraska reported substantial increases in row crops over time in their study areas. These changes have caused a shift from many diversified farms with small field sizes to fewer farms dominated by large fields of row crops (Taylor *et al.* 1978).

Row crops generally require larger amounts of fertilizers and pesticides (Grue *et al.* 1988). Several studies showed that pesticides reduced survival of ducklings (Sheehan *et al.* 1987, Grue *et al.* 1988, Martin *et al.* 1991, Dieter 1993). This may have occurred in the Waubay study area.

Introduction of Alfalfa. Alfalfa was not planted in the study area during the early 1950s (C. Evans, Lumni Island, Wash., and K. Black, Panama City, Fla., pers comm) but was growing on 3.4% of the tillable land in 1992-93.

Alfalfa is a nitrogen fixer and is regularly rotated with other crops in the Waubay study area. Farris *et al.* (1977) reported that alfalfa had largely replaced other hay crops in Iowa during 1950-74.

Alfalfa is often chosen as a nest site by upland-nesting ducks, and it is an important livestock forage. Alfalfa is usually harvested as hay three to four times annually. Many hens are killed by haying equipment each year, and nearly all of the clutches are left exposed to predators after cutting has occurred.

Therefore, if a substantial portion of dabbling duck hens nested in alfalfa in 1992-93, the reproductive output from this habitat type was probably low.

Trees and Shrubs. The percentage of land in the study area in trees and shrubs increased since 1950-53 because of new shelterbelts planted near agricultural fields to help prevent soil erosion and to protect farmsteads from the wind.

In contrast, aerial photographs revealed that most trees and shrubs in the study area during 1950-53 were native and grew near wetlands. Only a few shelterbelts existed.

The greater number of trees and shrubs and the maturation of older shelterbelts in the study area since 1950-53 may be indirectly lowering duckling numbers by providing numerous den sites for raccoons and striped skunks (Cowan 1973, Fritzell 1978).

Wetland Drainage. Frayer *et al.* (1983) estimated that 223,799 ha per year of palustrine emergent wetlands were destroyed from the 1950s through the 1970s, with large losses in Nebraska, North Dakota, South Dakota, and Texas. Dahl and Johnson (1991) estimated that 1,335,510 ha of palustrine emergent wetlands were lost in the U.S. between the mid 1970s and mid 1980s.

Many wetlands in the study area were drained prior to 1992-93, but we found no evidence of new drainage. Wetland losses in the Waubay study area were greatest before 1954 and after 1968. This is in agreement with other estimates. Wetland losses in northeastern South Dakota during 1974-80 were lower (1.5%) than those in southeastern portions of the state (7.6%; USFWS 1980).

Many wetlands (45.2%) in the Waubay study area were protected by federal easements, federal ownership (maps at Waubay National Wildlife Refuge), or by private landowners whose land use practices did not require drainage. This may

explain the relatively low loss of wetlands in the study area. Higgins and Woodward (1986) found lower drainage rates on wetlands protected by long-term federal easements.

Most drainage (85%) in the Waubay study area was for agriculture, although some earlier drainage (15%) was for road construction. Our findings are in agreement with Frayer *et al.* (1983) who found that 87% of the wetland losses between the 1950s and 1970s were associated with agriculture. Wetlands are often regarded as obstacles and are drained to gain cropland or to accommodate large modern farm machinery (Aus 1969).

Adequate wetland habitat for breeding pairs and broods still exists in the Waubay study area, but previous wetland drainage may be indirectly reducing the clutch success of ducks that nest over water. For example, flooding was the second leading cause of destruction in over-water nests in the study area in 1992-93.

Short, intense summer storms are a characteristic of this region, and a substantial amount of rain may fall in a short period. Smaller wetlands often drain into larger seasonal and semi-permanent wetlands by open ditches, resulting in rapid rises in water levels in the larger wetlands after summer storms. Most ducks that nest over water are able to elevate their nests with slowly rising water levels, but rapidly rising water levels can flood them out (Stoudt 1982).

Increased nest flooding because of wetland drainage could be one reason for lower brood densities by ducks that nested over water in 1992-93, but this may also have been a problem during 1950-53, because considerable drainage had already been completed.

Wetland Restoration. Since 1986, the USFWS has restored 28 drained wetland basins in the study area. These restored wetlands may benefit waterfowl populations by increasing the wetland habitat base for breeding pairs, nests, and broods and by decreasing the incidence of nest flooding.

Factors Remaining Unchanged Since 1950-53

Annual Precipitation. Precipitation data from 1950-93 shows that the fourth wettest summer on record in South Dakota was in 1992 and the wettest was in 1993 (A. R. Bender, South Dakota Weather in 1992 and 1993, Climatological Report). Precipitation data from the Waubay National Wildlife Refuge indicate that the summers of 1950 and 1953 were also wet.

The second coolest summer on record in South Dakota was in 1992, the third coolest was in 1993, and the fourth coolest was in 1951 (A. R. Bender, South Dakota Weather in 1992 and 1993, Climatological Report).

The combination of cool and wet weather during the summers of 1992 and 1993 could have lowered clutch success, brood survival, and overall recruitment of ducklings. Frequent rain and cold temperatures can lower the survival of young waterfowl (Untergasser and Hayward 1972, MacInnes *et al.* 1974) and reduce clutch success (Stoudt 1971, 1982).

Haying and Grazing Practices. The amount of land in the study area that was hayed or intensively grazed in 1992-93 was essentially unchanged since 1950-53.

However, new developments in haying equipment since the 1950s enable farmers to harvest forage more efficiently and more frequently. Haying destroys nests, kills hens, and removes residual nesting cover.

Hayed areas are usually dominated by cool-season forbs and grasses that do not regenerate immediately after cutting, thereby reducing the amount of residual cover available to early-nesting mallards and pintails the following spring.

All species of ducks that nest in uplands will begin nesting in mowed areas later than in unmowed areas (Martz 1967). Higher densities of duck nests also are found in residual cover associated with unmowed blocks of highway right-of-way than in mowed blocks in south-central North Dakota (Oetting and Cassel 1971, Voorhees and Cassel 1980).

Grazing can be beneficial or detrimental to ducks (Kirby *et al.* 1992). Sowls (1955) found that bluegrass pastures intensively grazed by livestock were useless to nesting ducks. Several studies have revealed higher densities of duck nests and higher clutch success in ungrazed fields than in grazed fields (Kirsch 1969, Miller 1971, Kirsch *et al.* 1978; Kaiser *et al.* 1979). However, Barker *et al.* (1990)

found that nest densities of ducks and clutch success were nearly equal on idle fields and pastures subjected to twice-over rotation, short duration, and switchback grazing systems. Cattle also trample cattails and create openings in plant-choked wetlands, benefitting breeding waterfowl by increasing the number of loafing sites and the number of potential breeding pairs (Sowls 1955).

Since the amount of land in the Waubay study area being hayed or grazed has not changed since 1950-53, it does not seem that these factors are responsible for lower brood densities in 1992-93.

Breeding Pair Densities. Breeding pair densities in 1992-1993 were greater than or equal to those during 1950-53 in the Waubay study area. Continent-wide breeding pair estimates did not follow a similar pattern, decreasing from 1992 to 1993 and remaining well below estimates from the 1950s.

Large numbers of breeding ducks in the study area in 1992 and 1993 paralleled good wetland conditions. Numerous studies have revealed sharp declines in pair densities on southern breeding areas during drought years and large increases in Arctic breeding areas during the same year (Smith 1970, Smith 1971, Stoudt 1971, Leitch and Kaminski 1985, Johnson and Grier 1988).

Northern pintails were the only species that failed to increase with the good wetland conditions in the study area in 1992-93. This suggests that the northern pintails are in a serious decline.

Since 1992-93 pair densities and wetland conditions were similar to those during 1950-53, we expected brood densities to be greater than or equal to those in 1950-53. However, 1992-93 brood densities were significantly lower.

When all environmental and cultural changes and their possible impacts on breeding waterfowl are considered, mammalian predation appears to be the factor most responsible for the lower reproductive output from upland and wetland habitats in the Waubay study area during 1992-93.

If mammalian predation is the main factor, further research is needed to find ways to limit their ability to destroy nests. For example, electric predator fences control predation and are socially acceptable (Lokemoen *et al.* 1982, Greenwood *et al.* 1990), but they are labor intensive, expensive to construct and maintain, and only applicable on a small scale. Techniques to reduce effects of predators on a larger area are needed, but they must be socially acceptable and economically feasible.

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Appendix A. Bird species[a] seen in the Waubay Study Area, Day County, South Dakota, 1992-1993, by common and scientific names.

Eared grebe, *Podiceps nigricollis*
Pied-billed grebe, *Podilymbus podiceps*
American white pelican, *Pelecanus erythrorhynchos*
Double-crested cormorant, *Phalacrocorax auritus*
American bittern, *Botaurus lentiginosus*
Great blue heron, *Ardea herodias*
Cattle egret, *Bubulcus ibis*
Snowy egret, *Egretta thula*
Black-crowned night heron, *Nycticorax nycticorax*
Lesser snow goose, *Chen caerulescens*
Canada goose, *Branta canadensis*
Wood duck, *Aix sponsa*
Green-winged teal, *Anas crecca*
Mallard, *Anas platyrhynchos*
Northern pintail, *Anas acuta*
Blue-winged teal, *Anas discors*
Northern shoveler, *Anas clypeata*
Gadwall, *Anas strepera*
American wigeon, *Anas americana*
Canvasback, *Aythya valisineria*
Redhead, *Aythya americana*
Ring-necked duck, *Aythya collaris*
Lesser scaup, *Aythya affinis*
Bufflehead, *Bucephala albeola*
Hooded merganser, *Lophodytes cucullatus*
Ruddy duck, *Oxyura jamaicensis*

Northern harrier, *Circus cyaneus*
Broad-winged hawk, *Buteo platypterus*
Swainson's hawk, *Buteo swainsoni*
Red-tailed hawk, *Buteo jamaicensis*
American kestrel, *Falco sparverius*
Cooper's hawk, *Accipiter cooperii*
Prairie falcon, *Falco mexicanus*

Gray partridge, *Perdix perdix*
Ring-necked pheasant, *Phasianus colchicus*
Sharp-tailed grouse, *Tympanuchus phasianellus*

Virginia rail, *Rallus limicola*
Sora rail, *Porzana carolina*
American coot, *Fulica americana*
Lesser golden plover, *Pluvialis dominica*
Killdeer, *Charadrius vociferus*
American avocet, *Recurvirostra americana*
Spotted sandpiper, *Actitis macularia*
Lesser yellowlegs, *Tringa flavipes*
Greater yellowlegs, *Tringa melanoleuca*
Willet, *Catoptrophorus semipalmatus*
Upland sandpiper, *Bartramia longicauda*
Hudsonian godwit, *Limosa haemastica*
Marbled godwit, *Limosa fedoa*
Short-billed dowitcher, *Limnodromus griseus*
Common snipe, *Gallinago gallinago*
Wilson's phalarope, *Phalaropus tricolor*

Franklin's gull, *Larus pipixcan*
Ring-billed gull, *Larus delawarensis*
Black tern, *Chlidonias niger*
Mourning dove, *Zenaida macroura*
Great horned owl, *Bubo virginianus*
Short-eared owl, *Asio flammeus*
Chimney swift, *Chaetura pelagica*

Red-headed woodpecker, *Melanerpes erythrocephalus*
Downy woodpecker, *Picoides pubescens*
Hairy woodpecker, *Picoides villosus*
Northern flicker, *Colaptes auratus*

Eastern wood-pewee, *Contopus virens*
Willow flycatcher, *Empidonax traillii*
Western kingbird, *Tyrannus verticalis*
Eastern kingbird, *Tyrannus tyrannus*
Horned lark, *Eremophila alpestris*

Tree swallow, *Tachycineta bicolor*
Cliff swallow, *Hirundo pyrrhonota*
Barn swallow, *Hirundo rustica*
Blue jay, *Cyanocitta cristata*
American crow, *Corvus brachyrhynchos*

Black-capped chickadee, *Parus atricapillus*
White-breasted nuthatch, *Sitta carolinensis*
House wren, *Troglodytes aedon*
Sedge wren, *Cistothorus platensis*
Marsh wren, *Cistothorus palustris*

Swainson's thrush, *Catharus ustulatus*
Eastern bluebird, *Sialia sialis*
American robin, *Turdus migratorius*
Brown thrasher, *Toxostoma rufum*
Gray catbird, *Dumetella carolinensis*
Cedar waxwing, *Bombycilla cedrorum*
European starling, *Sturnus vulgaris*

Yellow warbler, *Dendroica petechia*
Yellow-rumped warbler, *Dendroica coronata*
Common yellowthroat, *Geothlypis trichas*
American redstart, *Setophaga ruticilla*

American tree sparrow, *Spizella arborea*
Vesper sparrow, *Pooecetes gramineus*
Savannah sparrow, *Passerculus sandwichensis*
Grasshopper sparrow, *Ammodramus savannarum*
Swamp sparrow, *Melospiza georgiana*
Song sparrow, *Melospiza melodia*
Field sparrow, *Spizella pusilla*
White-throated sparrow, *Zonotrichia albicollis*
White-crowned sparrow, *Zonotrichia leucophrys*
Harris sparrow, *Zonotrichia querula*

Dark-eyed junco, *Junco hyemalis*
Bobolink, *Dolichonyx oryzivorus*
Red-winged blackbird, *Agelaius phoeniceus*
Western meadowlark, *Sturnella neglecta*
Eastern meadowlark, *Sturnella magna*
Yellow-headed blackbird, *Xanthocephalus xanthocephalus*
Common grackle, *Quiscalus quiscula*
Brown-headed cowbird, *Molothrus ater*
Northern oriole, *Icterus galbula*
Orchard oriole, *Icterus spurius*
American goldfinch, *Carduelis tristis*
House sparrow, *Passer domesticus*

[a]Common and scientific names follow Banks *et al.* (1987).

Appendix B. Wild mammals[a] seen in the Waubay Study Area, Day County, South Dakota, 1992-1993, by common and scientific names.

Coyote, *Canis latrans*
Red fox, *Vulpes vulpes*
Raccoon, *Procyon lotor*
Ermine, *Mustela erminea*
Least weasel, *Mustela nivalis*
Mink, *Mustela vison*
Badger, *Taxidea taxus*
Striped skunk, *Mephitis mephitis*
White-tailed deer, *Odocoileus virginianus*
Pronghorn, *Antilocapra americana*
Woodchuck, *Marmota monax*
Fox squirrel, *Sciurus niger*
Franklin's ground squirrel, *Spermophilus franklinii*

Richardson's ground squirrel, *Spermophilus richardsonii*
Thirteen-lined ground squirrel, *Spermophilus tridecemlineatus*
Plains pocket gopher, *Geomys bursarius*
Beaver, *Castor canadensis*
White-footed mouse, *Peromyscus leucopus*
Deer mouse, *Peromyscus maniculatus*
Meadow vole, *Microtus pennsylvanicus*
Muskrat, *Ondatra zibethicus*
Meadow jumping mouse, *Zapus hudsonius*
White-tailed jack rabbit, *Lepus townsendii*
Cottontails, *Sylvilagus*

[a]Common and scientific names follow Banks *et al.* (1987).

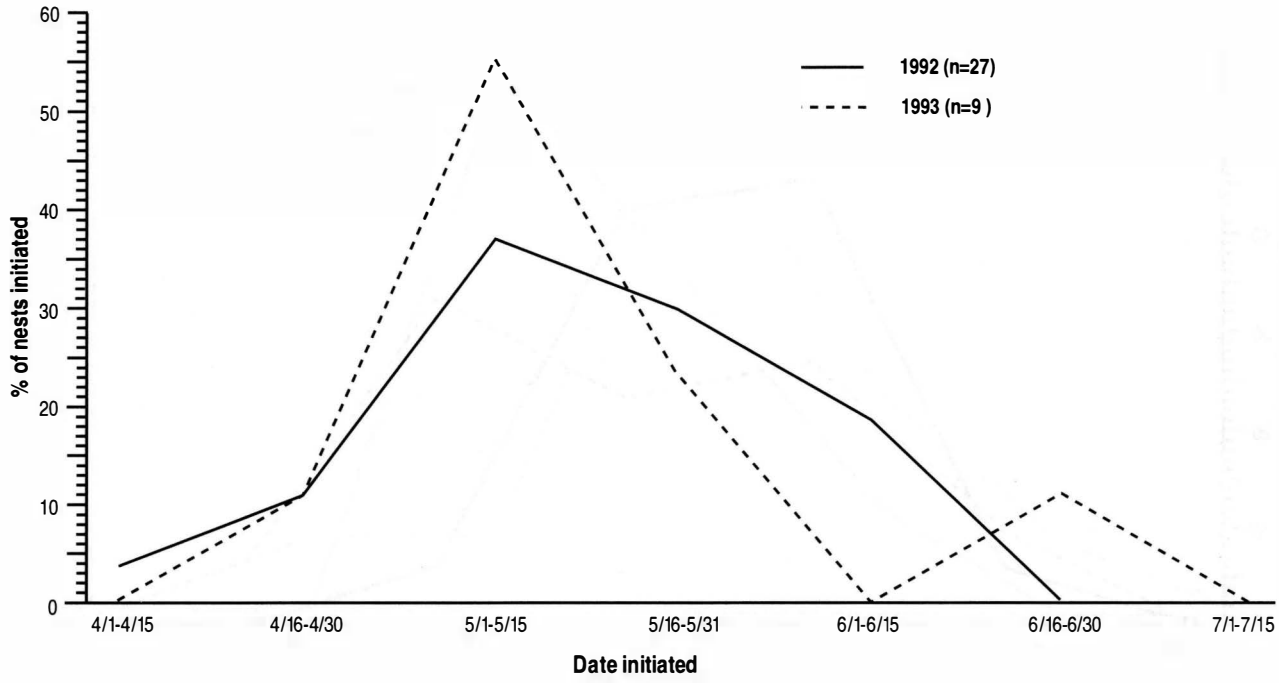
Appendix C. Reptiles and amphibians[a] seen in the Waubay Study Area, Day County, South Dakota, 1992-1993, by common and scientific names.

Northern prairie skink, *Eumeces septentrionalis*
Plains garter snake, *Thamnophis radix*
Painted turtle, *Chrysemys picta*
Plains leopard frog, *Rana blairi*
Northern leopard frog, *Rana pipiens*

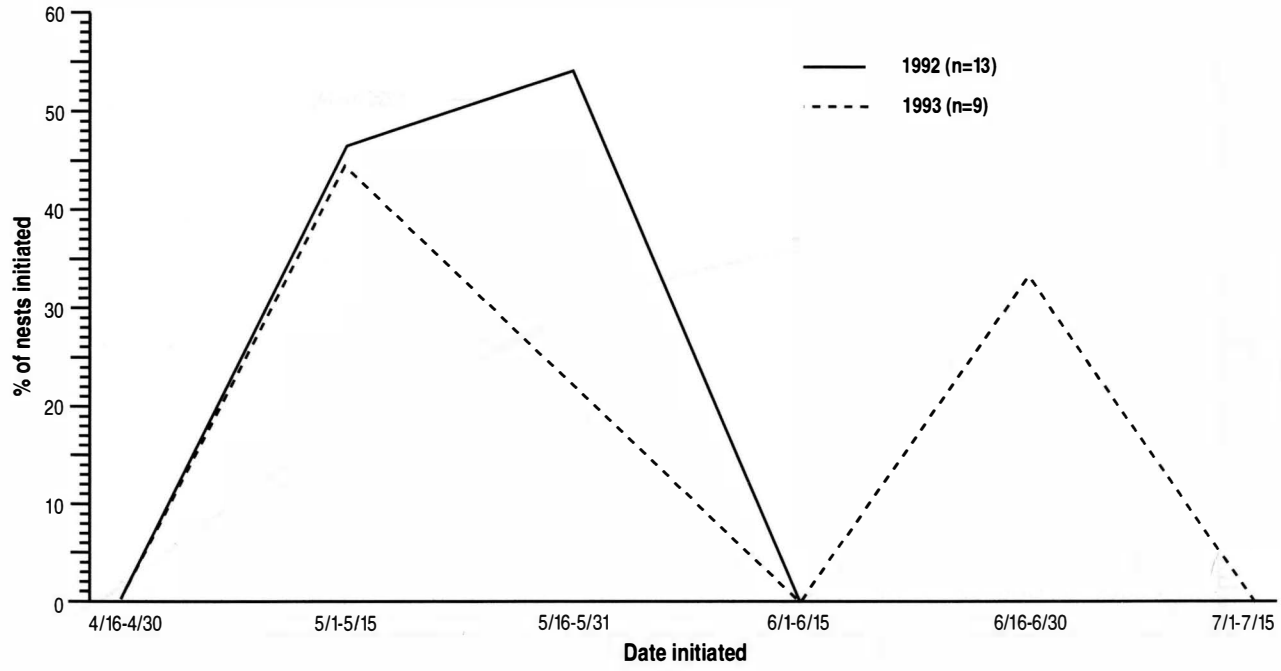
Great Plains toad, *Bufo cognatus*
Tiger salamander, *Ambystoma tigrinum*

[a]Common and scientific names follow Banks *et al.* (1987).

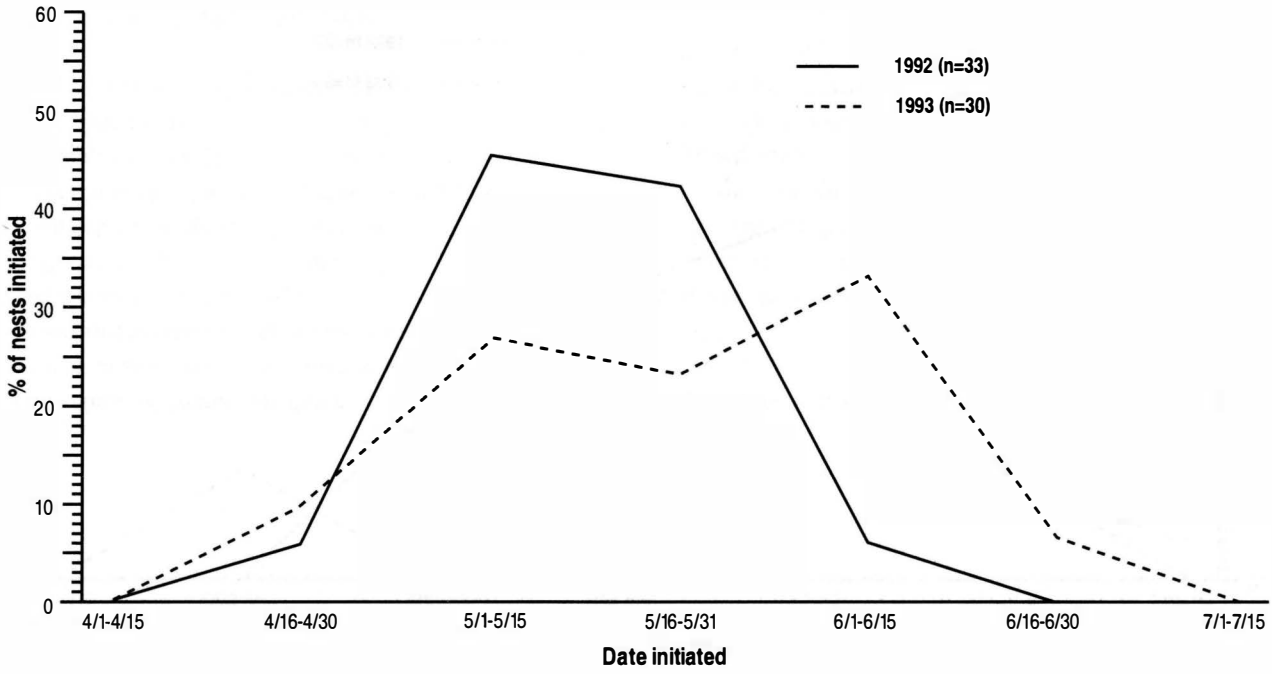
Appendix D. Percent distribution of nest intiation dates for 36 mallard nests found in the Waubay study area, Day County, South Dakota, 1992-1993.



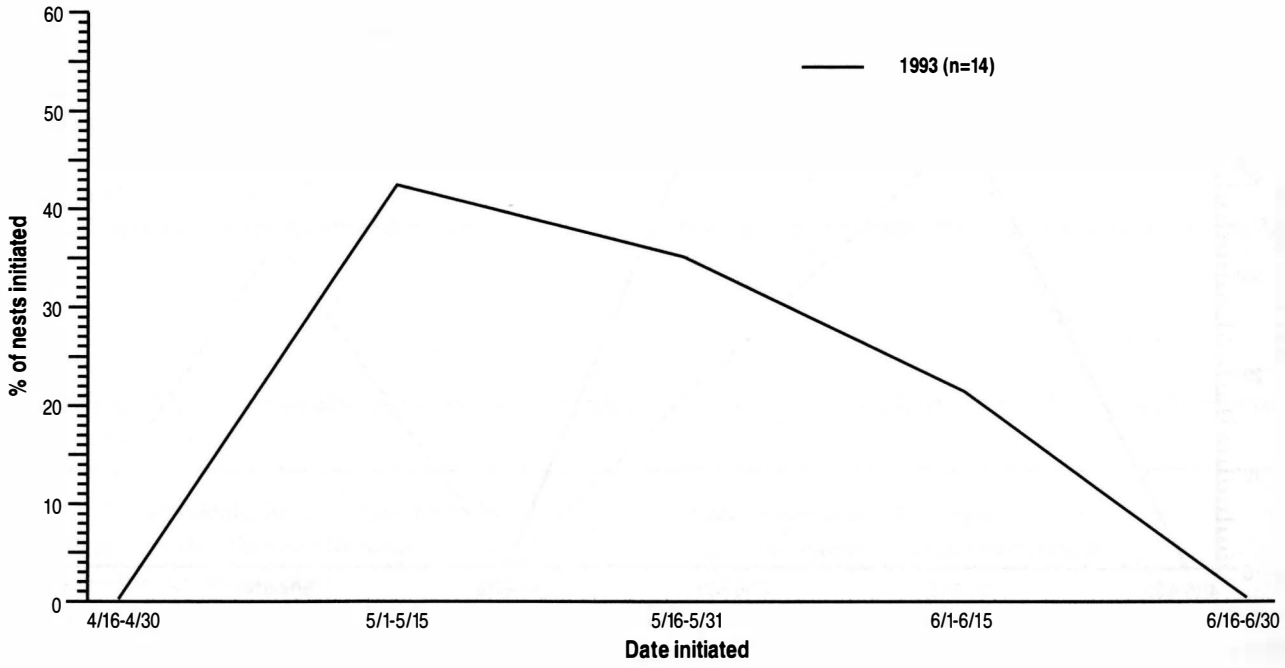
Appendix E. Percent distribution of nest intiation dates for 22 blue-winged teal nests found in the Waubay study area, Day County, South Dakota, 1992-1993.



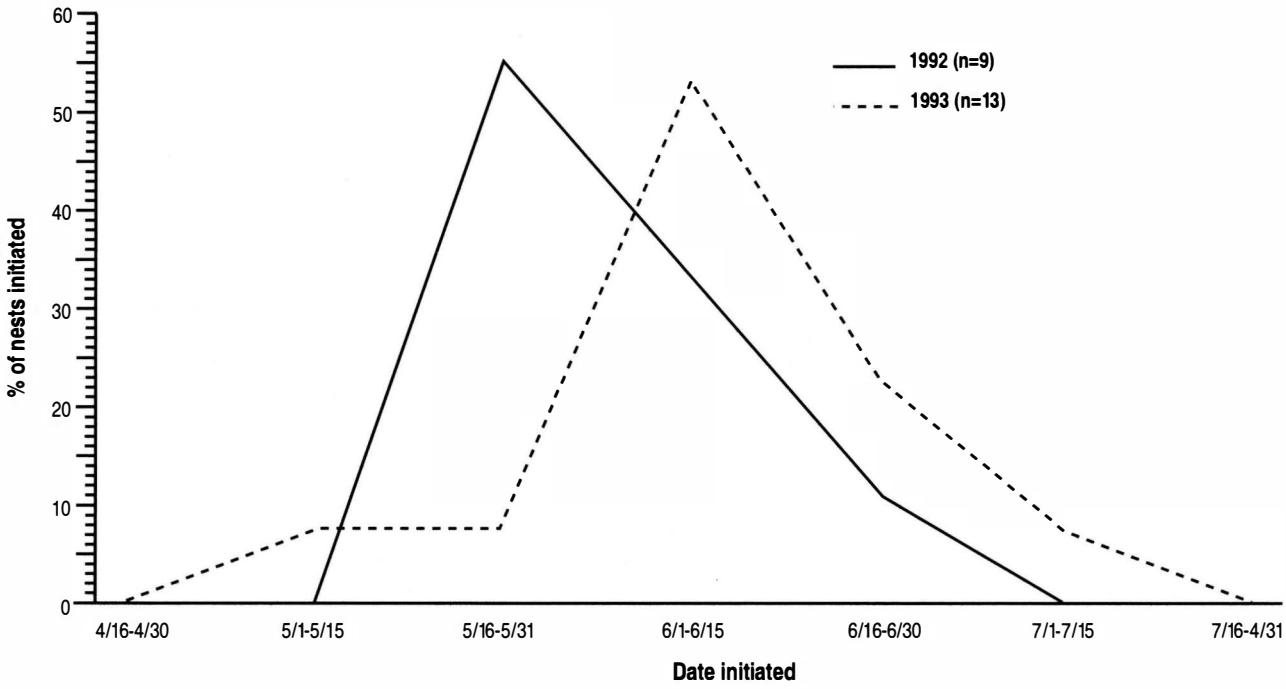
Appendix F. Percent distribution of nest intiation dates for 63 redhead nests found in the Waubay study area, Day County, South Dakota, 1992-1993.



Appendix G. Percent distribution of nest intiation dates for 14 canvasback nests found in the Waubay study area, Day County, South Dakota, 1992-1993.



Appendix H. Percent distribution of nest intiation dates for 22 ruddy duck nests found in the Waubay study area, Day County, South Dakota, 1992-1993.



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