

NUMBERS AND DISTRIBUTION OF  
WATERFOWL IN OKLAHOMA DURING  
WINTER AND SPRING

By

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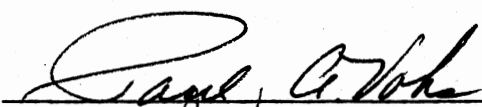
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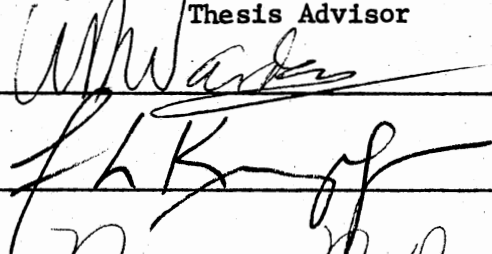
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## TABLE OF CONTENTS

	Page
INTRODUCTION . . . . .	1
DESCRIPTION OF STUDY AREA . . . . .	3
Climate . . . . .	3
Vegetation . . . . .	4
Water . . . . .	4
METHODS AND MATERIALS . . . . .	7
RESULTS . . . . .	10
Distribution of Study Sites . . . . .	10
Wetland Classification . . . . .	14
Waterfowl Numbers and Distribution . . . . .	14
DISCUSSION . . . . .	40
SUMMARY . . . . .	45
LITERATURE CITED . . . . .	47

# LIST OF TABLES

Table	Page
1. Distribution of $\frac{1}{4}$ -sections and wetlands throughout physiographic regions of Oklahoma during early winter (EW), late winter (LW), and spring (SP) . . . . .	11
2. Estimates ( $\pm$ SD) of hectares of surface water during early winter (EW), late winter (LW), and spring (SP) in Oklahoma . . . . .	12
3. Estimates of hectares of surface water per 100 hectares of land area during early winter (EW), late winter (LW), and spring (SP) in Oklahoma . . . . .	15
4. Distribution and numbers of wetlands in each stratum during early winter (EW), late winter (LW), and spring (SP) in Oklahoma . . . . .	16
5. Species and numbers of waterfowl observed on each wetland system during early winter in Oklahoma . . . . .	17
6. Species and numbers of waterfowl observed on each wetland system during late winter in Oklahoma . . . . .	18
7. Distribution of open and frozen (100% ice cover) wetlands during early winter (EW) and late winter (LW) in Oklahoma . . . . .	19
8. Species and numbers of waterfowl observed on each wetland system during spring in Oklahoma . . . . .	20
9. Numbers of waterfowl observed on each stratum during early winter (EW), late winter (LW), and spring (SP) in Oklahoma . . . . .	22
10. Population estimates ( $\pm$ SD) of species observed during early winter (EW), late winter (LW), and spring (SP) in Oklahoma . . . . .	23
11. Estimates ( $\pm$ SD) of waterfowl during early winter (EW), late winter (LW), and spring (SP) on each stratum in Oklahoma . . . . .	24

12. Population estimates ( $\pm$ SD) of species observed on each stratum during spring in Oklahoma . . . . .	25
13. Estimates of waterfowl per 100 hectares land area in each stratum during early winter (EW), late winter (LW), and spring (SP) in Oklahoma . . . . .	28
14. Population estimates for each species per 100 hectares land area in each stratum during spring in Oklahoma . . . . .	29
15. Estimates ( $\pm$ SD) of dabblers, divers, and geese during early winter (EW), late winter (LW), and spring (SP) in Oklahoma . . . . .	30
16. Estimates ( $\pm$ SD) of dabblers, divers, and geese on each stratum during early winter (EW) and late winter (LW) in Oklahoma . . . . .	31
17. Estimates ( $\pm$ SD) of dabblers, divers, and geese on each stratum during spring in Oklahoma . . . . .	32
18. Estimates of dabblers, divers, and geese per 100 hectares of land area during early winter (EW), late winter (LW), and spring (SP) in Oklahoma . . . . .	33
19. Population estimates ( $\pm$ SD) for each species observed on each stratum during early winter in Oklahoma . . . . .	34
20. Population estimates ( $\pm$ SD) for each species observed on each stratum during late winter in Oklahoma . . . . .	36
21. Population estimates for each species per 100 hectares of land area in each stratum during early winter in Oklahoma . . . . .	38
22. Population estimates for each species per 100 hectares of land area in each stratum during late winter in Oklahoma . . . . .	39

FIGURE

Figure

Page

1. Distribution of physiographic regions and location of study sites in Oklahoma . . . . .	4
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## INTRODUCTION

Recent information on numbers and distribution of wintering waterfowl and wetland habitats in Oklahoma is lacking. The purpose of this report is to provide information on the habitat preferences of waterfowl and capability of wetlands to support waterfowl during winter and during spring migration in Oklahoma.

Waterfowl numbers, species diversity, and distribution are directly related to the abundance, quality, and management of wetland habitat. Over 500,000 ducks and geese winter in Oklahoma and larger numbers occur during migration (Barclay 1976). The carrying capacity of the wintering habitat may influence the density of the breeding or nesting population in the subsequent spring (Heit 1948).

Activities of man, including creation of new wetland areas, planting of foods, and alteration of seasons and bag limits, influence the distribution of wintering waterfowl (Buller 1975). Construction of stock-watering ponds and reservoirs for irrigation, navigation, hydroelectric power, municipal and industrial water, and flood control purposes during recent decades has increased surface water in Oklahoma (Allen 1975, Gorham 1975, Slimak 1975) and created waterfowl habitat where little or none existed previously (Barclay 1976).

Objectives of this study were to provide data on numbers and distribution of waterfowl, and to determine the relative importance of specific wetland types to waterfowl in winter and during spring migration in Oklahoma.

The study was funded by Pittman-Robertson funds, project number W-128-R, in conjunction with the Oklahoma Department of Wildlife Conservation and the U.S. Fish and Wildlife Service.

## DESCRIPTION OF STUDY AREA

Oklahoma lies in the Central Lowlands region of the Central Flyway (Buller 1964). The surface area of Oklahoma is  $181,089 \text{ km}^2$  and includes  $2,945 \text{ km}^2$  of inland water (McReynolds 1979). Curtis and Ham (1957) stratified the state into 25 physiographic regions ranging in area from 47,738 to 4,545,802 ha. Study sites occurred in 23 of the physiographic regions (Fig. 1).

### Climate

Oklahoma has a continental climate with pronounced seasonal and geographic ranges in temperature and precipitation. The mean annual temperature ranges from 18 C in the extreme southeast to 12 C in the Panhandle. Average January temperatures are 0 C in the northwest and 7 C in the extreme southeast (Gray and Galloway 1959). The winters are usually short and mild, and snow is infrequent.

Annual precipitation averages 38 cm in the Panhandle, 65 cm in the northwest and 115 cm in the southeast (Duck and Fletcher ca 1943). Seventy-five percent of the annual precipitation falls during the March through October growing season. Average length of the growing season varies from 180 days in the Panhandle to 240 days in the extreme southeast (Gray and Galloway 1959).

Average annual evaporation from lakes varies from 122 cm in extreme eastern Oklahoma to 165 cm in the southwest (Oklahoma Water Resources Board 1976). Evapotranspiration and percolation amount to 85% of the



annual rainfall (Oklahoma Water Resources Board 1976).

During this study (1978-79) the winter was the most severe in 20 years. The average December (1978) temperature was 3.5 C, 1.5 C below average, with 24 days of temperatures below 0 C. An average of 4.8 cm of snow and sleet occurred, and the maximum depth of snow, sleet, and ice on the ground was 4.3 cm (U.S. Department of Commerce 1979a). The average January (1979) temperature was -4.2 C. Temperatures were 7.2 C below average, and temperatures were below 0 C for 30 days. An average of 21.5 cm of snow and sleet occurred, and the maximum depth of snow, sleet, and ice on the ground was 9.4 cm (U.S. Department of Commerce 1979b). The average February (1979) temperature was -1.2 C. Temperatures were 5.1 C below average, and temperatures were below 0 C for 23 days. An average of 14.2 cm of snow and sleet occurred, and the maximum depth of snow, sleet and ice on the ground was 14.6 cm (U.S. Department of Commerce 1979c).

## Vegetation

Eastern forests merge with the prairies and plains of the west in Oklahoma. The habitats of Oklahoma were classified by Duck and Fletcher (ca 1943) as forested types (post-oak blackjack, bottomland, oak pine, oak hickory, loblolly pine hardwood), shrub grassland types (pinon juniper-mesa, sand sage grassland, shinnery grassland, stabilized dune), and agricultural grasslands (tall grass prairie, mixed grass-eroded plains, and short grass-high plains).

## Water

Precipitation is the source of virtually all ground water in Oklahoma.

Oklahoma's major ground water aquifers are stream deposits of limestones, sandstone, and gypsum. These contain an estimated 370 billion kl of water (Marcher 1972). Ground water supplies over 56% of the total reported water used and 80% of the irrigation needs in Oklahoma (Oklahoma Water Resources Board 1976). Runoff ranges from 0.5 cm/yr in the Panhandle to 51 cm/yr in the southeast (Marcher 1972).

The state contains approximately 1,800 lakes with a surface area of 4 ha or more and approximately 190,000 farm ponds of less than 4 ha. The storage capacity of the 21 largest reservoirs is 13.6 billion kl (Marcher 1972).

## METHODS AND MATERIALS

The state was stratified according to the physiographic regions of Curtis and Ham (1957) (Fig. 1). Intersections of township and range lines were numbered within each physiographic region, and stratified random sampling (Steel and Torrie 1960:418) was used to select 123 cluster centers. These centers were proportionately distributed according to the area of each strata, with a minimum of 2 cluster centers per strata. Two physiographic strata were too small to contain a cluster center plus 36 surrounding sections. These 2 strata were dropped from the study. Four  $\frac{1}{4}$ -sections were randomly selected from each quadrant surrounding a cluster center. Similar methods were used to sample breeding waterfowl populations in North Dakota (Stewart and Kantrud 1973, 1974) and in South Dakota (Brewster et al. 1976, McEnroe 1976, Flake et al. 1977, Mack 1977, Roberson 1977).

The presence or absence of wetlands on the  $\frac{1}{4}$ -section study sites was determined from Agricultural Stabilization and Conservation Service (ASCS) aerial photographs, U.S. Geological Survey topographic survey maps, and visual observations. Ownership of the study sites was determined from ASCS plat maps, and permission for access was requested by an explanatory letter with returnable postcard followed by personal contact.

All study sites were visited twice between 15 December 1978 and 15 February 1979, and once between 12 March 1979 and 7 April 1979.

Waterfowl were censused on the study sites from  $\frac{1}{2}$  hr after sunrise until  $\frac{1}{2}$  hr before sunset by 2 observers equipped with binoculars and a 20X spotting scope. Waterfowl flushed on sites containing multiple wetlands were followed visually to avoid duplication in counting (Hammond 1969).

Aerial photographs of the study sites were obtained from the Aerial Photography Field Office in Salt Lake City if unavailable from county ASCS offices. All wetlands were identified and mapped on the photos. Surface area of each pond was drawn on cover maps during each visit. Area of the pond (ha), surface water area (ha), open water (ha), and shoreline length (m) were measured from the cover maps using a Numonics Model 1224 Digitizer.

Wetlands on the study sites were individually classified using the operational draft of Classification of Wetlands and Deep-water Habitats of the U.S., proposed by Cowardin et al (1977). Modifications of the modifier, subsystem, and class descriptions and terminology were made to more specifically identify wetlands in Oklahoma.

Data collected in the field were coded onto IBM 80 column cards. All computer analyses used programs in the Statistical Analysis System (SAS) (Barr and Goodnight 1971).

Estimates and variances of waterfowl populations and hectares of surface water were calculated using statistical procedures found in Cochran (1963). Expanded estimates of waterfowl present were calculated by multiplying the mean number of waterfowl observed per sample  $\frac{1}{4}$ -section by the total number of  $\frac{1}{4}$ -sections in each stratum or the number of  $\frac{1}{4}$ -section in Oklahoma to derive the statewide estimate. Expanded estimates of surface water were calculated by multiplying the mean hectares of

surface water occurring on the sample  $\frac{1}{4}$ -sections by the total number of  $\frac{1}{4}$ -sections in each stratum or the total number of  $\frac{1}{4}$ -sections in the state for the statewide estimate. A t-test (Steele and Torrie 1960) was used to evaluate differences in the number of waterfowl between strata.

## RESULTS

### Distribution of Study Sites

Random selection resulted in 492  $\frac{1}{4}$ -section study sites distributed throughout 23 physiographic strata (Table 1). This resulted in 1 study site per 36,650 ha. Stratum 12 and stratum 13 were not sampled because of the linear shape and the inability to meet the random selection criteria for a cluster center surrounded by 36 sections. Strata 8, 9, and 14 contained no wetlands on the  $\frac{1}{4}$ -sections selected for sampling.

A total of 177  $\frac{1}{4}$ -sections contained wetlands, 293  $\frac{1}{4}$ -sections contained no wetlands, and access was denied to 22  $\frac{1}{4}$ -sections. The 22  $\frac{1}{4}$ -sections were excluded from the study.

Of the  $\frac{1}{4}$ -sections sampled in the western strata (7, 8, 11-17), 89.8% contained no wetlands. Only 50.4% of the  $\frac{1}{4}$ -sections sampled in the eastern strata (1-6, 9, 10, 19-25) contained no wetlands. In stratum 18, central Oklahoma, only 46.0% of the  $\frac{1}{4}$ -sections sampled contained no wetlands.

Exclusive of riverine wetlands, total of 168,794 ha ( $SD \pm 9,908$ ) was calculated for a statewide estimate of wetland area in early winter. This total increased from early winter to late winter to spring (Table 2). The statewide proportion of surface water per 100 ha land area was 0.9.

Stratum 1, in southeast Oklahoma ranks 1st in ha of surface water (13.7-14.1/100 ha land) followed by stratum 10, in northeast Oklahoma

Table 1. Distribution of  $\frac{1}{4}$ -sections and wetlands throughout physiographic regions of Oklahoma during early winter (EW), late winter (LW), and spring (SP).

Stratum	Hectares(HA) of land	$\frac{1}{4}$ -Sections with water			$\frac{1}{4}$ -Sections without water <sup>1</sup>			$\frac{1}{4}$ -Sections with water Access denied
		EW	LW	SP	EW	LW	SP	
1	74,260	3	3	3	5	5	5	
2	742,605	2	2	2	21	21	21	1
3	254,607	2	2	2	6	6	6	
4	543,693	7	7	7	1	1	1	
5	74,260	1	1	1	7	7	7	
6	175,043	5	5	5	3	3	3	
7	177,043	3	3	3	5	5	5	
8	47,739				3	3	3	1
9	243,999				8	8	8	
10	400,476	5	5	5	5	5	5	2
11	1,108,603	2	3	3	14	13	13	
12	198,912							
13	53,043							
14	342,129				8	8	8	
15	1,188,168	1	1	1	11	11	11	
16	2,137,641	5	4	5	59	60	59	
17	697,518	1	1	1	15	15	15	
18	4,545,802	62	60	66	57	59	53	5
19	1,177,559	26	26	27	9	9	8	1
20	1,201,428	9	9	9	15	15	15	4
21	368,650	3	3	3	8	8	8	1
22	323,564	6	6	6	1	1	1	1
23	1,790,208	22	22	22	22	22	22	4
24	583,475	7	8	9	8	7	6	1
25	68,956	5	5	5	2	2	2	1
Total	18,519,381	177	176	185	293	294	285	22

<sup>1</sup> As determined from aerial photographs and topographic maps ca 1970.

Table 2. Estimates ( $\pm$  SD) of hectares of surface water during early winter (EW), late winter (LW), and spring (SP) in Oklahoma.

Stratum	EW		LW		SP	
1	10,151 $\pm$	4,953	10,455 $\pm$	5,101	10,460 $\pm$	5,103
2	60 $\pm$	42	60 $\pm$	41	60 $\pm$	41
3	3,244 $\pm$	2,124	3,244 $\pm$	2,124	3,242 $\pm$	503
4	1,609 $\pm$	31	1,609 $\pm$	31	2,321 $\pm$	31
5						
6	322 $\pm$	88	322 $\pm$	88	304 $\pm$	89
7	388 $\pm$	189	399 $\pm$	150	399 $\pm$	150
8						
9						
10	18,197 $\pm$	6,065	18,197 $\pm$	6,065	18,196 $\pm$	6,065
11	173 $\pm$	118	476 $\pm$	255	562 $\pm$	302
12						
13						
14						
15	309 $\pm$	309	309 $\pm$	309	1,113 $\pm$	1,113
16	744 $\pm$	322	806 $\pm$	393	1,139 $\pm$	493
17	10,624 $\pm$	10,624	10,624 $\pm$	10,624	10,624 $\pm$	10,624
18	15,665 $\pm$	1,363	17,334 $\pm$	1,561	18,613 $\pm$	1,510
19	19,964 $\pm$	1,928	21,747 $\pm$	2,099	35,530 $\pm$	3,149
20	34,269 $\pm$	9,225	34,207 $\pm$	9,208	35,208 $\pm$	9,477

Table 2. Continued.

Stratum	EW		LW		SP	
21	377	195	377	195	1,152	595
22	790	132	790	132	1,502	250
23	20,340	3,102	20,426	3,117	21,989	3,353
24	2,570	713	3,169	761	5,084	1,051
25	374	97	375	97	456	118
Total	168,749	9,908	174,572	10,249	198,798	11,193

(4.5/100 ha land) (Table 3).

The number of wetlands present increased from 321 (EW) to 330 (LW) to 349 (SP) as dry wetlands became filled from rainfall and runoff.

#### Wetland Classification

Three major wetland systems, lacustrine, palustrine, and riverine were identified on the  $\frac{1}{4}$ -section study sites in Oklahoma. Twenty classes were identified as riverine, 14 as lacustrine, and 42 as palustrine. Eighty-six percent of the wetlands visited were classified as palustrine. The remainder were 7% riverine and 7% lacustrine (Table 4).

#### Waterfowl Numbers and Distribution

A total of 980 waterfowl of 13 species was observed on 22  $\frac{1}{4}$ -sections in early winter, 1,122 waterfowl of 11 species on 22  $\frac{1}{4}$ -sections in late winter, and 984 waterfowl of 12 species on 44  $\frac{1}{4}$ -sections in spring.

Predominant species in winter included mallards (Anas platyrhynchos), Canada geese (Branta canadensis), and common mergansers (Mergus merganser). Green-winged teal (A. crecca) and Canada geese predominated in spring.

Eighty-four percent of the waterfowl observed in winter were seen on lacustrine systems (Tables 5, 6), while only 2-5% were seen on palustrine systems. Due to the prolonged cold weather, many wetlands were frozen during winter (Table 7). During spring, use of lacustrine systems was reduced to 61% of all waterfowl observed and use of palustrine systems increased to 37%. Only 2% of the total waterfowl were observed on riverine systems in spring (Table 8).

In early winter, 33% of the lacustrine wetlands sampled, 36% of the

Table 3. Estimates of hectares of surface water per 100 hectares of land area during early winter (EW), late winter (LW), and spring (SP) in Oklahoma.

Stratum	Season		
	EW	LW	SP
1	13.7 <sup>1</sup>	14.1	14.1
2	tr <sup>2</sup>	tr	tr
3	1.3	1.3	1.3
4	0.3	0.3	0.4
5			
6	0.2	0.2	0.2
7	0.2	0.2	0.2
8			
9			
10	4.5	4.5	4.5
11	tr	tr	tr
12			
13			
14			
15	tr	tr	0.1
16	tr	tr	tr
17	1.5	1.5	1.5
18	0.3	0.4	0.4
19	1.7	1.8	3.0
20	2.8	2.8	2.9
21	0.1	0.1	0.3
22	0.2	0.2	0.5
23	1.1	1.1	1.2
24	0.4	0.5	0.9
25	0.5	0.5	0.7
Total	0.9	0.9	1.1

<sup>1</sup> Does not include riverine wetlands

<sup>2</sup> Trace amount less than 0.1

Table 4. Distribution and numbers of wetlands in each stratum during early winter (EW), late winter (LW), and spring (SP) in Oklahoma.

Stratum	Lacustrine			Palustrine			Riverine		
	EW	LW	SP	EW	LW	SP	EW	LW	SP
1	3	3	3						
2				1	1	1	1	1	2
3	1	1	1	1	1	1			
4				14	14	15			
5							3	3	3
6				8	8	8			
7	1	1	1	4	4	4			
8									
9									
10	1	1	1	4	4	4			
11	1	1	1	1	2	2			
12									
13									
14									
15				1	1	1			1
16	1	1	1	4	4	8			
17	1	1	1						
18	5	5	5	87	88	93	5	7	8
19	3	3	3	45	49	50	5	5	5
20	1	1	1	10	8	10	2	2	2
21				5	5	5			
22				11	11	12	3	3	3
23	4	4	4	46	46	47	2	2	3
24	1	1	1	19	22	22	1	1	1
25	1	1	1	14	14	14			
Total	24	24	24	275	282	297	22	24	28

Table 5. Species and numbers of waterfowl observed on each wetland system during early winter in Oklahoma.

Species	Lacustrine (%)	Palustrine (%)	Riverine (%)	Total
Mallard	328 (81)	15 (4)	60 (15)	403
Pintail	50 (100)			50
Gadwall	8 (31)		18 (69)	26
Wigeon	50 (66)		26 (34)	76
Green-winged teal	15 (94)	1 (6)		16
Wood duck			17 (100)	17
Ring-necked duck	4 (100)			4
Lesser scaup	1 (100)			1
Common goldeneye	28 (65)		15 (35)	43
Common merganser	12 (100)			12
Hooded merganser	4 (100)			4
Canada goose	327 (100)			327
Blue goose	1 (100)			1
Total	828 (84)	16 (2)	136 (14)	980

Table 6. Species and numbers of waterfowl observed on each wetland system during late winter in Oklahoma.

Species	Lacustrine (%)	Palustrine (%)	Riverine (%)	Total
Mallard	245 (67)	13 (4)	106 (29)	364
Pintail	7 (50)	7 (50)		14
Gadwall			2 (100)	2
Wigeon	2 (100)			2
Green-winged teal	31 (97)	1 (3)		32
Ring-necked duck	10 (100)			10
Common goldeneye	2 (14)	1 (7)	11 (78)	14
Bufflehead	2 (100)			2
Common merganser	101 (100)			101
Hooded merganser	14 (77)		4 (23)	18
Canada goose	528 (94)	35 (6)		563
Total	942 (84)	57 (5)	123 (11)	1,122

Table 7. Distribution of open and frozen (100% ice cover) wetlands during early winter (EW) and late winter (LW) in Oklahoma.

Census	<u>Palustrine</u>		<u>Lacustrine</u>		<u>Riverine</u>	
	Open	Frozen	Open	Frozen	Open	Frozen
EW	185 (67%)	90 (33%)	17 (71%)	7 (29%)	20 (91%)	2 (9%)
LW	92 (33%)	190 (67%)	12 (50%)	12 (50%)	20 (83%)	4 (19%)

Table 8. Species and numbers of waterfowl observed on each wetland system during spring in Oklahoma.

Species	Lacustrine (%)	Palustrine (%)	Riverine (%)	Total
Mallard		10 (83)	2 (17)	12
Gadwall	8 (38)	13 (62)		21
Wigeon	2 (100)			2
Shoveler		12 (75)	4 (25)	16
Blue-winged teal	2 (50)	2 (50)		4
Green-winged teal	62 (16)	301 (80)	13 (4)	376
Wood duck		12 (100)		12
Redhead	14 (100)			14
Ring-necked duck		5 (100)		5
Lesser scaup		5 (100)		5
Bufflehead		6 (100)		6
Canada goose	510 (99)	1 (1)		511
Total	598 (61)	367 (37)	19 (2)	984

riverine wetlands, and only 1.5% of the palustrine wetlands were utilized by waterfowl. In late winter, 29% of the lacustrine wetlands, 25% of the riverine wetlands, and 2.8% of the palustrine wetlands sampled were utilized by waterfowl. Use of palustrine wetlands increased to 10.4% in spring, while 41.7% of lacustrine wetlands sampled and only 7.1% of riverine wetlands were used.

Waterfowl were observed in 8 strata during winter and 14 during spring (Table 9). Total numbers of waterfowl were greatest in stratum 17 during winter. Strata 18 and 19 had the greatest number of waterfowl during spring.

#### Estimates of Waterfowl

The statewide estimate and standard deviation for each species observed during early winter, late winter, and spring are presented in Table 10. Mallards, Canada geese, and common mergansers were the most prominent species in winter, while Canada geese and green-winged teal were the most prominent species in spring.

Estimates of mallard (A. acuta), gadwall (A. strepera), wigeon (A. americana), wood duck (Aix sponsa), lesser scaup (Aythya affinis), common goldeneye (Bucephala clangula), and blue goose (Anser caerulescens) decreased from early winter to late winter. Increases were observed in numbers of green-winged teal, ring-necked duck (Aythya collaris) and Canada geese (Table 10).

Increases in number of waterfowl were observed on strata 1, 11, 16, 17, 19 and 22 from early winter. Decreases were noted for strata 5, 18, 20, 23, and 24 (Table 11). Distribution of waterfowl in spring was more uniform with a greater number of strata being utilized (Table 12).

Table 9. Numbers of waterfowl observed on each stratum during early winter (EW), late winter (LW), and spring (SP) in Oklahoma.

Stratum	EW	LW	SP	Total
1		6		6
4			2	2
5	97	17		114
6			4	4
10			2	2
11		35	2	37
15			19	19
16		3	23	26
17	440	802	14	1,256
18	143	61	601	805
19	103	106	274	483
20	1		4	5
22	13	92	4	109
23	6		15	21
24	177		7	184
25			13	13
Total	980	1,122	984	3,086

Table 10. Population estimates ( $\pm$  SD) of species observed during early winter (EW), late winter (LW), and spring (SP) in Oklahoma.

Species	EW		LW		SP	
Mallard	246,173	$\pm$ 202,381	235,739	$\pm$ 150,256	8,911	$\pm$ 4,411
Pintail	33,664	$\pm$ 33,639	7,980	$\pm$ 5,649		
Gadwall	13,705	$\pm$ 9,585	1,427	$\pm$ 1,427	7,725	$\pm$ 3,774
Wigeon	37,391	$\pm$ 33,727	1,210	$\pm$ 1,209	2,140	$\pm$ 2,139
Green-winged teal	8,628	$\pm$ 7,509	18,363	$\pm$ 12,429	220,350	$\pm$ 137,779
Wood duck	2,437	$\pm$ 2,429			7,615	$\pm$ 3,176
Ring-necked duck	2,139	$\pm$ 1,488	5,625	$\pm$ 4,482	2,477	$\pm$ 1,708
Lesser scaup	773	$\pm$ 773			3,218	$\pm$ 3,216
Common goldeneye	18,301	$\pm$ 13,496	3,181	$\pm$ 1,965		
Common merganser	6,418	$\pm$ 5,023	67,863	$\pm$ 67,280		
Hooded merganser	2,139	$\pm$ 2,137	8,061	$\pm$ 5,724		
Canada goose	207,164	$\pm$ 132,984	391,041	$\pm$ 338,891	305,528	$\pm$ 302,372
Blue goose	605	$\pm$ 605				
Bufflehead			1,069	$\pm$ 1,069	3,184	$\pm$ 2,646
Shoveler					13,890	$\pm$ 7,769
Blue-winged teal					2,280	$\pm$ 1,614
Redhead					9,425	$\pm$ 9,418
Total	579,542	$\pm$ 378,112	741,564	$\pm$ 301,759	586,750	$\pm$ 329,852

Table 11. Estimates ( $\pm$  SD) of waterfowl during early winter (EW), late winter (LW), and spring (SP) on each stratum in Oklahoma.

Stratum	EW		LW		SP	
1			860 $\pm$	857		
4					2,099 $\pm$	2,098
5	13,906 $\pm$	6,835	2,437 $\pm$	2,429		
6					1,352 $\pm$	1,020
10					1,237 $\pm$	1,236
11			37,453 $\pm$	37,435	2,140 $\pm$	2,139
15					29,054 $\pm$	29,045
16			1,548 $\pm$	1,546	11,864 $\pm$	6,162
17	296,245 $\pm$	296,024	539,973 $\pm$	539,572	9,426 $\pm$	9,398
18	86,547 $\pm$	78,798	36,918 $\pm$	24,377	363,738 $\pm$	326,510
19	55,094 $\pm$	27,886	56,699 $\pm$	30,343	146,560 $\pm$	133,579
20	773 $\pm$	773			3,093 $\pm$	2,348
21						
22	9,280 $\pm$	8,471	65,677 $\pm$	65,631	2,856 $\pm$	2,854
23	3,770 $\pm$	2,187			9,425 $\pm$	9,418
24	113,928 $\pm$	113,839			4,506 $\pm$	3,370
25					1,978 $\pm$	1,398

Table 12. Population estimates ( $\pm$  SD) of species observed on each stratum during spring in Oklahoma.

Species	4	6	10	11	15	16	17
Mallard		676 $\pm$ 675			3,058 $\pm$ 3,057		
Gadwall							
Wigeon				2,140 $\pm$ 2,139			
Shoveler					6,117 $\pm$ 6,115		
Blue-winged teal							
Green-winged teal					19,879 $\pm$ 19,873	4,127 $\pm$ 2,491	
Wood duck	2,099 $\pm$ 2,098		1,237 $\pm$ 1,236				
Redhead							9,426 $\pm$ 9,419
Ring-necked duck		338 $\pm$ 337					
Lesser scaup							
Bufflehead						2,579 $\pm$ 2,577	
Canada goose		338 $\pm$ 337				2,579 $\pm$ 2,577	

Table 12. Continued.

Species	18	19	20	22	23	24	25
Mallard	3,631 $\pm$ 2,695		1,546 $\pm$ 1,545				
Gadwall	6,052 $\pm$ 3,600						1,674 $\pm$ 1,131
Wigeon							
Shoveler	3,631 $\pm$ 3,628			2,856 $\pm$ 2,853		1,287 $\pm$ 1,286	
Blue-winged teal	1,120 $\pm$ 1,209	1,070 $\pm$ 1,069					
Green-winged teal	45,997 $\pm$ 25,697	139,072 $\pm$ 133,543	1,546 $\pm$ 1,545		9,425 $\pm$ 9,418		304 $\pm$ 303
Wood duck							
Redhead		4,279 $\pm$ 2,038					
Ring-necked duck		2,140 $\pm$ 1,674					
Lesser scaup						3,218 $\pm$ 3,216	
Bufflehead	605 $\pm$ 605						
Canada goose	302,611 $\pm$ 302,361						

Approximately 42, 20, and 19 waterfowl per 100 ha were estimated for strata 17, 24, and 5 respectively during early winter. Largest numbers were estimated in stratum 17 (77/100 ha) and stratum 22 (20.3) during late winter. Stratum 19 (12.4) and stratum 18 (8.0) had the greatest number of waterfowl per 100 ha in spring (Tables 13, 14). The differences in total numbers of waterfowl in each strata were not significant ( $p > 0.05$ ).

Dabblers and geese were the most predominant waterfowl observed during winter and spring followed by divers (Table 15). Dabblers were observed on 7 strata during early winter, and on 7 strata during late winter (Tables 16, 17). Divers were observed on strata 5, 19, and 20 during early winter and on strata 5, 17, and 19 during late winter. During early winter geese were observed on strata 17, 18, and 24, and on strata 11, 17, and 18 during late winter. Differences in numbers of dabblers, divers and geese were not significant ( $p > 0.05$ ).

Estimates of dabblers per 100 ha of land decreased in strata 5 and 17 from early winter to late winter to spring, and increased on strata 19 and 22 (Table 18). Estimates of geese increased on stratum 17 and decreased on stratum 24 from early winter to late winter. Divers increased on stratum 17 and decreased on stratum 19 from early winter to late winter. Strata 19 and 5 had the greatest diversity and largest numbers of waterfowl in winter (Tables 19, 20, 21, 22).

Table 13. Estimates of waterfowl per 100 hectares of land area in each stratum during early winter (EW), late winter (LW), and spring (SP) in Oklahoma.

Stratum	Season		
	EW	LW	SP
1		1.2	
4			0.8
5	18.7	3.3	
6			0.8
10			0.3
11		3.4	0.2
15			2.4
16		0.1	0.5
17	42.5	77.4	1.4
18	1.9	0.8	8.0
19	4.7	4.8	12.4
20	0.1		0.3
22	2.9	20.3	0.9
23	0.2		0.5
24	19.52		0.8
25			2.9

Table 14. Population estimates for each species per 100 hectares of land area in each stratum during spring in Oklahoma.

Species	4	6	10	11	15	16	17	18	19	20	22	23	24	25
Mallard		0.4			0.3			0.1		0.1				
Gadwall								0.1						2.4
Wigeon				0.2										
Shoveler					0.5			0.1			0.9		0.2	
Blue-winged teal								tr <sup>1</sup>	0.1					
Green-winged teal					1.7	0.2		1.0	11.8	0.1		0.5		0.4
Wood duck	0.4		0.3							0.4				
Redhead							1.3							
Ring-necked duck		0.2							0.2					
Lesser scaup													0.5	
Bufflehead						0.1		tr						
Canada goose		0.2				0.1		6.7						

<sup>1</sup> Trace less than 0.1

Table 15. Estimates ( $\pm$  SD) of dabblers, divers, and geese during early winter (EW), late winter (LW), and spring (SP) in Oklahoma.

	EW	LW	SP
Dabblers	342,000 $\pm$ 269,844	264,722 $\pm$ 152,758	262,915 $\pm$ 140,829
Divers	29,773 $\pm$ 21,716	85,802 $\pm$ 69,184	18,306 $\pm$ 10,439
Geese	207,770 $\pm$ 133,306	391,041 $\pm$ 338,891	308,107 $\pm$ 302,405

Table 16. Estimates ( $\pm$  SD) of dabblers, divers, and geese on each stratum during early winter (EW) and late winter (LW) in Oklahoma.

Stratum	Dabblers		Divers		Geese	
EW						
5	12,186 $\pm$	5,930	1,720 $\pm$	1,122		
17	269,313 $\pm$	269,113			26,931 $\pm$	26,911
18	15,131 $\pm$	9,557			71,416 $\pm$	71,357
19	27,814 $\pm$	12,864	27,279 $\pm$	6,854		
20			773 $\pm$	773		
22	9,280 $\pm$	8,471				
23	3,770 $\pm$	3,187				
24	4,506 $\pm$	4,502			109,422 $\pm$	109,337
LW						
1	860 $\pm$	857				
5	287 $\pm$	286	2,150 $\pm$	2,143		
11					47,453 $\pm$	37,435
16	1,548 $\pm$	1,546				
17	134,657 $\pm$	134,556	68,675 $\pm$	68,624	336,642 $\pm$	336,391
18	19,972 $\pm$	15,856			16,946 $\pm$	16,932
19	41,722 $\pm$	25,838	14,977 $\pm$	8,524		
22	65,677 $\pm$	65,631				

Table 17. Estimates ( $\pm$  SD) of dabblers, divers and geese on each stratum during spring in Oklahoma.

Stratum	Dabblers		Divers		Geese	
4	2,099 $\pm$	2,098				
5						
6	676 $\pm$	675	338 $\pm$	337	338 $\pm$	337
10	1,237 $\pm$	1,236				
11	2,140 $\pm$	1,139				
15	29,054 $\pm$	29,045				
16	4,127 $\pm$	2,491	2,579 $\pm$	2,577	5,158 $\pm$	5,153
17			9,426 $\pm$	9,419		
18	60,522 $\pm$	27,444	605 $\pm$	605	302,611 $\pm$	302,361
19	144,421 $\pm$	134,588	2,140 $\pm$	1,674		
20	3,092 $\pm$	2,137				
22	2,856 $\pm$	2,853				
23	9,425 $\pm$	9,418				
24	1,287 $\pm$	1,286	3,218 $\pm$	3,216		
25	1,978 $\pm$	1,398				

Table 18. Estimates of dabblers, divers and geese per 100 hectares of land area during early winter (EW), late winter (LW), and spring (SP) in Oklahoma.

Stratum	Dabblers			Divers			Geese		
	EW	LW	SP	EW	LW	SP	EW	EW	SP
1		1.2							
4			0.4						
5	16.4	0.4		2.3	2.9				
6			0.4			0.2			0.2
10			0.3						
11			0.2					3.4	
15			2.4						
16		0.1	0.2			0.1			0.2
17	38.6	19.3			9.8	1.4 <sup>1</sup>	3.9	48.3	
18	0.3	0.4	1.3			tr <sup>1</sup>	1.6	0.4	6.7
19	2.4	3.5	12.3	2.3	1.3	0.2			
20			0.3	0.1					
22	2.9	20.3	0.9						
23	0.2		0.5						
24	0.8		0.2			0.6	18.7		
25			2.9						

<sup>1</sup> Trace less than 0.1

Table 19. Population estimates ( $\pm$  SD) for each species observed on each stratum during early winter in Oklahoma.

	5	17	18	19
Mallard	5,161 $\pm$ 2,537	201,985 $\pm$ 201,835	14,525 $\pm$ 9,191	15,512 $\pm$ 9,947
Pintail		22,664 $\pm$ 33,639		
Gadwall	860 $\pm$ 561			4,279 $\pm$ 4,275
Wigeon	3,727 $\pm$ 2,432	33,664 $\pm$ 33,639		
Green-winged teal			605 $\pm$ 605	8,023 $\pm$ 7,484
Wood duck	2,437 $\pm$ 2,429			
Ring-necked duck				2,140 $\pm$ 1,488
Lesser scaup				
Common goldeneye	1,720 $\pm$ 1,122			16,582 $\pm$ 13,449
Common merganser				2,140 $\pm$ 2,138
Canada goose		26,931 $\pm$ 26,911	70,811 $\pm$ 70,752	
Blue goose			605 $\pm$ 605	

Table 19. Continued.

	20	22	23	24
Mallard		714 $\pm$ 713	3,770 $\pm$ 3,187	4,506 $\pm$ 4,502
Pintail				
Gadwall		8,567 $\pm$ 8,560		
Wigeon				
Green-winged teal				
Wood duck				
Ring-necked duck				
Lesser scaup	773 $\pm$ 773			
Common Goldeneye				
Common merganser				
Hooded merganser				
Canada goose				109,422 $\pm$ 109,337
Blue goose				

Table 20. Population estimates ( $\pm$  SD) for each species observed on each stratum during late winter in Oklahoma.

Species	1	5	11	16
Mallard	860 $\pm$ 857	287 $\pm$ 286		1,032 $\pm$ 1,031
Pintail				
Gadwall				
Wigeon				
Green-winged teal				516 $\pm$ 515
Ring-necked duck				
Common goldeneye		1,577 $\pm$ 1,571		
Bufflehead				
Common merganser				
Hooded merganser		573 $\pm$ 571		
Canada goose			37,453 $\pm$ 37,435	

Table 20. Continued.

Species	17	18	19	22
Mallard	134,657+134,556	3,631+ 2,247	31,024+18,499	64,249+64,204
Pintail		4,237+ 4,233	3,744+ 3,741	1,428+ 1,427
Gadwall		1,210+ 1,209		
Wigeon				
Green-winged teal		10,894+10,293	6,954+ 6,947	
Ring-necked duck	1,347+ 1,346		4,279+ 4,275	
Common goldeneye				
Bufflehead			1,070+ 1,069	
Common merganser	67,328+ 67,278		535+ 534	
Hooded merganser			7,488+ 5,595	
Canada goose	336,642+336,391	16,946+16,932		

Table 21. Population estimates for each species per 100 hectares of land area in each stratum during early winter in Oklahoma.

Species	5	17	18	19	20	22	23	24
Mallard	6.9	29.0	0.3	1.3		0.2	0.2	0.8
Pintail		4.8						
Gadwall	1.2			0.4		2.6		
Wigeon	5.0	4.8						
Green-winged teal			tr <sup>1</sup>	0.7				
Wood duck	3.3							
Ring-necked duck				0.2				
Lesser scaup					0.1			
Common goldeneye	2.3			1.4				
Common merganser				0.5				
Hooded merganser				0.2				
Canada goose		3.9	1.6					18.7
Blue goose			tr					

<sup>1</sup> Trace less than 0.1.

Table 22. Population estimates for each species per 100 hectares of land area in each stratum during late winter in Oklahoma.

Species	1	5	11	16	17	18	19	22
Mallard	1.2	0.4		tr <sup>1</sup>	19.3	0.1	2.6	19.9
Pintail						0.1	0.3	0.4
Gadwall						tr		
Wigeon								
Green-winged teal				tr		0.2	0.6	
Ring-necked duck					0.2		0.4	
Common goldeneye	2.1						0.1	
Bufflehead							0.1	
Common merganser					9.6			
Hooded merganser	0.8						0.6	
Canada goose			3.4		48.3	0.4		

<sup>1</sup> Trace less than 0.1.

## DISCUSSION

The initial effort to estimate the wintering populations of waterfowl in Oklahoma by strata and for the state occurred simultaneously with record low temperatures and above normal snowfall. The above normal snowfall and below normal temperatures during the past winter (1978-79) probably altered "normal" wintering waterfowl numbers, species composition, and distribution. Low water conditions existed throughout 1978, and ice covered most large and small reservoirs during winter. Sixty-three percent of the wetlands in the sample were frozen during the late winter survey. Ice and snow cover present for a prolonged period corresponded with major changes in the species composition of the wintering populations and numbers of individuals within species.

The sampling method employed to estimate waterfowl numbers was designed to provide the best possible estimate based on land area. The data presented on waterfowl numbers present by strata vary in statistical validity with the number of samples in each stratum. Therefore, estimates of numbers within strata should be evaluated relative to the number of samples obtained. The numbers are presented to provide baseline information useful for comparison with data obtained in succeeding years.

Mallards, common mergansers, and Canada geese were the most prominent species in Oklahoma during the extreme weather conditions. Canada geese comprised 42.3% of all waterfowl observed, mallards 36.5%,

and mergansers 5.6%. Mallards were observed in the greatest number of strata and appeared to be the most flexible in habitat requirements. All 3 species were reported by Marquardt (1962), Miller (1973), and Slimak (1975) as common winter residents in Oklahoma, but no estimates were provided.

Within the limitations of the adequacy of the strata estimates, estimates of the numbers of dabblers, divers, and geese by strata indicate differences in distribution of wintering waterfowl in Oklahoma. Stratum 19, Dissected Coastal Plain, had the greatest diversity of waterfowl species throughout the winter, and an estimate of 4.8 waterfowl per 100 ha of land area. Increasing the available surface water and improving food resources at existing wetlands in this stratum would probably result in the maximum increase in wintering waterfowl per unit of cost.

Stratum 18, Central Redbed Plains, the largest stratum (24.5% of state), contributed little to total wintering waterfowl populations when evaluated on the basis of land area. Only a few dabblers (0.4/100 ha land area) and geese (1.6-0.4/100 ha land area) were present during winter. The amount of surface water was also low (0.4/100 ha land area). Large area, low current use by waterfowl, and low surface water/land area ratio provide the greatest opportunity for percentage improvement as a wintering area. Increasing the amount of surface water may attract more waterfowl to this area.

The highest concentrations of dabblers, divers, and geese were estimated to have occurred in stratum 17, Western Redbed Plains, during winter. The estimate may have been biased by encountering relatively large numbers of birds on 1 study site and none on the limited

number of other sites. Data from future surveys are needed to place the estimates for this stratum in perspective.

Stratum 1, Beavers Bend Hills, contained the greatest amount of surface water (13.7/100 ha land area) but only a waterfowl density of 1.2/100 ha land area in late winter. Factors other than availability of surface water may have influenced waterfowl use in this stratum.

Stratum 16, High Plains, had a low density of mallards (0.1/100 ha land area) during late winter and has a greater potential for supporting migrating waterfowl. Most  $\frac{1}{4}$ -sections (92%) in the stratum sample were void of wetlands. Stratum 22, Arkansas Hill and Valley Belt, appeared to be an important area for wintering dabbling ducks in late winter, and had the highest concentrations of dabblers (20.3/100 ha land area).

No waterfowl were observed during winter on the sample plots in strata 2-4, 6-10, 12-15, 21, or 25. These strata were located in both eastern and western Oklahoma. Several of the strata occur in mountainous regions, and contain surface water/land area ratios comparable to other strata utilized by waterfowl. Absence of use by waterfowl of wetlands on the study plots and representativeness of the sample to the strata bears further investigation.

Waterfowl distribution and presence of wetland acreage did not appear to be directly related. Waterfowl were observed on strata with a large area of surface water (13.7/100 ha land area) and also on strata with only a trace amount of surface water.

Many local movements and habitat shifts may occur in midwinter relative to food availability (Bellrose and Hawkins 1947, Heit 1948, Hartman 1963, Nilsson 1969, Cornelius 1977), ice cover and open water

(Beer 1945, Anderson and Timken 1972), and/or hunter disturbance (Hochbaum 1960). Midwinter movements were apparent in Oklahoma during 1978-79 because waterfowl numbers changed in most strata from early winter to late winter. Decreasing temperatures and increasing ice cover on wetlands in Oklahoma were probably responsible for reductions in numbers of some species. Southward movement to Oklahoma and concentration on open water areas were probably responsible for increasing numbers of mergansers.

The attractiveness of Oklahoma to wintering waterfowl appears limited since only 6% of all wetlands on the  $\frac{1}{4}$ -sections containing wetlands was utilized by waterfowl during winter 1978-79. Only 3% of the wetlands within the sample framework was natural, the remainder were artificial. Generally, artificial wetlands encountered in this survey were not attractive to wintering waterfowl.

The predominant species occurring during the spring survey were green-winged teal and Canada geese. Waterfowl were more widely distributed in spring than in winter, and utilized a greater number of wetlands. Strata 18 and 19 had the highest concentrations of waterfowl, 8.0/100 ha land area and 12.4/100 ha land area, respectively, during spring.

Lacustrine and riverine wetlands were utilized by waterfowl to a greater extent than palustrine wetlands during winter. Lacustrine wetlands were used by 84% of the waterfowl observed, riverine wetlands were used by 11-14% of the waterfowl, and palustrine wetlands were used by 2-5% of the waterfowl observed during winter. Lacustrine and riverine wetlands probably represent the greatest potential, on a per wetland type basis, for supporting wintering waterfowl.

Increased use of palustrine wetlands by waterfowl (37%) occurred in spring. Use of riverine and lacustrine wetlands decreased to 2% and 61%, respectively, of waterfowl observed. In spring, waterfowl movements are slow and waterfowl prefer small, shallow bodies of water (Slimak 1975, Palmer 1976). Greater food availability, and courtship behavior of waterfowl, with mated pairs seeking isolated areas, may contribute to the increased use of smaller impoundments and wider distribution of waterfowl.

## SUMMARY

The purpose of this study was to provide information on numbers and distribution of waterfowl, and to determine the relative importance of major wetland types to waterfowl in winter and during spring migration in Oklahoma.

The state was stratified into 23 physiographic regions and a random sample of 492  $\frac{1}{4}$ -sections was selected. A total of 177  $\frac{1}{4}$ -sections contained wetlands, 293  $\frac{1}{4}$ -sections contained no wetlands, and access was denied to 22  $\frac{1}{4}$ -sections. Of the  $\frac{1}{4}$ -sections sampled in the western strata (7, 8, 11-17), 89.8% contained no wetlands. Only 50.4% of the  $\frac{1}{4}$ -sections sampled in the eastern strata (1-6, 10, 19-25) contained no wetlands. Eighty-six percent of the wetlands visited was classified as palustrine, 7% as riverine, and 7% as lacustrine.

Exclusive of riverine wetlands, a total of 168,794 (SD $\pm$ 9,908) ha of surface water was estimated in early winter, 174,572 (SD $\pm$ 10,249) ha in late winter, and 198,798 (SD $\pm$ 11,193) ha in spring.

The sampling method employed was optimized to provide the best possible statewide estimate based on land area. The estimates of waterfowl populations present by strata vary in statistical validity with the number of samples in each stratum.

Severe weather conditions existed throughout the winter, with record low temperatures and above normal snowfall. These conditions probably altered "normal" waterfowl numbers, species composition, and distribution. Decreasing temperatures and increasing ice cover

on wetlands in Oklahoma were probably responsible for reductions of some species in winter.

A total of 980 waterfowl of 13 species was observed on 22  $\frac{1}{4}$ -sections in early winter, 1,122 waterfowl of 11 species on 22  $\frac{1}{4}$ -sections in late winter, and 984 waterfowl of 12 species on 44  $\frac{1}{4}$ -sections in spring. Canada geese comprised 42.3% of all waterfowl observed, mallards 36.5%, and mergansers 5.6%.

The statewide estimate of waterfowl was 579,542 ( $SD \pm 378,112$ ) in early winter, 741,564 ( $SD \pm 301,759$ ) in late winter, and 586,750 ( $SD \pm 329,852$ ) in spring. Dabblers and geese were the most predominant waterfowl observed during winter and spring.

Eighty-four percent of the waterfowl observed occurred on lacustrine wetlands, 11-14% occurred on riverine wetlands, and only 2-5% occurred on palustrine wetlands in winter. Use of palustrine wetlands increased to 37% of all waterfowl observed during spring.

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