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WATERFOWL AND SHOREBIRD USE OF SURFACE-MINED AND LIVESTOCK WATER IMPOUNDMENTS ON THE NORTHERN GREAT PLAINS

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ABSTRACT.—Cluster analysis and stepwise discriminant analysis were used to group waterfowl and shorebird use on water impoundments (bentonite, coal, livestock) on the Northern High Plains. Three bird-use categories—high, medium, and low—were delineated by these analytical procedures. Eleven physical, chemical, and biological parameters of impoundments were related to bird use; water area, nitrogen, and low basin slopes were found to be important parameters in estimating bird use on impoundments. Spring and summer were the best seasons for surveying waterfowl and shorebird water impoundment use.

Water impoundments created by mining activity provide habitat for waterfowl and shorebirds on the Northern Great Plains. An assessment of waterfowl use on natural wetlands and stock ponds was made by Ruwaldt et al. (1979). No such study has been done on strip-mine impoundments, although water quality and morphometry of strip-mine water areas examined in conjunction with this study on the same impoundments have been reported by Hawkes (1978), Bjugstad et al. (1983), Rumble et al. (1985), and Rumble (1985). These parameters have not been previously related to waterfowl and shorebird use of impoundments, nor have management recommendations relating waterfowl and shorebird production to surface-mine impoundments been suggested.

Early studies on waterfowl production on the Northern Great Plains were conducted only on livestock impoundments (Bue et al. 1952, Smith 1953). Other studies have related waterfowl and shorebird use to habitat conditions (surface water available, submergent and emergent vegetation, amount of shoreline and shallow water) of lakes, and livestock, dugout, ephemeral, temporary seasonal, semipermanent, and permanent water impoundments (Beard 1953, Uhlig 1963, Patterson 1976, Kantrud and Stewart 1977, Ruwaldt et al. 1979, Mack and Flake 1980, Kaminski and Prince 1981, Rumble et al. 1985). The importance and value of these impoundments to waterfowl and shorebird production on the Northern Great Plains has been emphasized by Lokemoen (1973), Evans and Kerbs (1977), Flake et al. (1977), Mack and Flake (1980), and Rumble and Flake (1983).

The purpose of this study was to determine waterfowl and shorebird use as related to bentonite clay, coal surface mine, and livestock watering impoundments; to identify impoundments characteristics that could increase waterfowl and shorebird use; and to recommend management strategies.

STUDY AREA AND METHODS

The study areas were located in northeastern Wyoming, western South Dakota, and western North Dakota. Four general areas were studied: (1) Colony, Wyoming; (2) Gascoyne, North Dakota; (3) Beulah, North Dakota; and (4) Firesteel, South Dakota. Seventeen coal surface-mine impoundments, 13 bentonite surface-mine impoundments, and 7 livestock ponds were selected for study. Impoundments were selected to represent a range of waterfowl and shorebirds in assigned use categories of low, medium, and high. Approximately one-half of the mine impoundments were distributed in low- and medium-use categories based on observations of waterfowl and shorebirds, with seven livestock ponds in the high-use category.

Livestock impoundments were the oldest, averaging 41 years, with well-developed aquatic vegetation. They were designed with minimal disturbance to provide water for livestock and were constructed in rolling topography with dams across natural drainages. Coal mine impoundments averaged 25 years in age

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TABLE 1. Selected physical, chemical, and vegetative characteristics of ponds in each analysis group. Means and standard errors calculated from data included in Anderson et al. (1979) and Olson (1979).

	Use class		
	Low	Medium	High
Number of ponds	17	3	1
Age (yr)	29.7 ± 3.9	43.3 ± 17.5	42
Impoundment area (ha)	2.4 ± 0.2	6.8 ± 4.0	14.9
Pond volume (m^3)	13546 ± 1733	28295 ± 12441	85350
Water depth—max (m)	5.0 ± 0.1	5.0 ± 0.5	2.0
$\bar{X}$ (m)	0.8 ± 0.0	0.8 ± 0.0	0.7
Shoreline development[1]	1.74 ± 0.09	2.21 ± 0.32	2.82
Percent shallow[2]	20.0 ± 1.2	36.7 ± 6.2	59.0
Percent slope (+1 m elev. to shoreline)	38.9 ± 6.01	26.3 ± 13.4	11.0
Plant density (stems/m^2/yr)	500 ± 104	1428 ± 380	1928 ± 216
Plant standing crop (kg/ha/yr)	30864 ± 6166	37578 ± 7375	41691 ± 3661
Nitrogen (mg/1)	0.37 ± 0.01	0.56 ± 0.16	1.31
Phosphorus (mg/1)	0.02 ± 0.00	0.07 ± 0.06	0.28

and resulted from open-pit mining where soil overburden and coal were removed. These impoundments had steep banks below and above the water surface with minimal aquatic vegetation. Bentonite impoundments averaged approximately 12 years in age. These impoundments were generally steep on three sides, but where scrapers removed the bentonite, gradual slopes occurred on at least one side of the impoundment allowing for growth of aquatic vegetation. A detailed description of impoundments is provided by Anderson et al. (1979), Olson (1979), and Rumble et al. (1985).

Waterfowl and shorebirds were sampled by species 25 times over seven seasons from 1976 to 1978 (two spring, two summer, three fall) on the 37 water impoundments. Within each season, three to seven successive surveys were conducted. All birds were observed, identified, and counted with the aid of spotting scopes and binoculars. Approximately 15 to 60 minutes was spent observing birds on each impoundment. In addition, measurements of 12 parameters were collected during the same period of bird observations and were compiled for 21 of the impoundments (Anderson et al. 1979, Olson 1979, Rumble et al. 1985, Rumble 1985): age of impoundment, basin area, impoundment volume, water depth, shoreline development, percent shallow (Lind 1974), percent slope (between the water line and +1 m elevation), percent shallow water slope (between the waterline and the −1 m elevation), plant density, plant standing crop, and nitrogen and phosphorus content of water (Table 1).

Waterfowl and shorebird data were averaged by impoundment types (mean birds/impoundment/observation) for cluster analysis (ISODATA) (Ball and Hall 1969). Cluster analysis was used to separate mean birds for spring, summer, and fall, with years combined. Stepwise discriminant analysis (Dixon 1983) was next used to estimate reliability of separations of cluster analysis (F to enter 4; F to remove 3.996). Kulzaynski's similarity index (Oosting 1956) and Spearman's rank order correlation (r_s) (Siegel 1956) compared species of birds among the three impoundment groups. All statistical inferences were made at $\alpha = 0.05$.

RESULTS

Waterfowl and shorebirds were separated into three significantly different use groups (Table 2): high bird use (158 birds/impoundment/observation, n = 1), medium bird use (30 birds/impoundment/observation, n = 3), and low bird use (3 birds/impoundment/observation, n = 33). Numbers on impoundments during spring were greatest for high- and moderate-use impoundments, while low-use impoundments had greatest numbers during fall. All bentonite and all coal impoundments, except one, were in the low-use group. Livestock impoundments were in all three groups.

Mallards (*Anas platyrhynchos*), American Widgeons (*A. americana*), Pintails (*A. acuta*), and Blue-winged Teals (*A. discors*) were the most abundant of the 32 species observed on impoundments in the low-use class (Table 2).

TABLE 2. Average (± SE) number of birds per impoundment observed by species at a given time in three use classes[1] during spring, summer, and fall.

	Low use			Medium use			High use		
	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
American Coot	0.06 ± 0.03	0.06 ± 0.03	0.05 ± 0.03	2.44 ± 1.80	2.39 ± 1.89	0.33 ± 0.26	28.83	31.67	80.23
American Widgeon	0.40 ± 0.22	0.21 ± 0.09	0.39 ± 0.19	3.94 ± 2.95	1.56 ± 1.39	1.23 ± 0.55	9.50	6.67	15.31
Bufflehead	0.07 ± 0.07	0	0.01 + 0.01	0.39 ± 0.24	0	0.05 ± 0.05	2.67	0	0
Blue-winged Teal	0.15 ± 0.06	0.49 ± 0.22	0.05 ± 0.03	1.22 ± 1.22	7.89 ± 5.40	1.23 ± 0.69	8.83	30.17	0.38
Canada Goose	0	0	0	0	0	0	12.00	0	0
Canvasback	0.02 ± 0.01	0	0.01 ± 0.01	3.61 ± 1.30	0	0	33.83	0.67	0.69
Common Goldeneye	0.01 ± 0.01	0	0.01 ± 0.01	0	0	0.13 ± 0.13	0	0	0.31
Common Loon	0	0	0	0	0	0.03 ± 0.03	0	0	0
Common Merganser	0.07 ± 0.04	0.02 ± 0.02	0	0.33 ± 0.33	0	0.05 ± 0.05	0	0	0
Common Snipe	0.01 ± 0.01	0	0	0	0	0	0	0	0
Double-crested Cormorant	0.02 ± 0.01	0	0.01 ± 0.01	0.61 ± 0.61	0	0.05 ± 0.05	0	0	0.38
Eared Grebe	0	0.01 ± 0.01	0	0.78 ± 0.78	0.28 ± 0.28	0.03 ± 0.03	0.67	4.17	0.08
Gadwall	0.08 ± 0.05	0.10 ± 0.09	0.13 ± 0.08	0.89 ± 0.89	0.94 ± 0.78	1.59 ± 0.86	12.83	0.50	12.92
Great Blue Heron	0.01 ± 0.01	0.04 ± 0.02	0.01 ± 0.01	0.11 ± 0.11	0.11 ± 0.11	0.03 ± 0.03	0	0.17	0.23
Green-winged Teal	0.18 ± 0.08	0.03 ± 0.03	0.11 ± 0.05	2.50 ± 1.25	0	2.31 ± 0.47	5.83	0.17	2.69
Horned Grebe	0.01 ± 0.01	0	0	0	0	0	0	0	0
Hooded Merganser	0	0	0	0	0	0	0.33	0	0
Killdeer	0.03 ± 0.03	0.08 ± 0.03	0.07 ± 0.07	0	0	0.10 ± 0.07	0	0	0
Long-billed Dowitcher	0	0	0	0	0	0	3.00	0	0
Lesser Scaup	0.19 ± 0.13	0	0.14 ± 0.06	15.89 ± 6.31	0	1.59 ± 1.55	30.67	0.17	0.31
Lesser Yellowlegs	0	0	0	0	0.06 ± 0.06	0	0	0	0
Marbled Godwit	0	0.10 ± 0.10	0	0	0	0	0	0	0
Mallard	1.04 ± 0.23	0.77 ± 0.35	1.32 ± 0.45	4.56 ± 0.53	7.67 ± 7.12	5.9 ± 2.51	34.83	21.50	19.23
Pied-billed Grebe	0	0.02 ± 0.02	0.02 ± 0.01	0.11 ± 0.11	0.17 ± 0.17	1.21 ± 0.65	0	2.33	1.08
Pectoral Sandpiper	0	0.01 ± 0.01	0	0	0	0	0	0	0
Pintail	0.27 ± 0.10	0.13 ± 0.07	0.22 ± 0.13	1.17 ± 0.23	0.94 ± 0.78	1.64 ± 1.41	20.17	3.0	1.85
Ring-billed Gull	0	0	0.01 ± 0.01	0	0	0.33 ± 0.29	0	0	0
Redhead	0.01 ± 0.01	0	0.06 ± 0.06	12.67 ± 9.82	0.06 ± 0.06	0.82 ± 0.47	6.33	0.50	3.31
Ring-necked Duck	0.16 ± 0.07	0	0.07 ± 0.07	4.67 ± 2.38	0	0.05 ± 0.05	8.00	0	0
Ruddy Duck	0.01 ± 0.01	0	0	1.44 ± 1.20	0	0	9.00	1.00	1.31
Sandhill Crane	0	0	0.01 ± 0.01	0	0	0	0	0	0
Shoveler	0.07 ± 0.04	0.14 ± 0.11	0.09 ± 0.05	0.50 ± 0.29	0.61 ± 0.61	0.23 ± 0.23	4.00	1.50	1.31
Snow Goose	0	0	0	0.06 ± 0.06	0	0	0	0	0
Spotted Sandpiper	0	0.01 ± 0.01	0	0	0	0	0	0	0
Unknown dabblers	0.03 ± 0.03	0.04 ± 0.02	0.16 ± 0.09	0	0.22 ± 0.22	0.82 ± 0.42	5.50	2.50	4.23
Western Grebe	0	0.02 ± 0.02	0.01 ± 0.01	0.06 ± 0.04	0	0	0	0.17	0.08
Whistling Swan	0	0	0.01 ± 0.01	0	0	0.05 ± 0.05	0	0	0
Willet	0	0	0.01 ± 0.01	0	0	0.05 ± 0.05	0.17	0	0.23
Wood Duck	0	0	0	0.06 ± 0.06	0	0	0	0	0

[1]Low n = 33 ponds; medium n = 3 ponds; high n = 1 pond.

Mallards, Lesser Scaup (*Aythya affinis*), and Redheads (*Aythya americana*) were the most abundant of the 30 species observed in medium-use impoundments. In high-use impoundments, American Coot (*Fulica americana*), Mallard, American Widgeon, Gadwall (*A. strepera*), and Blue-winged Teal were the most abundant species. Fewer species were observed on the high-use impoundment (25), but greater densities were reported.

Similarities were all low, ranging from 4% to 24%, when bird species were compared among the three classes. This indicates that the number of species did not occur in similar proportions among impoundments. Rank order correlations of bird species were significant ($P \leq .05$) among the three use classes. Correlations were: low vs. medium (.70), low vs. high (.51), and medium vs. high (.78). Bird abundance by species among classes was in the same relative rankings, indicating that the same population was available for all classes of ponds. Therefore, factors other than bird density influenced selection for certain impoundments.

Trends across use classes relative to the physical, chemical, and biological parameters given in Table 1 indicate that old, large, shallow impoundments with low basin slopes, irregular shorelines, and significant vegetation were favored by waterfowl. Nitrogen and phosphorus content of water was also greater in the high-use impoundments.

The three seasons were subjected to discriminant analysis on the medium and low groups, which showed spring and summer seasons as the most important in evaluating waterfowl and shorebird use on impoundments. These two seasons accounted for 93% of the variation. Discriminant analysis of low- and medium-use impoundments showed that impoundment area, nitrogen in water, and percent slope (+1 m elevation to shoreline) were important for bird use and accounted for 95% of the variation.

Discussion

Thirty-seven impoundments (coal, bentonite, and livestock) were analyzed with multivariate techniques (ISODATA, discriminant analysis) as related to waterfowl and shorebird use. These analyses resulted in grouping 33 impoundments in low-, 3 in medium-, and 1 in high-use categories. ISODATA (cluster analysis) examines response patterns of all variables in waterfowl and shorebird data and separates the data into groups that are more meaningful for interpretation because of group homogeneity with minimum variances. Discriminant analysis examines groupings for significant separation and also includes variables which best separate groups. As a result of these multivariate techniques, the original classification and number of impoundments for low, medium, and high use by birds was different. Field observations, even with preliminary data, are often too complex, and/or highly variable, to determine adequate sample size of impoundments in low- to high-use categories. Thus, when the complete data set with 25 sample periods over seven seasons was analyzed, a small number of impoundments resulted in medium- and high-use categories with multivariate techniques.

Species richness (number of species), which was higher on the low-use impoundments, primarily bentonite and coal, was 32, followed by medium- (30), and high- (25) use impoundments. However, total numbers (densities) of waterfowl and shorebirds showed opposite trends by impoundment grouping. Therefore, many researchers advocate that waterfowl and shorebird use of impoundments should be managed by criteria developed for high-use livestock impoundments (Smith 1953, Evans and Kerbs 1977, Flake et al. 1977, Lokemoen 1973, Mack and Flake 1980, Rumble and Flake 1983).

Average percent similarities were low when bird species were compared among the three classes of impoundments, indicating that selection for certain ponds occurred. Rank order correlations indicated that species and densities of waterfowl and shorebirds had a similar ranking in abundance among the three impoundment classes, which means that all ponds had the same opportunity of being selected for use.

Surface area of impoundments was an important criterion to consider for waterfowl and shorebirds in this study. Impoundments in our study ranged in size from 0.3 to 15 ha. Other studies (on impoundments that ranged in size from 0.4 to 9.5 ha) also reported that surface area was an important variable to consider for waterfowl (Smith 1953, Lokemoen 1973, Flake et al. 1977, Evans and Kerbs 1977, Rumble and Flake 1983). Lokemoen (1973) recommended that minimum pond size be 0.6 ha and largest be dictated only by topography and economics of construction. The percent of the total impoundment area between the waterline and −1 m elevation (percent shallow), and the submerged vegetation have been important for predicting waterfowl and shorebird use on impoundments (Rumble and Flake 1983). However, in our study the percent slope (+1 m elevation to shoreline) was our important variable for estimating bird use on impoundments. Impoundments with gently sloping shorelines and abundant vegetation in shallow water have greater densities of birds (Evans and Kerbs 1977).

Water nutrients are associated with increased plant production. Lokemoen (1973) found that as nutrients increased, plant abundance increased, and so did waterfowl use. In this study nitrogen was an important variable. Aquatic vegetation and grassy shorelines are extremely important for waterfowl use and do influence waterfowl densities (Rumble and Flake 1983, Lokemoen 1973, Flake et al. 1977, Mack and Flake 1980). Generally, aquatic vegetation will develop in newly constructed impoundments within a short period of time, provided adequate shallow areas no deeper than 1 m are available. In some stripmine impoundments (coal and bentonite) aquatic productivity could possibly be increased with addition of nitrogen and phosphate fertilizers.

Although all impoundments that were highly or moderately used by waterfowl and shorebirds in this study were livestock ponds, characteristics of such ponds may still be used to design impoundments resulting from bentonite and coal strip mining. In some cases parent spoil materials may adversely affect waterfowl use of strip-mine impoundments, because of chemical or soil texture problems, regardless of structural design. However, such cases may be mitigated by time or other management techniques such as fertilization or recovering with topsoil materials. Results obtained on livestock impoundments from this and other studies indicate that newly developed impoundments should have as minimum parameters 0.6 ha in surface area, 2.2 in shoreline development (index), 40% in shallow water (−1 m depth), 1500 stems/m^2 density in shallow areas, N content of 0.6 mg/l, and P content of 0.07 mg/l.

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