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WATERFOWL MANAGEMENT ON GRASS-SAGE STOCK PONDS

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Abstract: We studied waterfowl use of grass-sage stock ponds in north-central Wyoming during the 1988 and 1989 breeding seasons. Dabbling ducks, particularly mallards, were the most common breeders. Indicated breeding pair density averaged 2.7 pairs/ha of wetland surface, while brood density averaged 1.0 brood/ha of wetland surface. Waterfowl use and productivity were greatest on large (>3 ha), clear, deep ponds with grass shorelines and abundant submergent macrophytes. Pair use was positively correlated with water clarity, pond area, and macroinvertebrate diversity. Brood use was related to macroinvertebrate diversity, pond depth, and Shoreline Development Index. We recommend management priority be given to ponds that are deeper than 1 m to provide more water that is clear so macrophytes can be established. Macroinvertebrates should be artificially introduced into ponds. Fencing should be used to improve ponds for waterfowl use and brood rearing.

Key Words: waterfowl, stock ponds, grass-sage, aquatic macroinvertebrates, breeding ducks, broods

INTRODUCTION

Prairie stock ponds are well-known for their importance to breeding waterfowl (Giron 1981, Rumble and Flake 1983, Ball et al. 1995). Waterfowl use of stock ponds in grass-sage ecosystems, however, has received little attention (Giron 1981). An understanding of this use is important for land-management planning. The potential benefit to waterfowl is great, as grass-sage ecosystems cover wide portions of the western United States. Our study objectives were to 1) describe waterfowl use of grass-sage stock ponds, 2) identify habitat variables which affected waterfowl use, and 3) develop habitat management recommendations.

STUDY AREA

The study area encompassed 1.2 million ha of Washakie, Park, Hot Springs, and Bighorn counties in the north-central part of Wyoming, USA. All research was conducted on public land administered by the U.S.D.I. Bureau of Land Management (BLM). Stock ponds were the major wetland habitat available within the study area. Perennial streams and natural wetlands were rare and largely absent during our study due to drought conditions. All ponds were dam-retention-type livestock watering facilities (Eng et al. 1997). Topography consisted of gently rolling pasture lands interspersed with extensively eroded, sparsely vegetated buttes and arroyos. Elevation ranged from 1,300 to 1,800 m. Annual precipitation in the study area averages 17 cm/year (National Oceanographic Atmospheric Administration 1982). Common shrubs and grasses included sage (*Artemisia* spp.), saltbush (*Atriplex* spp.), greasewood (*Sarcobatus vermiculatus* Hook) (Stubbendieck et al. 1996), blue grama (*Bouteloua gracilis* Humboldt, Bonpland, Kunth), blue-bunch wheatgrass (*Agropyron spicatum* Pursh), and needle-and-thread (*Stipa comata* Trinius and Ruprecht). Aquatic vegetation associated with study ponds was largely limited to green algae (*Cladophora* spp.), bulrush (*Scirpus* spp.), cattail (*Typha* spp.), spikerush (*Eleocharis* spp.), rush (*Juncus* spp.), willow (*Salix* spp.), salt cedar (*Tamarix* spp.), coontail (*Ceratophyllum demersum* Linnaeus), and pondweed (*Potamogeton* spp.) (Land Inventory and Development, Inc. 1987). In 1988 and 1989, extremely low water levels occurred throughout the study area. Seventeen study ponds dried during the course of field work.

METHODS

We studied 56 dam-retention ponds for which road access was available throughout the spring and summer period. Study ponds were considered representative of the study area and were classified as palustrine emergent, palustrine aquatic bed, or palustrine unconsolidated bottom wetlands (Cowardin et al. 1979). We conducted field work in 1988 and 1989 from 1 April to 30 August. In 1988, 30 ponds located near Worland, Wyoming were studied. In 1989, we focused on 26 ponds near Cody and Greybull, Wyoming. Data from both years were combined for analysis.

Waterfowl Use

Waterfowl counts were conducted biweekly from sunrise to 1800 hours following the census protocol described by Rumble and Flake (1982). A minimum of four counts were conducted per pond from 1 April to 15 June to determine use category of birds (migrator vs. local breeder) (Hammond 1969), number of indicated breeding pairs (Hammond 1969), and pair days (Ball 1973), and at least three counts were conducted per pond from 16 June to 30 August to calculate number of broods, brood age (Gollup and Marshall 1954), brood days (Ball 1973), and brood productivity (broods/100 pairs) (Ball et al. 1995).

Physical Habitat Variables

We measured 10 independent physical habitat variables at each pond (Svingen 1991). Pond area was estimated from field maps made with range finders, clinometers, and rolatapes (Smith 1953). Shoreline Development Index was calculated as described by Wetzel (1975), where each pond's perimeter was expressed as a ratio of the perimeter of a circle containing the same area. To estimate water depth, we plumbed a line to the pond bottom and measured to the nearest decimeter. Readings were taken every 8 m on the main axis of the pond and every 8 m along five transects perpendicular to the main axis. Maximum water depths and mean water depth were recorded.

Water clarity, measured with a 10-cm-diameter secchi disk (s.c.), was included as both a continuous and a categorical value. Depths at which the secchi disk was no longer visible were recorded and classified as turbid (s.c. depth = 0–0.05 m), muddy (s.c. = 0.05–0.2 m), milky (s.c. = 0.2–0.4 m), cloudy (s.c. = 0.4–0.6 m), or clear (s.c. > 0.6 m) (Hudson 1983). Readings were taken at the same location during each pond visit and averaged for data analysis.

Biological Habitat Variables

We measured 20 independent biological habitat variables at each pond (Svingen 1991). Emergent macrophyte presence/absence, species diversity, and density were recorded for each pond (Nudds 1977, Svingen 1991). Submergent vegetation presence/absence and species diversity were sampled with a 225 cm^2 Ekman Grab (Huggins et al. 1985). Five samples per hectare of surface water were collected from random points. Locations of emergent and submergent vegetation were also mapped.

Shorelines within a 2-m border above the high water mark were visually categorized as "bare," "grass," or "brush." Bare shorelines were those with <25% ground cover. Grass shorelines had >25% ground cover, with dominant vegetation being graminoids <50 cm high. Brush shorelines had >25% ground cover, with dominant vegetation being >50 cm high (Lokemoen 1973).

Low water levels often created a beach area between pool level and high water mark. Beach width was measured at 10 random points around the pond and averaged. The presence or absence of beach vegetation was also noted. Average grazing pressure within 100 m of each pond was visually qualified as "heavy," "moderate," or "light."

Aquatic Macroinvertebrates

To quantify the availability of aquatic macroinvertebrates, five ponds were chosen at random each year. Each pond was sampled monthly for aquatic macroinvertebrates. Ten samples (five benthic and five nektonic) were collected from each pond per sample date. A 225 cm^2 Ekman Grab was used for collecting benthos (Huggins et al. 1985). All Ekman Grab samples collected for a particular pond on a particular date were combined for data analysis. A 698 cm^2 sweep net (1-mm mesh) was used to sample nekton (Huggins et al. 1985). Each sweep-net sample was collected by making five 1-m-length sweeps along the pond substrate and through the water column. All sweep-net samples collected for a particular pond on a particular date were combined for data analysis. All Ekman Grab and sweep-net samples were taken along the 50-cm depth contour in areas where ducks had been seen actively feeding. All samples were washed through a sieve (1-mm mesh) and fixed in 10% buffered formalin. After 2–5 days storage, large samples were floated in sucrose solution to separate plant and animal matter (Flannagen 1973). Specimens were identified to order (Merrit and Cummings 1984, Pennak 1978) and counted. The total number of benthic and nektonic macroinvertebrate orders sampled at a given pond was used as an index of faunal diversity (Belanger and Couture 1988).

Data Analysis

Histograms of waterfowl use versus habitat variables were examined for general relationships. Non-

Table 1. Waterfowl breeding population and brood production at study ponds, 1988–1989. Density = no./ha of wetland surface. Productivity = no. broods/100 indicated breeding pairs. Taxonomy follow American Ornithologists' Union (1983).

Species	Pair Density	Brood Density	Productivity
Canada Goose			
Branta canadensis Linnaeus	0.08	0.03	33
Mallard			
Anas platyrhynchos Linnaeus	0.89	0.25	29
Gadwall			
Anas stepera Linnaeus	0.17	0.08	46
American Wigeon			
Anas americana Gmelin	0.22	0.14	65
Green-winged Teal			
Anas crecca Linnaeus	0.40	0.15	33
Blue-winged Teal			
Anas discors Linnaeus	0.21	0.17	87
Cinnamon Teal			
Anas cyanoptera Vielillot	0.13	0.01	10
Northern Shoveler			
Anas clypeata Linnaeus	0.04	0.00	33
Northern Pintail			
Anas acuta Linnaeus	0.25	0.08	33
Redhead			
Aythya americana Eyton	0.09	0.01	17
Ring-necked Duck			
Aythya collaris Donovan	0.15	0.00	0
Barrow's Goldeneye			
Bucephala islandica Gmelin	0.00	0.03	100
Ruddy Duck			
Oxyura jamaicensis Gmelin	0.06	0.03	75
Total	2.70	1.00	37*

* Weighted average.

parametric statistics were appropriate as several of the habitat variables lacked a normal distribution. Spearman's rank correlations were used to test linear associations between habitat variables and waterfowl use (SOLO: BMDP Statitical Software, Inc.). A "biological significance level" of rho >0.62 was set ($P<0.05$); rho <0.62 was not considered significant (Montgomery 1984).

Mann-Whitney and Kruskal-Wallis tests ($\alpha=0.10$) were used to determine differences among selected habitat variables and rank means of pair and brood numbers (Belanger and Couture 1988). Stepwise logistic regression ($\alpha=0.10$) was used to model relationships between habitat variables and pair and brood use. Ponds that had two or more indicated breeding pairs were coded as "high use," while ponds with zero or one indicated breeding pairs were coded as "low use." Presence of a brood was coded as use and absence of any broods as non-use.

Table 2. Comparison of pair densities (no./ha of wetland surfaces), brood density (no./ha of wetland surface), and productivity (broods/100 breeding pairs).

Reference	Location	Density		Productivity
		Pair	Brood	
This study	WY stock ponds	2.7	1.0	37
Ball et al. 1995	MT stock ponds	7.7	3.0	39*
Lokemoen 1973	ND stock ponds	4.4	2.0	44

* Calculated by us for all duck species (546 broods/1,380 pairs).

RESULTS

Waterfowl Counts

A total of 472 counts found 22 waterfowl species using study ponds. Ninety percent (90%) of all birds recorded were dabbling ducks, and 93% were classified as local breeders. Mallard (*Anas platyrhynchos*) and green-winged teal (*Anas crecca*) were the most common species (Table 1). Waterfowl pairs totaled 203, averaging 2.7 pairs/ha of wetland surface (s.d.=5.7; Table 2). Seventy-six waterfowl broods were found, for an average density of 1.0 brood/ha of wetland (s.d.=5.1; Table 2). Productivity averaged 37 broods/100 pair (s.d.=37; Table 1).

Breeding Pair Use and Habitat Variables

At least one breeding pair was seen on all wet ponds. Habitat variables significantly correlated with pair number included water clarity (rho=0.9, $P<0.01$, n=56), pond area (rho=0.63, $P<0.01$, n=56), and number of invertebrate taxa present (rho=0.65, $P<0.05$, n=10). Mann- Whitney and Kruskal-Wallis tests showed significantly more rank pairs on ponds with: Shoreline Development Index >1.5 ($P<0.015$), grass shorelines ($P<0.031$), clear water ($P<0.045$), and submergent vegetation ($P<0.04$). Ponds dominated by coontail received significantly higher breeding pair use ($P<0.03$) than did ponds dominated by green algae, pondweed, or pondweed/coontail. Stepwise logistic regression selected presence of grass shoreline, pond area, and water clarity as the variables explaining the most variation in pair use of study ponds (Table 3).

Brood Use and Habitat Variables

Although the majority of broods were seen on ponds over 0.6 ha in area, no significant correlation between brood use and pond area was noted. The ponds that contained the highest number and diversity of broods were >3 ha. On the 10 ponds sampled for macroinvertebrates, number of brood days spent at a given

Table 3. Habitat variables selected by stepwise logistic regression as important breeding pairs and broods.

Variable	Standard Error	Prob. Beta = 0
	PAIR USE	
Grass shore	0.64	0.0237
Pond area	0.21	0.0561
Water clarity	0.20	0.0678
	BROOD USE	
Maximum depth	0.31	0.0572

pond was significantly correlated with the number of invertebrate taxa present (rho=0.70, $P<0.05$). Both brood number (rho=0.56, n=10) and productivity (rho=0.54, n=10) approached significant correlation ($P<0.05$) with number of invertebrate taxa present.

Mann-Whitney U tests showed that both rank number of broods present ($P<0.02$) and rank number of brood days spent at a given pond ($P<0.02$) were significantly greater on ponds with Shoreline Development Index >1.5. Productivity was also significantly greater ($P<0.03$) on ponds with Shoreline Development Index>1.5. Stepwise logistic regression selected maximum depth as the variable that explained the greatest amount of variation in brood use of study ponds (Table 3).

DISCUSSION

Waterfowl Use of Grass-Sage Stock Ponds

Breeding dabbling ducks numerically dominated wetlands on our study site, as has been found on prairie stock ponds (Lokemoen 1973, Rumble and Flake 1983, Ball et al. 1995). Mallards were the most common species, followed by green-winged teal and northern pintail (*Anas acuta*). Of the dabbling ducks, these species are the best adapted to low wetland density due to their large home ranges (Dzubin 1955, Lokemoen 1973, Dwyer et al. 1979, Nudds and Ankney 1982). Stock-pond density on our study area averaged 0.2 pond/km^2. On eastern Montana prairie stock ponds, mallards dominated where pond density was 0.1 pond/km^2 (Smith 1953), but American wigeon (*Anas americana*) (which have a smaller home range) were the most numerous species where pond density was 0.8 pond/km^2 (Ball et al. 1995).

Breeding pair density, brood density, and productivity found on our study ponds were lower than those of North Dakota and Montana prairie stock ponds. The severe drought likely exaggerated this difference. Even during non-drought conditions, prairie stock ponds in North Dakota and Montana likely attract greater waterfowl pair densities than do ponds in our study area, due to higher quality nesting cover and higher pond density (Lokemoen 1973, Rundquist 1973, Ball et al. 1995). Because the 37% productivity observed in our study exceeded the 30% minimum thought to be needed to maintain local populations (Cowardin et al. 1983), study area duck populations were probably stable in spite of the drought. Due to isolation of study ponds, inter-wetland movement by waterfowl was not considered a significant bias in calculating productivity estimates or pair or brood densities. If such movement did occur, we assume that ingress equaled egress.

Habitat Variables Associated with Pair Use

Breeding pairs used all water sources, indicating water availability was the most limiting habitat feature (Stewart and Kantrud 1974). The fact that statistical associations were found between pair use and other habitat features, however, shows that some wetlands were preferred. In general, these habitat features can be grouped into two categories: those that affect territorial spacing and those that affect invertebrate availability.

We believe pairs were positively associated with pond area and Shoreline Development Index >1.5 because larger, more complex ponds provide greater visual separation between territorial pairs, as has been shown elsewhere (Lokemoen 1973, Flake et al. 1977, Hudson 1983, Uresk and Severson 1988).

Pair associations with water clarity, invertebrate diversity, and the presence of coontail were likely interrelated. Clearer water supported denser submergents stands, which in turn supported higher diversity and density of aquatic macroinvertebrates (Svingen 1991). The importance of water clarity was confirmed by its selection as both a continuous and categorical variable during analysis. Lokemoen (1973) and Flake et al. (1977) also found water clarity as an important habitat feature to waterfowl pairs.

Association between submergent plants and waterfowl pairs was also shown by Leschisin et al. (1992), who found blue-winged (*Anas discors*) and green-winged teal, mallard, and gadwall (*Anas strepera*) correlated positively with submergent diversity. In our study, the submerged plant most preferred by breeding pairs was coontail. This species has highly dissected leaves and typically supports greater aquatic macroinvertebrate biomass than other macrophytes (Krecker 1939, Andrews and Hasler 1943, Rosine 1955, Krull 1970, McCrady et al. 1986). The importance of aquatic macroinvertebrates to waterfowl pairs, particularly laying hens, is well established (Beard 1953, Hawkins 1964, Joyner 1980, Belanger and Couture 1988).

The only habitat variable associated with pair use that was likely not a function of territorial spacing or aquatic macroinvertebrate availability was grass shoreline. Grass shorelines may have been preferred over bare ones because bare shorelines were typically found in heavily grazed pastures (Svingen 1991). Suitable nesting sites were likely limiting in heavily grazed areas (Mundinger 1976). We believe that pair preference of grass shorelines over brush shorelines, however, was related to predator avoidance (Beard 1953, McDonald 1955). In our study area, brush shorelines typically formed "habitat islands" amidst surrounding grazed uplands. Incidental observations of waterfowl predators and predator sign were common in these areas.

Habitat Variables Associated with Brood Use

Broods were associated with the number of invertebrate taxa found, Shoreline Development Index >1.5, and depth. The association with invertebrate taxonomic diversity is not surprising, as invertebrates are the primary food source for young ducklings (Chura 1961, Bartonek and Hickey 1969). Macroinvertebrate diversity found on study ponds (9 taxa) was about average compared to semipermanent natural wetlands in the Northern Great Plains (Bartonek and Hicky 1969, Swanson et al. 1974). Densities (average 101 nektonic animals/m3 and 18 benthic animals/m2) were low, however. These are among the lowest ever reported for constructed wetlands (Street 1977, Belanger and Couture 1988). Inefficiencies in our sampling may explain some of this disparity, but actual densities are likely very low. Although aquatic macroinvertebrates are well-known for their dispersal capabilities (Merrit and Cummings 1984), the extreme isolation of study ponds from natural water sources likely limits colonization by many species. Dispersal barriers to aquatic macrophytes may also be a factor in slowing aquatic macroinvertebrate colonization of study ponds.

We believe that broods preferred ponds with Shoreline Development Index >1.5 because irregular shorelines offered sheltered areas for feeding and predator avoidance. The bays and inlets typical of ponds with Shoreline Development Index >1.5 seemed particularly important on those ponds that lacked extensive emergent vegetation. Brood association with irregular shorelines has also been shown by Mack and Flake (1980), Hudson (1983), and Belanger and Couture (1988). Security from predators is also the reason we believe deeper ponds were preferred. Shallow ponds were unreliable as brood ponds during this study due to the drought. The greater susceptibility of grass-sage stock ponds to drying may mean that deep water is more important to waterfowl in these ecosystems than is the extent of shallow water. This is perhaps the biggest difference between prairie and grass-sage stock ponds (Flake et al. 1977, Mack and Flake 1983).

MANAGEMENT RECOMMENDATIONS

1. Management priority should be given to ponds that have a maximum depth >1 m and are larger than 3.0 ha (at full pool), although any pond >0.6 ha is suitable.
2. Management goals should be to increase water availability and improve water clarity.
3. Establishing aquatic macrophytes is likely the most cost-effective technique for improving water clarity, and would also improve habitat conditions for aquatic macroinvertebrates. Based on our data, the most useful species are coontail and pondweed.
4. After submerged plants are established, aquatic macroinvertebrates should be artificially introduced into stock ponds to increase taxonomic diversity.
5. Reservoir fencing has been suggested for improving stock pond use by waterfowl (Bue et al. 1952). Eleven study stock ponds were protected by such exclosures, but no significant difference in waterfowl use of fenced vs. unfenced ponds was noted (Mann-Whitney U tests, $\alpha=0.10$). Similar results have been reported in western North Dakota (Lokemoen 1973) and eastern Montana (Berg 1956). Stock pond fencing, therefore, is not a cost-effective waterfowl management tool.
6. Managers should be aware of the importance of providing brood habitat at grass-sage stock ponds throughout the fledgling period. Unlike waterfowl in other ecosystems, grass-sage waterfowl cannot easily move their broods to neighboring wetlands due to the extreme isolation of suitable habitat.

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