LANDSCAPE CHARACTERISTICS AFFECTING HABITAT USE AND PRODUCTIVITY OF DUCKS ON STOCKPONDS IN WESTERN SOUTH DAKOTA

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ABSTRACT

In comparison to the volumes of research conducted in the Prairie Pothole Region (PPR) assessing habitat characteristics and the effects on waterfowl productivity, relatively few studies have been conducted on the periphery of the PPR. This project focused on Western South Dakota, an area where agricultural fragmentation has only recently expanded. The effects of local- and landscape-level characteristics on waterfowl pair and brood density and rates of productivity (broods/100 pairs) were evaluated in 1999 and 2000 in western South Dakota. Waterfowl use and productivity were assessed relative to 105 semipermanent class stockponds located in fragmented and unfragmented landscapes in 52, 10-mi^2 cells using a standard protocol for surveying waterfowl. Eleven species of waterfowl occurred on stockponds, the most common being mallard, blue-winged teal, and gadwall. Overall productivity was 50 broods/100 pairs for both landscapes with data combined for mallards, blue-winged teal, and gadwalls. Waterfowl productivity was significantly higher in fragmented landscapes

(58 broods/100 pairs) than in unfragmented landscapes (40 broods/100 pairs). Waterfowl pairs per hectare of water for the three most common breeding species were significantly higher on small stockponds (1 ha or smaller) than on medium (1.0 to 2.0 ha) (P = 0.001) or large (P = 0.001) stockponds. Waterfowl broods per hectare for the three most common breeding species did not significantly (P = 0.510 and 0.103) differ by wetland area. While both fragmented and unfragmented landscapes in western South Dakota have fewer basins to attract breeding waterfowl than most areas in the PPR, the unfragmented landscapes have significantly fewer natural seasonal and temporary wetlands than fragmented areas. Thus, stockponds in fragmented landscapes have a higher abundance of seasonal and temporary wetlands to attract breeding ducks. Secondly, stockponds in fragmented landscapes currently have vegetation characteristics that are more attractive to greater waterfowl pair and brood densities, resulting in higher productivity. Prioritized restoration and preservation of large tracts of grasslands in areas that hold the highest numbers of seasonal and temporary wetlands should be an important conservation goal in order to maintain the high level of waterfowl productivity in western South Dakota. If the amount of tilled cropland continues to increase in this portion of western South Dakota the amount of fragmentation will become similar to that in the prairie pothole region, and, as such, waterfowl productivity will decrease considerably.

INTRODUCTION

The Landscape Perspective

European settlement in the northern Great Plains has transformed this region from a contiguous expanse of grassland into a highly fragmented agricultural landscape. While this transformation has been generally detrimental to most wildlife populations, one positive change for wetland dependant wildlife has been the increase in constructed stockponds since the 1930's, primarily to facilitate better distribution of cattle grazing. However, current landscape fragmentation is threatening the existence of stockponds through the introduction of agricultural chemicals and increased siltation rates (Neely and Baker 1989). Upland nesting waterfowl require secure grasslands and productive wetlands for foraging in order to successfully raise offspring. Agricultural activities in the Prairie Pothole Region (PPR) have forced many waterfowl to nest in small patches of remaining grass (Clark and Nudds 1991) or in annually-tilled croplands. Several studies conducted in the PPR have shown that some land use types, especially annually tilled croplands, suppress reproductive success of upland nesting ducks (Duebbert and Kantrud 1974, Higgins 1975, Higgins 1977, Miller 1971, Milonski 1958). However, no-till winter wheat fields have been shown to provide suitable habitat to upland nesting waterfowl (Duebbert and Kantrud 1987).

In relatively unfragmented grassland landscapes of eastern Montana, Ball et al. (1995) found that waterfowl pair density (ducks/ha of water) and brood: adult ratios compared favorably to breeding density and success metrics from the most productive years in the prairie pothole regions. Clark and Nudds (1991) hypothesized that where landscape fragmentation patterns favor large grassland patches and low predator populations, duck nesting success should be high. The relatively unfragmented landscapes of the mixed- and short-grass prairies of the western Dakotas and eastern Montana, and the lack of high predator densities associated with high levels of fragmentation and habitat heterogeneity were identified as factors contributing to high use and productivity (Ball et al. 1995). However, agricultural fragmentation in central and western South Dakota has been a recent trend and one that has accelerated due to current agricultural policies and high commodity prices. Landscape fragmentation has not been a random process in western South Dakota. Much of the region is characterized by rolling terrain, which is conducive to grazing, but makes tillage nearly impossible. In areas with flatter topography, not only are naturally occurring seasonal and temporary wetlands more abundant, but tillage has become the primary land use.

Some earlier duck studies in the western Dakotas and eastern Montana have provided insights into the local habitat preferences of breeding pairs and broods (Bue et al. 1952, Evans and Kerbs 1977, Gjersing 1975, Hudson 1983, Lokemoen 1973, Rumble and Flake 1983, Ruwaldt et al. 1979). In the PPR, it is well understood that in areas of high wetland density, large tracts of grassland are the most productive landscapes for nesting waterfowl (Greenwood et al. 1995, Sovada et al. 2000, Stephens et al. 2005), but, to our knowledge, no studies have compared waterfowl productivity in fragmented and unfragmented landscapes in western South Dakota.

As landscape fragmentation continues to increase in western South Dakota, resource managers will require more information concerning habitat requirements of waterfowl in fragmented and unfragmented landscapes. This study was designed to explore the effects of grassland fragmentation on waterfowl use and productivity. One of the primary objectives of this study was to examine local and landscape-level characteristics affecting waterfowl use of and productivity (broods/100 pairs) on man-made stockponds in western South Dakota.

STUDY AREA

South Dakota is divided into two nearly equal eastern and western halves by the Missouri River. This study was conducted in the western half of the state, between 41° and 46° N latitude and 98° and 105° W longitude and excluded the Black Hills and the Badlands. Western South Dakota is delineated into 5 physiographic regions: the Northern Plateaus, the Southern Plateaus, the Missouri Coteau, the Sand Hills, and the Black Hills (Johnson et al. 1995).

Nearly all of the native grassland in western South Dakota is considered northern wheatgrass – needlegrass plains (Johnson and Larson 1999). Approximately half of South Dakota is in pasture and rangeland, while nearly 40% is in cropland. From 1974 to 1997, cropland in western South Dakota increased by 900,000 acres changing the percentage of the total area of cropland in the state that occurs west of the Missouri River from 24% in 1974 to nearly 29% in

1997. More acres of wheat *(Triticum aestivum)* are planted each year than corn *(Zea mays)* or soybeans *(Glycine max)* in western South Dakota. However, the greatest increase from the same time period was in the acreage of soybeans (194 acres in 1974 to 19,556 acres in 1997) (U.S. Department of Commerce 1977 and 1999).

While 92% of South Dakota's natural prairie wetlands and lakes occur in the eastern half of the state (Ruwaldt et al. 1979), over 86% of the livestock watering ponds (77,000 stockponds) occur in the unglaciated western portion (Ruwaldt 1975). More recently, Rieger et al. (2006) reported a total of 86,782 created wetlands in western South Dakota of which 72,668 were impoundments and 14,114 were excavations. Most of the stockponds were constructed since 1930. The three most common types of stockponds are (1) pit reservoirs or "dugouts" which are steep sided, rectangular excavations that usually lack emergent vegetation, (2) pit-retention reservoirs which are a combination of a dam and a dugout in that the excavated material from the pit is used to create the dam immediately below the pit, and (3) retention reservoirs which are constructed by building a dam across a natural waterway (Eng et al. 1979). Stockponds are constructed to enhance livestock grazing management in arid grasslands. The majority of surveyed stockponds in this study occurred on private land. However, six were surveyed on public land (Figure 1) (May 2001).

METHODS

Study Design

As part of the Northern Great Plains Steppe Assessment, the U.S. Geological Survey's EROS Data Center, in cooperation with The Nature Conservancy, mapped land use (1:250,000 scale at 30 m resolution) in western South Dakota using 1991-1993 imagery. Polygons delineated on the map represent large continuous grasslands. We used a South Dakota Atlas and Gazetteer (1:200,000 scale) in conjunction with the Northern Great Plains Steppe Assessment map to select 98 study sites, each 25.9 km^2, within large polygons of similar land use. Study areas were then stratified by land use and wetland density on National Wetlands Inventory (NWI) maps. Grassland landscapes containing <5% cropland were compared to intensively farmed landscapes (>75% cropland). High wetland density areas containing ≥13 semipermanent wetlands were compared to low wetland density landscapes with <13 wetlands. Lastly, two stockponds were randomly selected from each of the 98 study areas (N = 196; Figure 1). Excavated ponds were excluded from this study because they receive limited wetland bird use (Ruwaldt et al. 1979). Permission to conduct surveys on privately-owned stockponds was obtained from landowners. Wet temporary and seasonal wetlands (Stewart and Kantrud 1971) were also counted within study areas in spring (31 May – 6 June) to characterize hydrologic conditions at the onset of nesting.

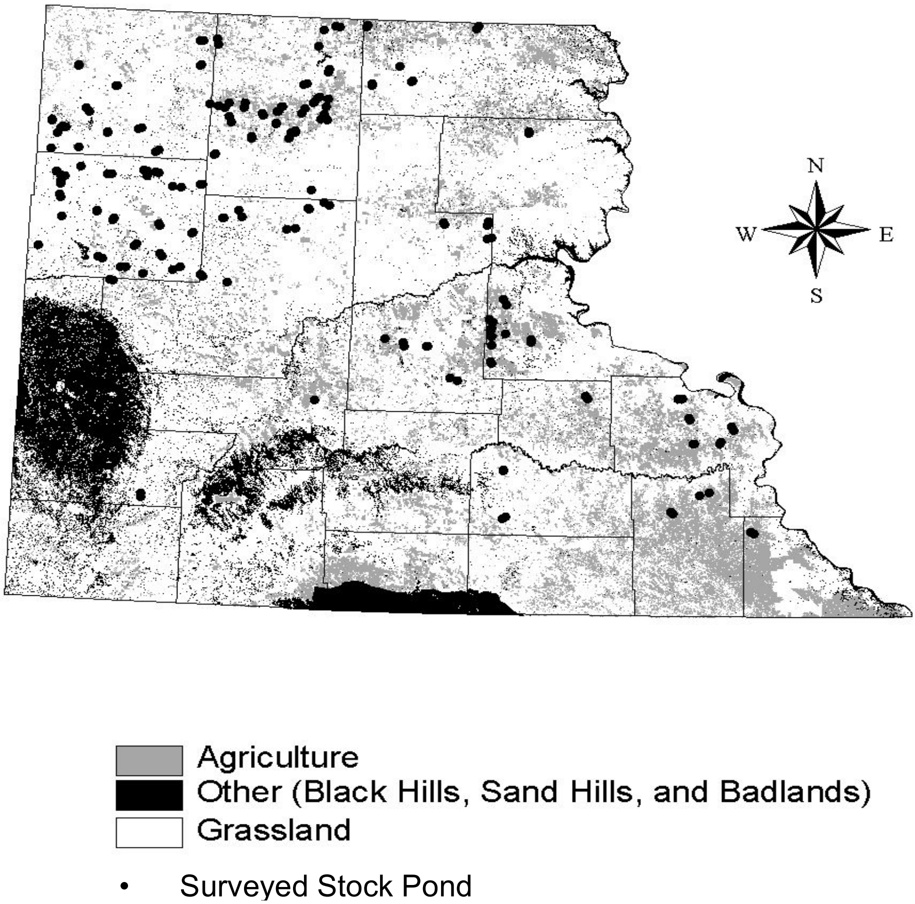

Figure 1. Locations of 196 surveyed stock ponds in western South Dakota, 1999 and 2000, overlaid on land coverage.

Waterfowl Survey Methodology

Waterfowl pair counts were conducted on 91 stockponds in 1999 and 105 stockponds in 2000. However, the 1999 pair counts were conducted at a later than optimal time (i.e., May 1 through June 1) (Higgins et al. 1992), and thus pair and productivity estimates are from the 2000 data only so as not to bias results towards late nesting species. In 2000, pair counts were conducted from late April to mid May. Observers counted waterfowl pairs from a distance, and then approached the wetland quietly on foot in order to finalize the count. Pair groupings were segregated or aggregated following Higgins et al. (1992): several ducks close to each other constituted a group, several ducks spaced distantly apart constituted several groups, and a single duck constituted a group. Pairs were tabulated following Hammond (1969).

Two brood counts were conducted at each wetland, the first in mid June and the second in late July in both 1999 and 2000. During brood counts, each stockpond was visually scanned for broods from a vantage point for a brief time before the stockpond perimeter was traversed to flush broods from cover. Counts were conducted from ½ hour after sunrise until late afternoon (1700 h) (Higgins et al. 1992). Incidental brood sightings (i.e., during pair counts or nongame wetland bird surveys) were also recorded and used in data summaries. Hens performing distraction displays were recorded as having a brood (indicated brood) even though neither the number of ducklings per brood nor the brood age was determined. Brood species, size, and age were recorded according to Gollop and Marshall (1954). Duplicate records of broods were removed from productivity estimates. Waterfowl productivity estimates were calculated by dividing the total number of broods by the total number of breeding pairs (Lokemoen 1973) and are expressed as broods/100 pairs. Scientific names of waterfowl species occur in Table 2.

Habitat Measurements

Percent cover of emergent vegetation on sample basins was estimated visually by using a modification of the Daubenmire (1959) scale by Bailey and Poulton (1968) in which the entire wetland was treated as a single quadrat. Class intervals used to estimate the percentage of the basin covered by vegetation were defined as: (1) <1%; (2) 1-5%; (3) 6-25%; (4) 26-50%; (5) 51-75%; (6) 76-95%; (7) >95%. Class interval midpoints were used as continuous data during analysis.

Grazing intensity within each wetland basin was visually estimated as light (class 1), moderate (class 2), or heavy (class 3) based on the degree of grazing and trampling of residual and new growth vegetation. Shoreline grazing intensity was estimated by visual inspection of residual and new growth vegetation and recorded in the same seven cover class intervals as percent emergent cover. The percent of the wetland perimeter surrounded by woody hydrophytes (i.e., willow [*Salix* spp.] and cottonwood [*Populus deltoides*]) was also visually estimated into one of the seven cover class intervals. The predominant land use adjacent to the surveyed wetland was also recorded, regardless of the land use polygon in which the wetland was located. The number of dominant emergent plant species present was recorded as an index to wetland vegetation heterogeneity.

Waterfowl Statistical Analysis

A two-sample t-test was used to evaluate differences in waterfowl pair and brood density between fragmented and unfragmented landscapes. The number of pairs (SUMPAIRS) and number of broods (SUMBROODS) from the three most abundant waterfowl species were passively sampled variables created in order to draw direct comparisons with other studies. In order to eliminate the effect of larger stockponds having more pairs and broods due to passive sampling, two other variables were created: the number of pairs per hectare of water (SUMPAIRSHA) and the number of broods per hectare of water (SUMBROODSHA) for the combined three most abundant waterfowl species. These variables are the result of dividing the number of pairs and broods by the size of the basin surveyed. The three most abundant waterfowl species (mallard, blue-winged teal, and gadwall) were combined to create four independent variables: SUMPAIRS, SUMBROODS, SUMPAIRSHA, and SUMBROODSHA, which were then grouped by LANDSCAPE (fragmented or unfragmented).

Waterfowl productivity estimates were obtained for each species and by summing mallard, blue-winged teal and gadwall pair and brood totals overall and by landscape. Brood totals were divided by pair totals before multiplying by 100 in order to obtain waterfowl productivity on a broods per 100 pairs basis. Giant Canada geese *(Branta canadensis maxima)* were present throughout the study area, however, due to their early arrival in spring, they were excluded from analysis.

Analysis of variance was used to evaluate the effect of size in determining waterfowl density of combined pairs (SUMPAIRS and SUMPAIRSHA) and broods (SUMBROODS and SUMBROODSHA). Thirty-eight stockponds less than 1 ha were grouped into size category 1 and ranged from 0.108 to 0.764 ha; the 33 stockponds that were greater than 1 ha but less than 2 ha were grouped into size category 2 and ranged from 1.142 to 1.803 ha; and the 34 stockponds greater than 2 ha were grouped into size category 3 and ranged from 2.350 ha to 10.196 ha. Tukey's post hoc test was used to compare differences in means across size categories.

RESULTS

Landscape Fragmentation Affecting Stockpond Characteristics

A two-sample t-test was used to compare 6 local (n = 196 stockponds) and 3 landscape-level (n = 98 cells) characteristics between fragmented and unfragmented landscapes from both survey years (Table 1). The average size of surveyed stockponds did not significantly differ between fragmented and unfragmented landscapes in both survey years (P = 0.647) or in only 2000 (P = 0.628). The average size of surveyed stockponds was nearly 2 hectares, and ranged from 0.108 to 10.196 ha. The mean number of semipermanent stockponds within cells was not significantly different (P = 0.696) between landscapes for both years combined (Table 1). In 1999 and 2000, the grazing intensity of shorelines adjacent to each basin differed significantly (P = 0.002) between landscapes, while in 2000 no significant difference (P = 0.946) was detected.

The results of the two-sample t-tests showed that the landscapes are similar only in average size of semipermanent stockponds. Seasonal (P = 0.046) and temporary (P =0.066) stockponds are more numerous in fragmented landscapes, thus reflecting the topography of the area. In the more steeply rolling terrain of unfragmented landscapes, on average, only 6 seasonal and 7 temporary wetlands were present per cell, whereas in the more level areas in fragmented landscapes where tillage can occur, approximately 8 seasonal and 11 temporary wetlands were present per cell.

The results of the two-sample t-tests on basin-level characteristics reflect the less intense grazing and trampling pressure on stockponds in agricultural areas. On average, more dominant emergent vegetation types were present in stockponds in fragmented landscapes (P = 0.001), and the percent of the basin covered by emergent vegetation (P = 0.001) and trees (P = 0.001) was also significantly higher in fragmented landscapes. While some grazing does occur in cells that are primarily tilled, the intensity of grazing within the stockponds is substantially less in these fragmented landscapes.

Trees covered a greater percentage of stockpond perimeters in fragmented landscapes (n = 93) where grazing and trampling effects from livestock were suppressed. The average percent of the basin perimeter covered by woody hydrophytes was higher in fragmented landscapes (18%) than in unfragmented landscapes (4%) (P = 0.001). Only 5 of 93 stockponds in fragmented landscapes had greater than 75% of the perimeter covered by woody hydrophytes.

Waterfowl Pairs

A total of 658 waterfowl pairs representing 10 species were counted on 105 stockponds in 2000 (Table 2). Pair count data from 1999 were biased due to survey timing and thus not used in analysis. Nearly 80% of all pairs seen were mallard, blue-winged teal, or gadwall. In 2000, a total of 377 pairs were present on 50 stockponds in fragmented landscapes, compared to 281 pairs on 55 stockponds in unfragmented landscapes. One hundred of the 105 stockponds surveyed in 2000 had at least 1 pair of waterfowl present during the surveys.

Table 1. Results of analyses comparing local- and landscape-level factors in stockponds between unfragmented (n = 103) and fragmented (n = 93) landscapes surveyed in western South Dakota, 1999-2000.

	Unfragmented Landscapes	**Fragmented Landscapes**	
	Mean (SE)	*Mean (SE)*	*P-value*
Size of Surveyed Stockpond	1.7 (0.2)	1.9 (0.2)	0.647
Number of Semipermanent Wetlands within the Cell	14.0 (0.6)	13.6 (0.7)	0.696
Number of Seasonal Wetlands within the Cell	5.5 (1.3)	8.2 (0.5)	0.046
Number of Temporary Wetlands within the Cell	7.3 (1.5)	10.6 (1.1)	0.066
Number of Dominant Vegetation Types	1.7 (0.1)	2.4 (0.1)	0.001
Percent of the Basin Covered by Trees	3.6 (0.9)	17.6 (2.5)	0.001
Percent of the Basin Covered by Emergent Vegetation	20.5 (2.3)	38.0 (2.7)	0.001
Grazing Intensity Within Stockpond	28.0 (2.3)	18.2 (1.4)	0.001
Grazing Intensity on Shoreline Adjacent to Stockpond	49.1 (3.5)	32.2 (4.0)	0.002

Waterfowl Broods

A total of 613 broods representing 11 waterfowl species were counted on 196 stockponds in 1999 (n = 91) and 2000 (n = 105) (Table 3). Three hundred thirtythree broods were counted on the 93 stockponds surveyed in fragmented landscapes, compared to 280 broods on 103 stockponds in unfragmented landscapes. In 2000, 322 broods were counted, of which 204 occurred on 50 stockponds in fragmented landscapes and 118 occurred on 55 stockponds in unfragmented landscapes. Mallard, blue-winged teal, and gadwall comprised 82% of all broods (Table 3). A greater percentage of stockponds in fragmented landscapes (78%) had at least 1 brood of any species compared to 55% in unfragmented landscapes. Of the 31 hens performing distraction displays (an indication of a brood), 12 were mallards, 11 were blue-winged teal, four were northern pintails, two were gadwalls, one was a green-winged teal and one was an American wigeon.

Table 2. Waterfowl pair summary data from 105 stockponds, of which 55 occurred in unfragmented landscapes and 50 occurred in fragmented landscapes, during 2000 in western South Dakota.

				Number of Pairs		Stockpond Occupancy	
Species *Scientific Name*	**Total Pairs**	**Pairs per Stockpond**	**Pairs per 100 ha** *Total Area= 207 ha*	**Unfragmented Landscapes**	**Fragmented Landscapes**	**Unfragmented Landscapes n%**	**Fragmented Landscapes n%**
Mallard *Anas platyrhynchos*	236	2.25	113.59	101	135	37 (67)	41 (82)
Blue-winged teal *Anas discors*	188	1.79	90.49	71	117	32 (58)	36 (72)
Gadwall *Anas strepera*	99	0.94	47.65	52	47	34 (62)	24 (48)
American wigeon *Anas americana*	47	0.45	22.62	26	21	15 (27)	13 (26)
Northern pintail *Anas acuta*	26	0.25	12.51	15	11	12 (22)	9 (18)
Northern shoveler *Anas clypeata*	44	0.42	21.18	9	35	9 (16)	16 (32)
Green-winged teal *Anas crecca*	6	0.06	2.89	4	2	3 (5)	2 (4)
Woodduck *Aix sponsa*	2	0.02	0.96	2	0	2 (4)	0 (0)
Redhead *Aythya americana*	5	0.05	2.41	1	4	1 (2)	3 (6)
Canvasback *Aythya valisneria*	5	0.05	2.41	0	5	0 (0)	5 (10)
Lesser scaup *Aythya affinis*	0	0.00	0.00	0	0	0 (0)	0 (0)
TOTAL	**658**	**6.27**	**316.71**	**281**	**377**	**51 (93)**	**49 (98)**

Ducklings

A total of 2,955 ducklings were seen in both years (Table 4), with over 300 more ducklings in fragmented landscapes (1,644 ducklings) than in unfragmented landscapes (1,311 ducklings). Fragmented landscapes in both 1999 and 2000 also had a higher number of ducklings per brood, per wetland, and per 100 ha (Table 5).

Waterfowl Productivity

Productivity (broods/100 pairs) was higher in fragmented landscapes for 5 species of waterfowl in 2000 (Table 6). Only northern pintail productivity was higher in unfragmented landscapes (67 broods/100 pairs) than in fragmented landscapes (55 broods/100 pairs). Green-winged teal productivity was higher in unfragmented landscapes (50 broods/100 pairs), however, in fragmented landscapes no broods were associated with the two pairs surveyed. Canvasback and lesser scaup broods outnumbered pairs in unfragmented landscapes, and subsequently no productivity estimates can be made.

Table 3. Waterfowl brood summary data from 196 stockponds, of which 103 occurred in unfragmented landscapes and 93 occurred in fragmented landscapes, during 1999 and 2000 in western South Dakota.

				Number of Broods		Stockpond Occupancy	
Species	**Total Broods**	**Broods per Stock-pond**	**Broods per 100 ha Total Area = 351 ha**	**Unfrag-mented Land-scapes**	**Frag-mented Land-scapes**	**Unfrag-mented Land-scapes**	**Fragment-ed Land-scapes**
Mallard	207	1.06	59.00	82	125	45 (44)	57 (61)
Blue-winged teal	148	0.76	42.18	70	78	41 (40)	46 (49)
Gadwall	146	0.74	41.61	63	83	32 (31)	42 (45)
American wigeon	44	0.22	12.54	29	15	20 (19)	10 (11)
Northern pintail	35	0.18	9.98	22	13	14 (14)	11 (12)
Northern shoveler	19	0.10	5.42	7	12	6 (6)	10 (11)
Green-winged teal	4	0.02	1.14	4	0	3 (3)	0 (0)
Woodduck	1	0.01	0.29	0	1	0 (0)	1 (1)
Redhead	1	0.01	0.29	0	1	0 (0)	1 (1)
Canvasback	7	0.04	2.00	2	5	2 (2)	3 (3)
Lesser scaup	1	0.01	0.29	1	0	1 (1)	0 (0)
TOTAL	**613**	**3.13**	**174.71**	**280**	**333**	**71 (69)**	**71 (76)**

Table 4. Waterfowl duckling summary data from 196 stockponds, of which 103 occurred in unfragmented landscapes and 93 occurred in fragmented landscapes, during 1999 and 2000 in western South Dakota.

					Number of Ducklings	
Species	**Total Ducklings**	**Ducklings per Brood**	**Ducklings per Stockpond**	**Ducklings per 100 ha**	**Unfrag-mented Landsca-peds**	**Frag-mented Land-scapes**
Mallard	908	4.66	4.63	258.78	329	579
Blue-winged teal	758	5.53	3.87	216.03	354	404
Gadwall	831	5.77	4.24	236.84	365	466
American wigeon	223	5.19	1.14	63.56	137	86
Northern pintail	119	3.84	0.61	33.92	80	39
Northern shoveler	72	3.79	0.37	20.52	29	43
Green-winged teal	10	2.50	0.05	2.85	10	0
Woodduck	8	8.00	0.04	2.28	0	8
Redhead	1	1.00	0.01	0.29	0	1
Canvasback	22	3.14	0.11	6.27	4	18
Lesser scaup	3	3.00	0.02	0.86	3	0
TOTAL	**2955**	**4.82**[a]	**15.08**[b]	**842.19**[c]	**1311**	**1644**

[a] Denotes division of total number of ducklings for all species (n = 2955) by total number of broods for all species (n = 613).
[b] Denotes division of total number of ducklings for all species (n = 2955) by total number of stockponds surveyed (n = 196).
[c] Denotes division of total number of ducklings for all species (n = 2955) by total area of surveyed stockponds (351 ha).

Stockponds in fragmented landscapes had, on average, two more pairs ($P = 0.018$) and twice the number of broods ($P = 0.001$) for combined mallard, blue-winged teal and gadwall. Fragmented landscapes also had more waterfowl pairs per hectare and broods per hectare of basin surface water. Overall, the rate of waterfowl productivity for the three most common breeding species in western South Dakota was 50 broods/100 pairs. The rate of waterfowl productivity was higher in fragmented landscapes (58 broods/100 pairs) than in unfragmented landscapes (40 broods/100 pairs).

Waterfowl Brood Hatch Dates

Waterfowl hatch dates were back calculated for commonly occurring species in western South Dakota from brood counts conducted in 1999 and 2000 (May 2001). All waterfowl species combined had a mean peak hatch date of June 26,

Table 5. Waterfowl duckling summary data by landscapes from 196 stockponds, of which 103 occurred in unfragmented landscapes and 93 occurred in fragmented landscapes, during 1999 and 2000 in western South Dakota.

	Ducklings per Brood		**Ducklings per Stockpond**		**Ducklings per 100 ha**	
Species	**Unfragmented Landscapes**	**Fragmented Landscapes**	**Unfragmented Landscapes**	**Fragmented Landscapes**	**Unfragmented Landscapes**	**Fragmented Landscapes**
Mallard	4.22	4.95	3.19	6.23	184.66	335.25
Blue-winged teal	5.36	5.69	3.44	4.34	198.69	233.92
Gadwall	5.79	5.75	3.54	5.01	204.86	269.82
American wigeon	4.89	5.73	1.33	0.92	76.89	49.80
Northern pintail	4.21	3.25	0.78	0.42	44.90	22.58
Northern shoveler	4.14	3.58	0.28	0.46	16.28	24.90
Green-winged teal	2.50	0.00	0.10	0.00	5.61	0.00
Woodduck	0.00	8.00	0.00	0.09	0.00	4.63
Redhead	0.00	1.00	0.00	0.01	0.00	0.58
Canvasback	2.00	3.60	0.04	0.19	2.25	10.42
Lesser scaup	3.00	0.00	0.03	0.00	1.68	0.00
TOTAL	**4.89**[a]	**5.22**[a]	**12.73**[b]	**17.68**[b]	**735.83**[c]	**951.91**[c]

[a] Denotes division of total number of ducklings for all species (n = 1311 in unfragmented landscapes, 1644 in fragmented landscapes) by total number of broods for all species (n = 268 in unfragmented landscapes, 315 in fragmented landscapes).
[b] Denotes division of total number of ducklings for all species (n = 1311 in unfragmented landscapes, 1644 in fragmented landscapes) by total number of stockponds surveyed (n = 103 in unfragmented landscapes, 93 in fragmented landscapes).
[c] Denotes division of total number of ducklings for all species (n = 1311 in unfragmented landscapes, 1644 in fragmented landscapes) by total area of stockponds surveyed (178 ha in unfragmented landscapes, 173 ha in fragmented landscapes).

and hatch dates ranged from May 4 to July 29 (Fig. 2). Mallard hatch dates ranged from May 4 to July 29 and peaked on June 15. Blue-winged teal hatch dates ranged from May 24 to July 24 and peaked on June 21. Gadwall hatch dates ranged from June 2 to July 24 with a peak on June 26. American wigeon hatch dates ranged from June 3 to July 17. Northern pintail hatch dates ranged from May 28 to July 13. Northern shoveler hatch dates ranged from May 31 to July 16.

Three green-winged teal broods hatched between June 5 and June 25. Seven canvasback broods hatched between June 5 and July 5. One wood duck brood hatched on May 26, one redhead brood hatched on May 24, and one lesser scaup brood hatched on June 15.

DISCUSSION

The Effects Of Landscape Characteristics On Wetland Avifauna

Landscape fragmentation has not been a random process in western South Dakota. Much of the region is characterized by steeply rolling terrain, which is conducive to grazing, but makes tillage nearly impossible. In flatter areas, not only are naturally occurring seasonal and temporary wetlands more abundant, but also, with the advent of bigger tillage equipment, agriculture has become the primary land use. Many cultivated areas still have some remnant blocks of grassland for grazing adjacent to stockponds. However, these areas receive less intensive grazing and trampling pressure and have a more gently rolling topography than unfragmented landscapes. As a result of these influences, stockponds in fragmented landscapes contain greater amounts of emergent vegetation and a greater number of trees. With the exception of the size and abundance of semipermanent stockponds in the cells, all measured factors combined to form a picture of hemi-marsh wetlands with more seasonal and temporary wetlands present within the wetland complex in fragmented landscapes. In unfragmented landscapes, stockponds are isolated and have little vegetation due to both grazing and trampling by cattle and the lack of shallow tail water due to steep sided shorelines in rugged topography.

Table 6. Summary data for waterfowl pairs, broods, and rates of productivity (broods/100 pairs) based on surveys of 105 stockponds, of which 55 occurred in unfragmented landscapes and 50 occurred in fragmented landscapes, during 2000 in western South Dakota.

	Unfragmented			Fragmented			
Species	**Pairs**	**Broods**	**Productivity**	**Pairs**	**Broods**	**Productivity**	**Overall Productivity**
Mallard	101	51	50.5	135	92	68.1	60.6
Blue-winged Teal	71	26	36.6	117	50	42.7	40.4
Gadwall	52	13	25.0	47	31	66.0	44.4
American Wigeon	26	11	42.3	21	11	52.4	46.8
Northern Pintail	15	10	66.7	11	6	54.5	61.5
Northern Shoveler	9	2	22.2	35	9	25.7	25.0
Green-winged Teal	4	2	50.0	2	0	0.0	33.3
Woodduck	2	0	0.0	0	0	0.0	0.0
Redhead	1	0	0.0	4	0	0.0	0.0
Canvasback	0	2	X	5	5	100.0	140.0
Lesser Scaup	0	1	X	0	0	0.0	0.0
Total	**281**	**118**	**42.0**[a]	**377**	**204**	**54.1**[b]	**48.9**[c]

X denotes division by 0

[a]Denotes productivity of all species (118 broods/281 pairs).

[b]Denotes productivity of all species (204 broods/377 pairs).

[c]Denotes productivity of all species (322 broods/658 pairs).

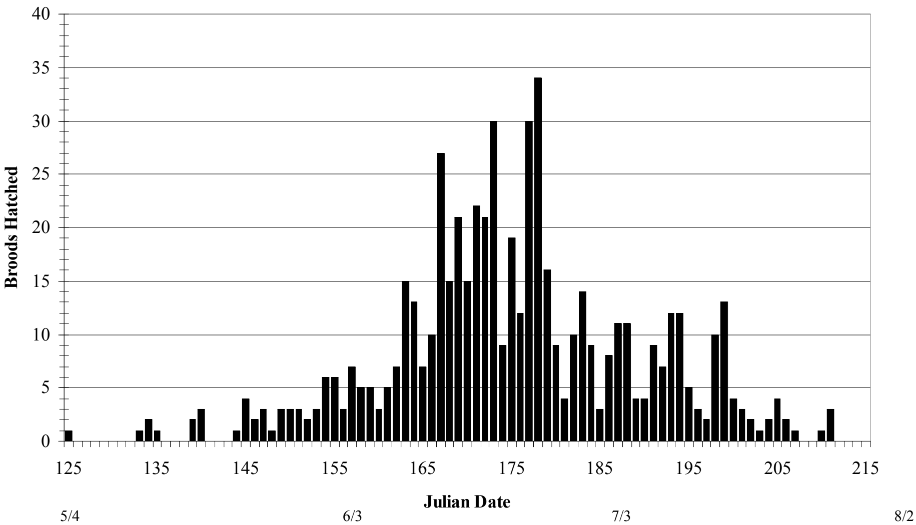

Figure 2. Combined calculated hatch dates of 11 waterfowl species in 1999 and 2000 based on 581 broods on 196 stockponds in western South Dakota.

Although the results of this study show that stockponds in fragmented landscapes in western South Dakota support higher waterfowl productivity rates, these results should be viewed with caution relative to the increasing amounts of tillage agriculture in western South Dakota. The possibility exists that a tillage threshold would eventually be reached in which the western South Dakota landscape would become similar to the eastern PPR, and, as such, upland nesting waterfowl productivity would likely be negatively affected. Stockponds in fragmented landscapes receive nutrient enrichment and sedimentation as a result of tillage and erosion of adjacent lands (Freeland et al. 1999). Heavy siltation rates in stockponds have been shown to decrease waterfowl use (Lokemoen 1973). In fragmented areas, it is hypothesized that siltation rates are high due to tillage of erodable land, and thus, pond longevity may be shortened. Research should be conducted in western South Dakota evaluating the effects of siltation on basin longevity and the effects of turbidity on marsh bird use of stockponds in fragmented and unfragmented landscapes.

The effects of grazing on wetland vegetation have been widely studied. Overgrazing effects on wetlands can result in a decrease in average yearly standing crop of wetland vegetation (Reimold et al. 1975), an increase in water turbidity (Freeland et al. 1999) and areas devoid of vegetation (Bassett 1980). Studies of stockponds have also shown the deleterious effects of overgrazing uplands adjacent to stockponds on waterfowl use (Shearer 1960, Uhlig 1963). Waterfowl prefer an interspersion of cover and open water areas (Weller and Spatcher 1965) that provides better food resources and pair isolation. The findings of this study are in agreement with the findings of these earlier studies.

Woody plant growth around the perimeters of wetlands has been shown to decrease waterfowl brood use in South Dakota (Rumble and Flake 1983).

On the 196 stockponds we surveyed in western South Dakota, trees covered a greater percentage of wetland perimeters in fragmented landscapes where grazing and trampling effects from livestock were suppressed. However, Naugle et al. (1999) showed that prairie wetland bird richness did not significantly decrease until at least 75% of the perimeter of the wetland was encompassed by woody vegetation. Only 5 of the 196 stockponds we surveyed had greater than 75% of the perimeter encompassed by woody hydrophytes. While less grazing and trampling in stockponds in agricultural areas has resulted in more woody hydrophytes around pond perimeters, the 75% wetland perimeter coverage threshold at which waterfowl occurrence and density begin to decrease has not, on average, been exceeded.

Natural wetland basins (not constructed) in western South Dakota are less numerous than in the glaciated eastern half of the state. The greatest number of natural basins per 10 mi2 (n = 98 cells) during this study was 188 (includes temporary, seasonal, and semipermanent basins). In eastern South Dakota, Johnson and Higgins (1997) reported many areas that had more than 420 natural basins per 10 mi^2. Waterfowl pairs are attracted to areas of high wetland densities for breeding. While both fragmented and unfragmented landscapes in western South Dakota have fewer basins to attract breeding waterfowl than most areas in the PPR, the unfragmented landscapes have significantly fewer natural seasonal and temporary wetlands than fragmented areas. Thus, stockponds in fragmented landscapes have a higher abundance of seasonal and temporary wetlands to attract breeding ducks. Secondly, stockponds in fragmented landscapes currently have vegetation characteristics that are more attractive to greater waterfowl pair and brood densities, resulting in higher productivity.

The Effects Of Wetland Basin Area On Wetland Avifauna

Passive sampling is responsible for many species being termed “area sensitive” when in fact it is an artifact of sampling methods. Analysis of variance estimates did not explain the variation in waterfowl density of the three most common breeding species attributed to wetland area for any independent waterfowl variable that did not exceed 20%. Thus, the importance of basin area in predicting waterfowl pair or brood density in western South Dakota stockponds is extremely low. Passive sampling could lead to inaccurate recommendations to managers. By only reporting the average numbers of pairs for each size class of wetland, significantly more pairs would be were present on stockponds larger than 2.0 ha. However, when standardizing sampling to compare waterfowl pairs per hectare, significantly more pairs occurred on smaller stockponds. Obviously, when pair isolation is considered, small stockponds attract more breeding waterfowl pairs than large ones. When waterfowl broods per hectare were compared, there was no significant difference in brood use between size classes of stockponds. However, if only the number of broods present on differing size classes of stockponds was used as a basis for management recommendations, large stockponds would be deemed more important to waterfowl broods than small basins.

The Effects Of Landscape Fragmentation Patterns On Predator Populations And Subsequent Waterfowl Productivity

It has commonly been argued that agricultural activities suppress duck populations by leaving only small patches of upland in which to nest, thereby increasing predation rates and reducing nest success (e.g., Moyle 1964, Fritzell 1975, Oetting and Dixon 1975, MacFarlane 1977, Sargeant et al. 1984, Cowardin et al. 1985, Krasowski and Nudds 1986, Sovada et al. 2000). In western South Dakota, 10 mi^2 cells (2,590 ha) were selected for study that contained at least 75% tilled land. This leaves a maximum of 647 ha of untilled land per 10 mi^2 cell in highly fragmented areas, occurring in large patches (surrounding stockponds or highly erodable land). The findings of Greenwood et al. (1995) and Sovada et al. (2000) have shown that the most productive landscapes for upland nesting ducks contain sufficient wetlands and large tracts of grassland.

The predator component in various landscapes has also been shown to be important to duck nesting success (Klett et al. 1988, Johnson et al. 1989, Sovada et al. 1995). Duck nest success was not used as a measure of productivity in this study due to the low number of nesting ducks per unit of potential nesting cover (Ball et al. 1995). Instead, accurate counts of pairs and broods on stockponds enabled a direct measure of productivity (broods/100 pairs) (Lokemoen 1973). Populations of most upland duck nesting predators are sparse throughout northcentral Montana (Ball et al 1995) and throughout much of western South Dakota (Kost 1997). Coyotes were the dominant predator throughout most of western South Dakota, however, in the northwest corner of the state, aerial gunning has artificially inflated the red fox population to levels higher than those reported throughout the United States (Kost 1997). Western South Dakota has not seen the artificially inflated predator populations or the change in predator species composition due to anthropogenic effects (i.e., increased fencerows, abandoned buildings, culverts, etc.) with the increase in tilled lands.

As a whole, western South Dakota is supporting high waterfowl productivity through large tracts of grasslands and a sparse, coyote-dominated predator community. Since productivity was a direct measure of broods per 100 pairs and not measured from nest searches, it is not directly comparable to nest success due to renesting and the loss of entire broods before the pond was surveyed. Waterfowl productivity for mallard, blue-winged teal, and gadwall combined averaged 50 broods/100 pairs for fragmented and unfragmented landscapes in western South Dakota. Fragmented landscapes had a higher productivity rate (58 broods/100 pairs) than unfragmented landscapes (40 broods/100 pairs) due to better wetland conditions that aid in brood survival, and generally more seasonal and temporary wetlands per cell to attract breeding pairs.

The high rates of waterfowl productivity found in this study support the hypothesis that high waterfowl productivity is common in large, coyote-dominated tracts of grassland (Greenwood et al. 1987, 1995; Ball et al. 1995, Sovada et al. 1995). Hudson (1983) found waterfowl productivity ranged from 40 to 61 broods/100 pairs in differing age classes of stockponds in Phillips County, Montana. Lokemoen (1973) found waterfowl productivity ranged from 22 to 67 broods/100 pairs depending on species in western North Dakota. Ball et al.

(1995) reported an average of 48 broods/100 pairs in large grassland tracts in northcentral Montana. Waterfowl productivity reports from outside the PPR have consistently been high, and all have come from large grassland patches where coyotes dominated the predator community. In sharp contrast, many areas within the PPR are considered sinks, where many females nest, but low rates of productivity are common. Ball et al. (1995) reported that waterfowl nesting in large tracts of grassland in northcentral Montana is probably 2 – 4 times more productive than most populations studied recently (Cowardin et al. 1985; Greenwood et al. 1987, 1995; Hochbaum et al. 1987; Klett et al. 1988; Fleskes and Klaas 1991; Higgins et al. 1992). In agreement with Ball et al. (1995), we contend that nesting waterfowl throughout western South Dakota and northcentral Montana are 2 – 4 times more productive than many areas in the PPR.

Managing Western South Dakota's Stockponds At A Landscape-Level For Avifauna

Large-scale losses of native prairie due to tillage, combined with continued wetland loss and degradation, prompt studies that focus on a landscape scale to complement past local studies and aid in wetland conservation decisions. Managers continue to extrapolate recommendations from local studies to regional scales due to the lack of available landscape-level information. Through recent advances in geographic information systems and remote sensing technologies, research can now be designed for evaluations at a landscape scale. Results of this study can be applied to most of the western half of South Dakota, and presumably much of the southern and western periphery of the PPR.

When possible, construction of new stockponds in fragmented areas for the benefit of ducks should be placed in areas supporting high natural seasonal and temporary wetland basin densities. In unfragmented landscapes, the importance lies in the number of watering ponds available for livestock in order to maintain high quality rangelands and livestock condition.

Fencing off parts of wetlands to livestock use has been recommended as a way to increase emergent vegetation in basins. Bue et al. (1952) noted that fencing should be used selectively, and only in areas where extreme overgrazing occurs. Lokemoen (1973) and Svingen and Anderson (1998) both reported no difference in waterfowl use between fenced or unfenced stockponds. Due to the high costs involved in pond fencing, and the lack of a considerable increase in avifauna use, fencing of stockponds may not be justified on the sole basis of increasing pond use by marsh ducks.

In contrast to fencing stockponds, rest-rotation grazing of uplands has been shown to increase avifauna use. Gjersing (1975) reported that the increase in upland vegetation due to a rotational grazing system provided increased nesting and/or brood-rearing security. In western South Dakota, Evans and Kerbs (1977) reported that vegetation was lusher after implementation of rest-rotation grazing systems, and was thus a cost-effective means of increasing waterfowl production. Thus, it is recommended that in order to increase duck numbers and productivity in unfragmented landscapes, resource managers should focus on grazing systems that enable vegetation in uplands and wetlands time for regrowth before grazing resumes.

Development of wetlands for better livestock management and/or for wildlife enhancement has been a recent topic of potential environmental concern relative to a variety of aquatic macroinvertebrates, amphibians, and wetland plant species (Euliss and Mushet 2004). However, in contrast to several earlier waterfowl and non-game bird studies (May et al. 2002) that involved multiple classes of wetlands and of which most occurred on privately-owned and managed rangelands (see literature cited in this paper), their research results were based on a sample of 12 excavated wetlands of seasonal wetland class only, and all were located on publicly-managed U.S.D.A. Forest Service grasslands.

Water development practices in a largely rangeland landscape is a primary factor enabling private livestock operations to remain sustainable while also providing several environmental benefits to a variety of wildlife and fish (see reference list in Willis and Neumann 1994). Higgins et al. (2002) have pointed out that conservation of the ranching industry is critical to the preservation of grassland-wetland landscapes in the northern Great Plains region in lieu of the rapidly changing land use practices that are directed to more tillage and conversion of rangelands to croplands.

Thus, with consideration to the pros and cons relative to large rangeland/grassland landscapes based on our research and that of others, we opt to recommend the construction of more stockponds within western South Dakota landscapes and other similar landscapes in neighboring states and provinces in Canada. However, we would also recommend that consideration be given to the development of an updated checklist(s) that would enhance, but not restrict, wetland developments in northern Great Plains rangeland/grassland landscapes. We would also recommend that the development of any checklists be made focusing on how to choose wetland development sites that enhance multiple wildlife, fisheries and livestock species while preserving the private property rights of landowners. A similar type of checklist for publicly-owned grasslands might be more restrictive because of their stricter regulation and management practices per se.

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