1998

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PATTERNS IN AVIAN COMMUNITY STRUCTURE AND NON-POINT SOURCE DISTURBANCE POTENTIAL ALONG THE LAND-WATER INTERFACE OF A PRAIRIE POTHOLE LAKE

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ABSTRACT

This study was conducted to test the hypothesis that bird community structure varies significantly between areas which are prone versus not prone to disturbance within the land-water interface of a prairie lake. On-site assessment of land cover and a Geographic Information System (GIS) with coverages of slope, soil erodability, soil hydrologic group and drainages were used to delineate sites prone and not prone to non-point source disturbance. Habitat and community attributes were examined within these site classes during the summer of 1995. While habitat differences between classes (prone and not prone) were inconclusive, results of avian community analyses indicated that sites prone to disturbance had significantly higher average densities (69 individuals/ha vs. 56), species richness (10.9 vs. 8.1 species) and diversity (H'=2.05 vs. 1.72) than sites not prone to disturbance. These results are consistent with observations of other ecological communities exposed to intermediate levels of disturbance. Furthermore, these results suggest a relationship between GIS generated non-point source disturbance potential and ecological communities within the land-water interface.

INTRODUCTION

Pickett and White (1985) state "A disturbance is any relatively discrete event in time that disrupts ecosystem, community or population structure, and changes resources, availability of substratum, or the physical environment". Disturbance is also viewed as any irregular, erratic or unusual event that forces organisms from a static, near-equilibrium condition (Pickett and White 1985). These deviations from the norm, whether positive or negative, may lead to elimination of ill-adapted species within a community (Odum et al. 1979).

Ecological monitoring programs are often implemented to detect these changes and understand factors that influence them. Biomonitoring uses the characteristics of organisms to assess the environment (Hunsaker and Carpenter

1990). The use of organisms has several advantages over physical and chemical measurements, including integration of environmental changes through time, simultaneous consideration of multiple trophic levels and consideration of organism health (Furness and Greenwood 1993).

Standing freshwater makes up less than 4-5% of the Earth=s surface, yet as many as 11-23% of all bird species are dependent on these waters and their margins and many more species use these areas during their life cycle (Furness and Greenwood 1993). In eastern South Dakota alone, 100 bird species depend on wetlands (Johnson et al. 1997). Freshwaters, like all ecosystems, are subject to natural and anthropogenic changes which may have many biological repercussions. Prairie wetlands have been altered by drainage, siltation and changing agricultural practices leading to marked changes in vegetation (Kantrud 1990). These alterations in habitat may lead to dramatic changes in resident animal species.

This research was conducted to determine if habitat characteristics and avian community structure differ between areas of high and low disturbance potential from non-point source pollution.

METHODS AND MATERIALS

Research efforts were conducted along the shoreline of Oak Lake, Brookings County, SD (T112N, R48W, Section 12) (Figure 1). Oak Lake has an area of 163 ha and perimeter of 9.8 Km. Habitats around the lake include shallow and deep water wetlands, oak forest, upland mixed grass prairie and agroecosystems.

Eight sampling sites were chosen along the perimeter of Oak Lake based on their disturbance potential (Figure 1, Table 1). Shoreline patch attributes along the perimeter of the Oak Lake basin (erodability, hydrologic soil group, slope, land use and drainages) were scored individually and summed to provide an overall site disturbance potential score following Sivertun et al. (1988) (Table 1). A detailed description of GIS scoring procedures is provided in Foley (1997). Drainages were the focal point of sites with high disturbance potential as they are linked to the hydrology of the basin through runoff events, making them critical areas for study. Each of the study sites encompassed an area of 6000 square meters. Four sites each were selected representing low and high disturbance potential.

Habitat sampling was conducted in July, after avian counts were completed so that nesting habitat would not be disrupted (Ralph et al. 1993). Vegetation composition and density were measured using randomly placed, nested quadrants along five random transects at each site (Higgins et al. 1994). Measurements included grass, forb, cattail and woody stem species occurrence and density. In addition, tree species, diameter at breast height, visual obstruction and canopy cover measures were taken within a 10x10m quadrant.

A fixed-width transect survey (Mikol 1980) was used to determine avian species richness, avian density and presence/absence of species. Counts were initiated on 16 May 1995 and ended 30 June 1995. These dates were chosen so counts would not be biased by migrants or young birds (Ralph et al. 1993 and Mikol 1980). Transects were walked between one half hour before and three to four hours after sunrise (Emlen 1971; Ralph et al. 1993). Sites were rotated after each round of counts to eliminate bias due to time of day. Counts were not completed when 1) there was heavy to moderate rain, 2) heavy fog, 3) strong winds (> 10 km per hour), or 4) extreme temperatures (<7 or > 24 C) (Ralph et al. 1993).

Birds leaving the transect during approach were counted, if they were within the 100m length and 60 m fixed width (Mikol 1980). Transects were walked at an approximate speed of 0.5 to 1.5 mph (Ralph et al. 1993). Species and the number of each occurring within the transect width were counted and recorded (Mikol 1980). Short stops were allowed to observe detected birds (Mikol 1980, Ralph et al. 1993). Both visual and auditory detections were counted.

Avian species richness, density, and Shannon-Wiener diversity index (Shannon and Weaver 1963; Washington 1984) were analyzed for site class and date effects using a two-way analysis of variance with date as a blocking variable (Steel and Torrie 1980). Habitat differences between site classes were analyzed using a one-way analysis of variance. Means comparisons among site classes and dates were analyzed using the Tukey=s mean comparison test.

Runs and Wilk-Shapiro tests were used on all data to determine if the data were normally and independently distributed. Data not normally distributed were ranked and analyses were performed on the ranks (Conover and Iman 1981).

RESULTS

Typha glauca, grass, forb and shrub stem densities were higher and more variable at sites prone to disturbance (Table 2). In addition, measured canopy cover was zero at prone sites due to small numbers of scattered, large trees. However, no statistical differences could be detected for vegetation attributes between site classes (ANOVA, $p > 0.05$).

Fifty-six avian species were recorded from Oak Lake study sites, 50 of which were observed at sites prone to disturbance and 43 of which were observed at sites not prone to disturbance (Table 3). Red-winged blackbirds were the most abundant species observed at all eight sites, accounting for 32% of the total individuals observed (Table 3). Common yellowthroats, yellow warblers, song sparrows and marsh wrens were also abundant, accounting for 30% of all observed individuals. Species occurring on more than one date and observed only in sites not prone to disturbance included the white-breasted nuthatch, house wren, rose-breasted grosbeak and belted kingfisher (Table 3).

Bird densities were higher at sites prone to disturbance relative to not prone sites (69 individuals/ha versus 56 individuals/ha; 2-way ANOVA, $p = 0.001$, $n=4$)(Table 4). Lower densities were observed late in the counting session (2-way ANOVA, $p = 0.005$, $n=12$) but no significant treatment by date interaction was observed ($p = 0.362$).

Sites prone to disturbance had a mean richness of 10.9 (n=48) species while sites not prone had a mean richness of 8.1 (n=48) species (2-way ANOVA, $p<0.001$, n=4) (Table 4). Lower richness values were observed toward the end of the counting period (2-way ANOVA, $p<0.049$, n=12). No treatment by date interaction was observed (p=0.668).

Shannon-Wiener diversity was significantly higher at sites prone to disturbance with a mean index value of 2.05 (n=48) while not prone sites had a mean index value of 1.72 (n=48)(2-way ANOVA, $p<0.001$, n=4) (Table 4). No significant date (p=0.378, n=12) or interaction (p=0.870) effects were observed.

DISCUSSION

Avian density, richness and diversity were all significantly higher in patches which were prone to disturbance. Prone sites had higher mean stem densities and greater variance between replicates for *Typha glauca,* forbs and grasses. In addition, scattered trees and shrubs increased habitat heterogeneity relative to not prone sites. Marsh wrens, yellow-headed blackbirds and sedge wrens all require wetland vegetation types for nesting habitat (Ehrlich et al. 1988). These species were two to three times more abundant at prone sites. In addition, several edge species, including common grackles, American goldfinches and brown-headed cowbirds, were three to ten times more abundant at prone sites.

Sites not prone to disturbance exhibited lower habitat heterogeneity and supported greater numbers of mature trees and shrubs. Three avian species occurring only in sites not prone to disturbance, the white-breasted nuthatch, house wren and rose-breasted grosbeak, depend on mature trees. White-breasted nuthatches and house wrens are cavity nesters while rose-breasted grosbeaks prefer deciduous woodlands and nest 5 to 15 feet off the ground (Ehrlich et al. 1988). In addition, belted kingfishers were observed foraging only from the canopy of not prone sites.

The presence of more heterogeneous habitat at sites prone to disturbance (i.e., some trees and shrubs and higher densities of grasses, forbs and cattails) provided greater habitat diversity for avian species. Greater heterogeneity facilitates nonrandom use of habitat and food resources by resident animals and improves foraging efficiency (Pickett and White 1985).

The results of this study may provide support to the Intermediate Disturbance Hypothesis (Connell 1978). This hypothesis contends that disturbances occur at various scales, intensities and frequencies (Connell 1978). Greater habitat diversity and reduced competitive interactions result from intermediate frequencies and intensities of disturbance. Our results suggest that disturbances to littoral patches around Oak Lake maintain greater habitat heterogeneity at prone sites,
leading to greater avian abundance, species richness and species diversity.

Reice (1994) suggests that biological systems are normally in some stage of recovery from the last disturbance. Successional processes follow these disturbance events, leading toward habitat homogeneity and strong competitive interactions. Oak Lake patches not prone to disturbance exhibit characteristics of more mature successional stages with lower habitat heterogeneity, avian numbers and species. These results are consistent with those of others who have found higher avian species richness and density during intermediate stages of succession (Odum 1950; Johnston and Odum 1956; Karr 1968; Shugart and James 1973; Meslow 1978; Morrison and Meslow 1984; Raphael et al. 1987; Meyers and Odum 1991).

Data collected from Oak Lake indicate differences in avian community structure between sites with high and low disturbance potential. Avian abundance, species richness and species diversity were all higher at sites prone to disturbance. These differences appear to be related to maintenance of high habitat heterogeneity at sites prone to disturbance and are consistent with observations of other ecological communities exposed to intermediate levels of disturbance. Furthermore, these results suggest a relationship between GIS generated disturbance classification and ecological attributes of pothole habitats.

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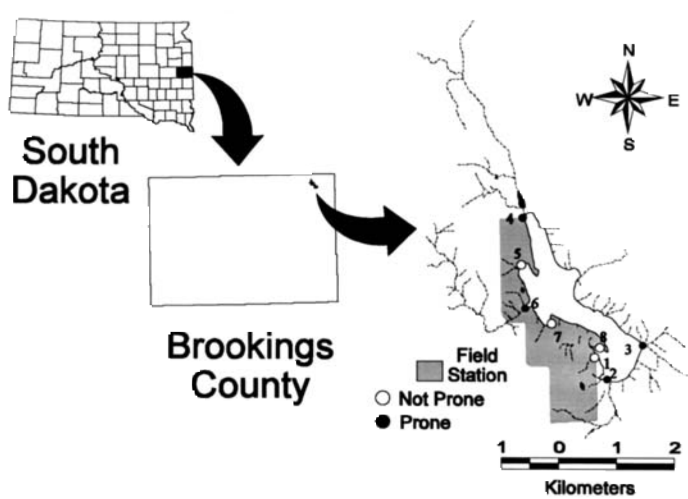

Figure 1. Habitat and avian sampling sites in the land-water interface of Oak Lake, Brookings County, South Dakota.

Table 1. Habitat patch characterization within the land-water interface of Oak Lake, Brookings County, SD. Patch attributes were combined to provide and overall rating of disturbance potential. Sites with total scores exceeding 200 were classified as prone to disturbance.*

Site	Drainage Present	Mean Slope	Soil K-Factor	Hydrologic Group	Disturbance Potential	Total Score
1	Yes	27.5	0.28	B	Low	90
2	Yes	0.50	0.37	D	High	4000
3	Yes	1.0	0.28	C	High	480
4	Yes	1.0	0.37	D	High	800
5	No	1.0	0.28	D	Low	60
6	Yes	1.0	0.28	C	High	300
7	No	1.0	0.28	C	Low	12
8	No	27.5	0.28	B	Low	9

*Average percent slope, soil K-factor and soil hydrologic group were drawn from Natural Resource Conservation Service Soil Survey data, Brookings County, South Dakota. See Sivertun et al. (1988) for a description of the original site classification method and Foley (1997) for a description of its application to shoreline patches.

Table 2. Habitat characteristics at sites with high and low disturbance potentials at Oak Lake, Brookings County, SD, including grass, forb, cattail and shrub densities (stems per square meter) and percent tree canopy cover.

Vegetational Attribute	Mean	Range	Median
PRONE TO DISTURBANCE			
Grasses	874.6	0.0-6704.0	476.0
Forbs	62.0	0.0-184.0	60.0
Typha glauca	44.2	0.0-184.0	4.0
Shrubs	0.6	0.0-4.1	0.0
% Tree Canopy Cover	0.0	0.0-0.0	0.0
NOT PRONE TO DISTURBANCE			
Grasses	408.2	0.0-2124.0	38.0
Forbs	47.4	0.0-144.0	42.0
Typha glauca	25.8	0.0-140.0	6.0
Shrubs	1.7	0.0-9.0	0.0
% Tree Canopy Cover	33.8	0.0-90.0	22.5

Table 3. Average abundance (number of individuals per site) of species and total individuals observed at sites not prone (n=4) and prone (n=4) to disturbance over 12 counting dates.

SPECIES	SCIENTIFIC NAME	Not Prone	Prone	Total
American White Pelican	*Pelecanus erythrorhynchos*	0.3	0	4
Great Blue Heron	*Ardea herodias*	0	0.1	1
Canada Goose	*Branta canadensis*	0.2	2	4
Mallard	*Anus platyrhynchos*	3.8	1.8	68
Blue-winged Teal	*Anus discors*	1.8	0.2	35
Wood Duck	*Aix sponsa*	0.5	0.5	12
Red-tailed Hawk	*Buteo jamaicensis*	0.3	1.1	5
Sora	*Porzana carolina*	0.3	0.1	4
Killdeer	*Charadrius vociferus*	0	0.3	3
Forster's Tern	*Sterna forsteri*	0	0.2	2
Black Tern	*Chlidonias niger*	0.8	3.3	50
Common Snipe	*Gallinago gallinago*	0	0.3	3
Woodcock	*Scolopax minor*	0	0.2	2
Mourning Dove	*Zenaida macroura*	1.3	2.9	50
Great Horned Owl	*Bubo virginianus*	0	0.1	1
Belted Kingfisher	*Ceryle alcyon*	0.2	0	2
Downy Woodpecker	*Picoides pubescens*	0	0.4	5
Northern Flicker	*Colaptes auratus*	0.5	0.1	7
Willow Flycatcher	*Empidonax trailii*	1.5	2.3	46
Eastern Phoebe	*Sayornis phoebe*	0	0.1	1
Eastern Kingbird	*Tyrannus tyrannus*	2.4	2	53
Barn Swallow	*Hirundo rustica*	4	4.8	106
Tree Swallow	*Tachycineta bicolor*	3.3	3	51
Blue Jay	*Cyanocitta cristata*	2.3	0.1	28
Black-capped Chickadee	*Parus atricapillus*	0.1	0.2	3
White-breasted Nuthatch	*Sitta carolinensis*	0.7	0	8
Marsh Wren	*Cistothorus palustris*	4.8	9.3	168
Sedge Wren	*Cistothorus platensis*	1.2	3.5	56
House Wren	*Troglodytes aedon*	0.8	0	10
American Robin	*Turdus migratorius*	1.4	1.4	34
Swainson's Thrush	*Catharus ustulatus*	0.1	0.1	2
Gray Catbird	*Dumetella carolinensis*	4.6	3.8	100
Brown Thrasher	*Toxostoma rufum*	0.7	0.5	14
Cedar Waxwing	*Bombycilla cedrorum*	1.1	1.6	32
European Starling	*Sturnus vulgaris*	0	0.8	10
Yellow Warbler	*Dendroica petechia*	11.8	13.5	303
Common Yellowthroat	*Geothlypis trichas*	14	14.3	340
Yellow-rumped Warbler	*Dendroica coronata*	0.6	0.3	10
Orange-crowned Warbler	*Vermicvora celata*	0	0.7	8
Warbling Vireo	*Vireo gilvus*	0.1	0.1	2
Northern Waterthrush	*Seiurus noveboracensis*	0.2	0	2
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	1.1	0	13
Dickcissel	*Spiza americana*	0	0.1	1
Chipping Sparrow	*Spizella passerina*	0.2	0.2	4
Clay-colored Sparrow	*Spizella pallida*	1	1.2	26
Song Sparrow	*Melospiza melodia*	9.8	12.1	263
Swamp Sparrow	*Melospiza georgiana*	0.3	1.1	16
Bobolink	*Dolichonyx oryzivorus*	0.2	2	26
Red-winged Blackbird	*Agelaius phoeniceus*	51	45.3	1156
Western Meadowlark	*Sturnella neglecta*	0	0.08	1
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	1.8	3.6	65
Common Grackle	*Quiscalus quiscula*	1.9	8.4	124
Brown-headed Cowbird	*Molothrus ater*	0.5	5.2	68
Orchard Oriole	*Icterus spurius*	0	0.2	2
Baltimore Oriole	*Icterus galbula*	0.83	0.43	21
American Goldfinch	*Carduelis tristis*	3.2	10.2	160

Table 4. Summary statistics for avian density (individuals/ha), species richness (species/site) and species diversity (H') at sites prone and not prone to disturbance (n=4 each) over twelve counting dates at Oak Lake, Brookings County, SD.

Statistic	**n**	**Mean**	**Standard Error**	**Range**
PRONE TO DISTURBANCE				
Density	48	69.2	2.41	30.0-101.7
Richness	48	10.9	0.41	3-16
Diversity	48	2.10	0.05	1.00-2.50
NOT PRONE TO DISTURBANCE				
Density	48	56.1	1.71	33.3-88.3
Richness	48	8.1	0.39	3-15
Diversity	48	1.70	0.06	0.90-2.40