SUBSIDENCE WETLANDS: AN ASSESSMENT OF VALUES [1]

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Abstract. Underground coal mining and unplanned subsidence have occurred adjacent to and under Rend Lake, an 18,000 Ac impoundment in southern Illinois, for more than 90 years. Recent longwall mining permits for Rend Lake have emphasized wetland habitat enhancement as a benefit of planned subsidence that occurs under upland areas adjacent to the shoreline. However, planned subsidence under existing mudflats was viewed as a potential habitat loss. To evaluate subsidence effects, shorebird and waterfowl utilization, benthic invertebrate density, and plant communities of subsided and unsubsided habitats were monitored during 2000 to 2002. Spring waterfowl surveys (2001 and 2002) documented greater than 120,000 ducks and geese using the Rend Lake study areas. Surveys identified 3,780 shorebirds using the wetland study areas during summer - fall surveys of 2000, and 6,382 shorebirds during 2001. Shorebird utilization in 2000 was approximately two times greater at the subsided study area compared to the unsubsided study area; however, in 2001 shorebird abundance was greater at the unsubsided study area. Wetland surveys identified benthic invertebrate density and biomass values were also higher at the subsided basins during 2000; however, there was no difference between sites in 2001, suggesting that lake hydroperiod may be the principal factor affecting habitat suitability.

Additional Key Words: waterfowl, shorebirds, mitigation.

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Introduction

Illinois has lost approximately 90 percent of its original 3.2 million ha (8 million Ac) of presettlement wetlands (Suloway and Hubbell 1994). Protection and/or mitigation of existing wetlands is required to eliminate or minimize short and long-term effects of mining activities. Regulatory programs of the Illinois Department of Natural Resources (IDNR) - Office of Mines and Minerals have been instrumental in protecting unmined wetlands. The IDNR reclamation - regulatory program also provides opportunities for establishment of productive wetlands in reclaimed surface coal mine areas (Nawrot and Klimstra 1989) and subsidence panels of underground coal mines (Nawrot et al. 1995).

The potential for both wetland impact and/or development opportunities of subsided areas in Illinois is great due to the lengthy mining history and extensive areas affected by underground mines. Since commercial underground mining for coal began in 1810, more than 4,000 underground mines underlying more than 300,000 ha (750,000 Ac) have operated in Illinois (IDNR - pers. comm). Conventional room and pillar mining conducted during the early-mid 1900s has produced diverse areas (>1,300 Ac) of unplanned subsidence wetlands in the Big Muddy and Saline River bottoms of southern Illinois (Fig. 1). The seasonally inundated hydrology of these unplanned room and pillar subsidence areas resulted in diverse palustrine emergent and shrub-scrub wetlands. Subsidence wetlands provide habitat for several of Illinois' wetland associated threatened and endangered species (Sternburg and Nawrot 1993).

The shift to longwall mining during the 1980s, and the ability to predict the topography and altered hydrology of subsidence areas, provided opportunities for wetland habitat development and enhancement of subsidence panels. Three longwall panels encompassing more than 12 ha (30 Ac) in the floodplain of Ewing Creek were one of the first planned subsidence wetlands permitted by IDNR in southern Illinois. The Ewing Creek longwall panels were mined during 1984-1986 at a depth of 165 m (540 ft) resulting in subsidence depressions of approximately 1.5 m (3.5 ft) over the panels. The Ewing Creek subsidence wetlands were characterized by palustrine emergent and forested plant communities that rapidly colonized the seasonally inundated subsidence basins. Avian utilization of the subsidence wetlands was documented during 1990 and 1991; 55 species representing

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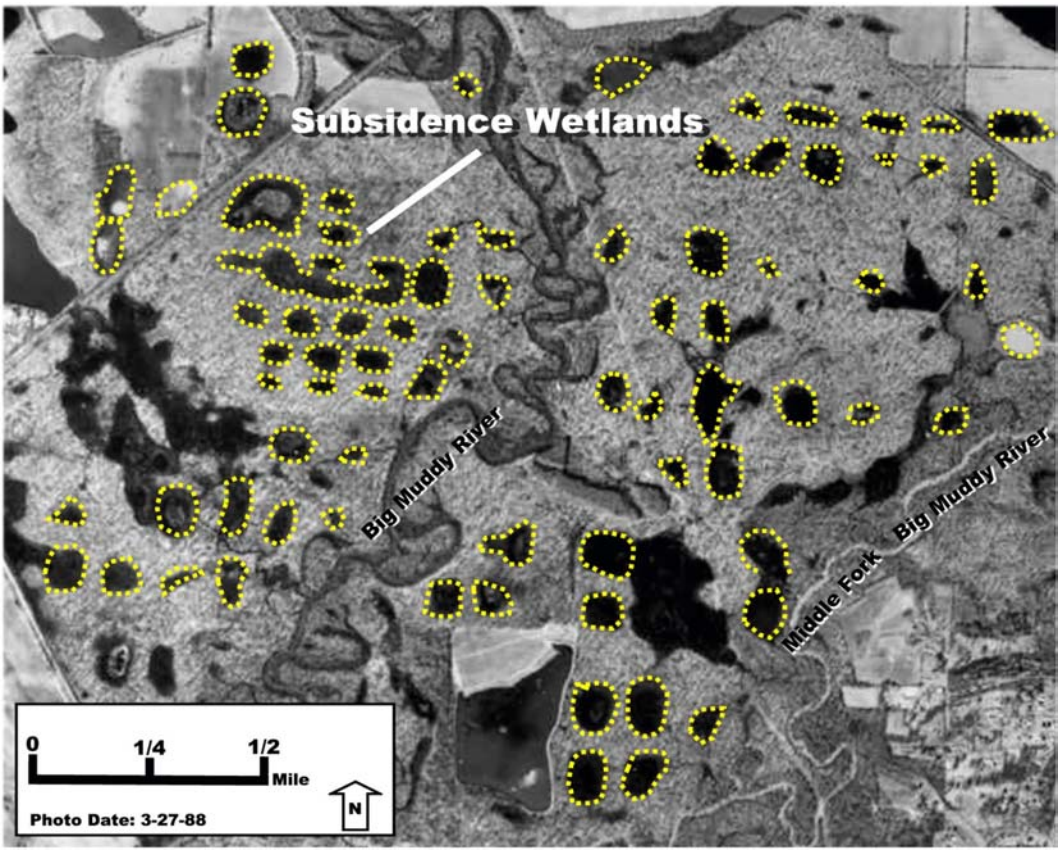

Figure 1. Unplanned subsidence wetlands (dotted outline) resulting from underground room and pillar coal mining in Franklin County, IL. Coal extraction occurred at a depth of 660 ft during the early to mid 1900s.

25 taxonomic families were identified (Nawrot et al. 1995). Neotropical warblers, including the prothonotary warbler (*Protonotaria citrea*), wetland wading birds such as great blue heron (*Ardea herodias*), and numerous species of waterfowl utilized the diverse Ewing Creek subsidence wetlands for feeding.

Longwall mining practices were adopted by other southern Illinois coal operators during the mid to late 1980's. Consolidation Coal Company (CONSOL) expanded longwall extraction operations adjacent to, and under Rend Lake, including portions of the Illinois Department of Natural Resources 2,025 ha (5,000 Ac) Nason Point Wildlife Refuge. The effect of subsidence on a 34 ha (85 Ac) island located 500 m (1,800 ft) southwest of Nason Point, used by wintering Canada geese,

was investigated during 2000 to 2001 (Brennan 2002). To address the effects of subsidence on littoral
zones and adjacent mudflat habitats on the east side of Nason Point, assessments of waterfowl and shorebird utilization were initiated in 2000 and continued through 2002. Habitat assessments of three subsidence panels located on the west shore of Rend Lake (Ward Branch) were conducted during 1987-1988, and 1991 (Owen 1992).

This paper summarizes current shorebird, wading bird, and waterfowl assessments of the subsided and unsubsided wetland habitats associated with the Nason Point (unmined) and the Ward Branch (mined) study areas of Rend Lake. Plant community and benthic macroinvertebrate data summaries are also included.

Study Area

Rend Lake, a 7,560 ha (18,680 Ac) impoundment on the Big Muddy River located in Jefferson and Franklin counties in southern Illinois, was constructed by the Army Corps of Engineers in the late 1960s for water supply, flood control, and recreation. Rend Lake, located in the Mt. Vernon Hill County section of the southern Illinois Till Plain Division of Illinois (Mohlenbrock 2002), is characterized by poor soils with a high clay content. Bottomland and riparian forests associated with the Big Muddy River were dominated by silver and red maple (*Acer saccharinum, A. rubrum*), pin oak, (*Quercus palustris*), American elm (*Ulmus americanus*), sycamore (*Platanus occidentalis),* river birch (*Betula nigra*), ash (*Fraxinus* spp.), hackberry (*Celtis occidentalis*), and willow (*Salix nigra*). Land use associated with the 2,025 ha (5,000 Ac) Nason Point Wildlife Refuge located at the northern end of Rend Lake is predominately cropland (810 ha); and, adjacent mudflats and littoral zones (1,215 ha).

Pre-subsidence land use associated with the Ward Branch and Nason Point study areas was characterized by upland old field, forested hedgerows, and small woodlots. Four years after subsidence, the seasonally inundated and moist soil zones of the Ward Branch study area were characterized by scrub-shrub and emergent plant communities dominated by obligate and facultative wetland hydrophytes such as willow, buttonbush (*Cephalanthus occidentalis*), silver

maple, nut sedges (*Cyperus* spp.), smartweeds (*Polygonum* spp.) and wild millet (*Echinochloa* spp.) (Owen 1992).

Hydrology

Rend Lake water levels are passively maintained by discharge through the main spillway (elevation 125 m (410 ft)) and the auxiliary spillway (elevation 126.5 m (415 ft)). The annual hydroperiod of Rend Lake is characterized by increased water levels throughout the late winter and spring, and decreased water elevations in late summer and fall. Lake levels average ≤123.6 m (405.5 ft) from August through late October (Elliott-Smith 2003). Exposed shorelines and mudflats associated with the late summer to early fall drawdowns coincide with peak southward shorebird migrations. Seasonal inundation of moist soil zones, subsidence wetlands, and unsubsided coves and shorelines during late winter and early spring high water levels (≥123.9-125.0 m (406.5-410.0 ft)) coincides with spring migration patterns of waterfowl returning to northern breeding grounds.

Mining

Since the early 1900s eight mines extracted coal adjacent to or under the current boundaries of Rend Lake (Barkley 2000). Previous room and pillar operations, including high extraction retreat methods, and the current CONSOL longwall mine, extracted coal from an average 2.4 m (8 ft) thick seam of the Illinois No. 6 (Herrin) coal at depth of approximately 200 m (660 ft). Two longwall units recently operated by CONSOL have extracted coal from under Rend Lake. CONSOL's west unit passed under the Ward Branch study area in 1988 (Fig. 2). Longwall mining associated with the Nason Point island and peninsula includes 12 proposed panels located on the west side of the peninsula and 9 panels planned for the east side of the peninsula (Fig. 3). Panel width averages 305 m (1,000 ft); and, length varies from 790 to 3,050 m (2,800-10,000 ft) (Barkley 2002). Currently, four panels have been mined on the southwest and southeast portion of Nason Point. The four southwestern panels passed under Nason Point island between February 1999 and July 2000 inundating ~24 ha (60 Ac) of the 34 ha island (Brennan 2002). Portions of two panels have extended under the southern tip of Nason Point peninsula resulting in seasonally inundated subsidence wetlands totaling >6 ha (15 Ac). Mining of the

remaining panels underlying Nason Point peninsula was suspended indefinitely during spring 2002 due to unfavorable coal market conditions.

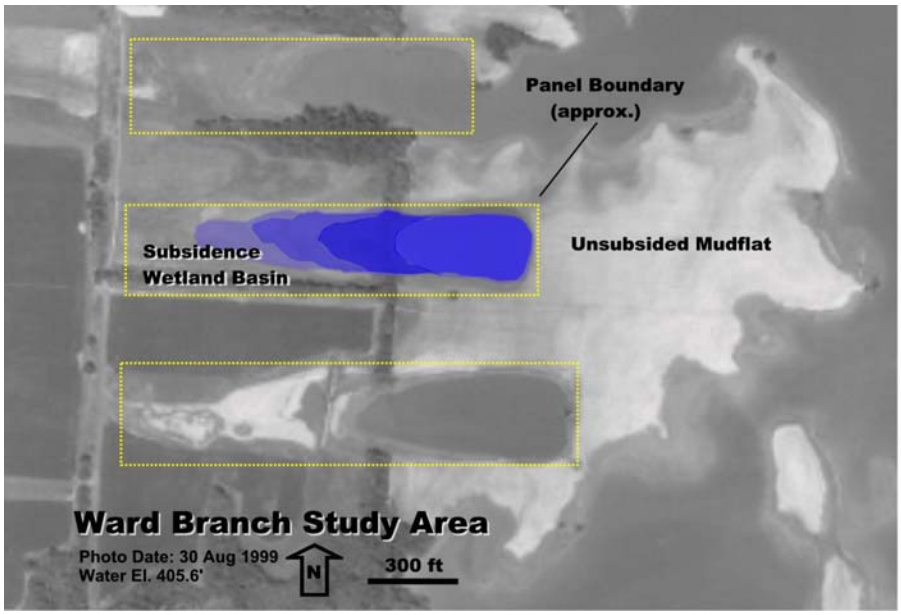

Figure 2. Planned subsidence wetlands (three of four panels illustrated) resulting from longwall mining in Franklin County, IL. Coal extraction occurred in 1989 at a depth of ~660 ft.

Although mining adjacent to and under Rend Lake has occurred for more than 90 years, evaluations of subsided wetlands and littoral zones did not occur until 1987 (Owen 1992). Owen's (1992) pre- and post-subsidence evaluation of the Ward Branch study area identified the establishment of diverse moist soil, emergent, and scrub-shrub wetlands plant communities in the seasonally inundated subsidence depressions that extended into the littoral zone and upland habitats. Avian utilization of the Ward Branch subsidence wetlands was not addressed. However, recent

surveys (Robinson 1996, McMullen and Zoanetti 1999) documented the use of Rend Lake's shallow water and mudflat habitats by migrant shorebirds. Potential loss of goose loafing habitat downwind of Nason Point island, and loss of mudflats on the east shoreline of Nason Point peninsula prompted the establishment of a Resource Evaluation Team (RET) to address habitat loss and mitigation issues (Barkley 2000). The RET selected a habitat modeling process (Wildlife Habitat Appraisal Guide - WHAG) to enumerate specific habitat values of Nason Point island for wintering Canada geese; and, the Nason Point peninsula mudflats for lesser yellowlegs. Although the WHAG process addressed specific habitat values for selected indicator species such as the Canada goose and lesser yellowlegs, more extensive avian **utilization and habitat studies were initiated in January 2001** by research assistants (Elliott-Smith 2003, Kirk 2003) of the Cooperative Wildlife Research Laboratory of Southern Illinois University Carbondale.

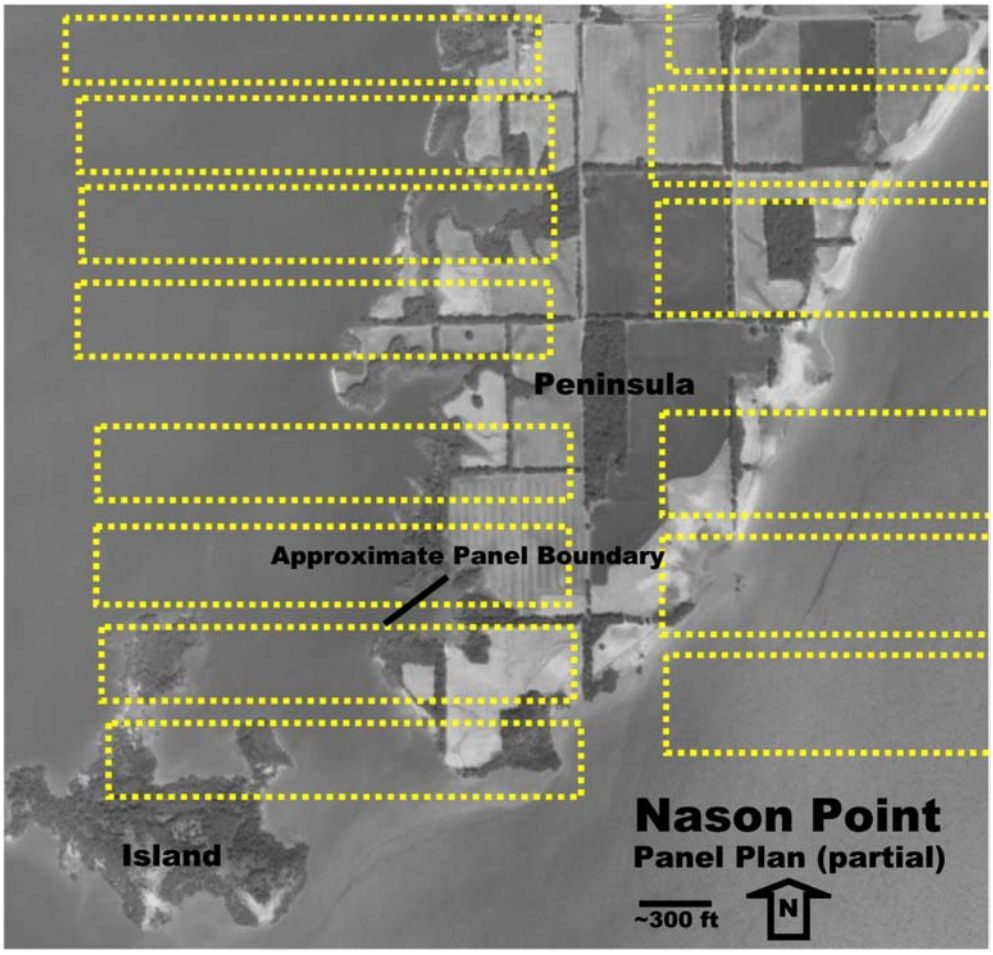

Figure 3. Longwall mine panel plan (partial) for coal extraction under the southern tip of the Nason Point peninsula, Rend Lake IL. Photo date: 30 Aug. 1999 - water elevation 405.6 ft.

Previous Environmental Assessments

Methods

Waterbird (Shorebird and Waterfowl) Surveys

Weekly surveys of the Ward Branch subsidence area and the east side of Nason Point peninsula were conducted during late summer and fall (July - October) of 2000 and 2001 to document the southward migration chronology of shorebirds and examine habitat use patterns. Waterfowl surveys were completed weekly for spring 2000 (beginning 12 February and ending 1 May) and more frequently for spring 2001 (beginning 28 January and ending 25 May) along Ward Branch and the east side of Nason Point peninsula. Potential shorebird habitat surrounding the four Ward Branch subsidence basins and two sites along the east side of Nason Point peninsula, representing very gradual (≤0.5%) and moderate (>0.5%) slopes, were surveyed by

foot (Fig. 4). Microhabitat variables at shorebird observation locations were recorded. Microhabitat classifications included: Dry Mud - parched substrates <30% vegetative cover >10 cm tall; Wet Mud - wet substrate, <30% cover >10 cm tall; Shallow Water - standing water, <30% cover >10 cm tall; Vegetated Flats - dry or moist substrates, >30% cover >10 cm tall; and, Flooded Vegetation - emergent vegetation, >30% cover >10 cm tall. Waterfowl habitat classification also included Open Water Habitat - habitat below 123.4 m above sea level(405 ft), normal pool level for Rend Lake.

Vegetation Surveys

Moist soil vegetation was surveyed along eight transects at Nason Point peninsula (1 subsided cove, 4 unsubsided cove, 3 exposed shoreline) and four transects at Ward Branch (3 subsided cove, 1 exposed shoreline) during September 2001 (Fig. 4). Transects were placed along a gradient from the shoreline to crops or upland vegetation. Percent cover for each species present in a 0.25 m^2 sample plot was recorded at five equally spaced sample points along the transect.

Invertebrate Sampling

Invertebrates were sampled from five transects (slopes $\leq$0.5%) on the northeast shore of Nason Point, and five transects representing somewhat gradual slopes (>0.5%) on the southeast shoreline of Nason Point (Fig. 4). Ten transects representing subsided areas, and unsubsided areas between subsidence basins were sampled at the Ward Branch study area (Fig. 4). Two 5 cm diameter x 5 cm deep sediment cores were collected from the mud - water interface within a 1 m^2 quadrat along each transect. Cores were collected during each of four sample periods between 8 September and 22 October 2000, and three sample periods between 21 August and 23

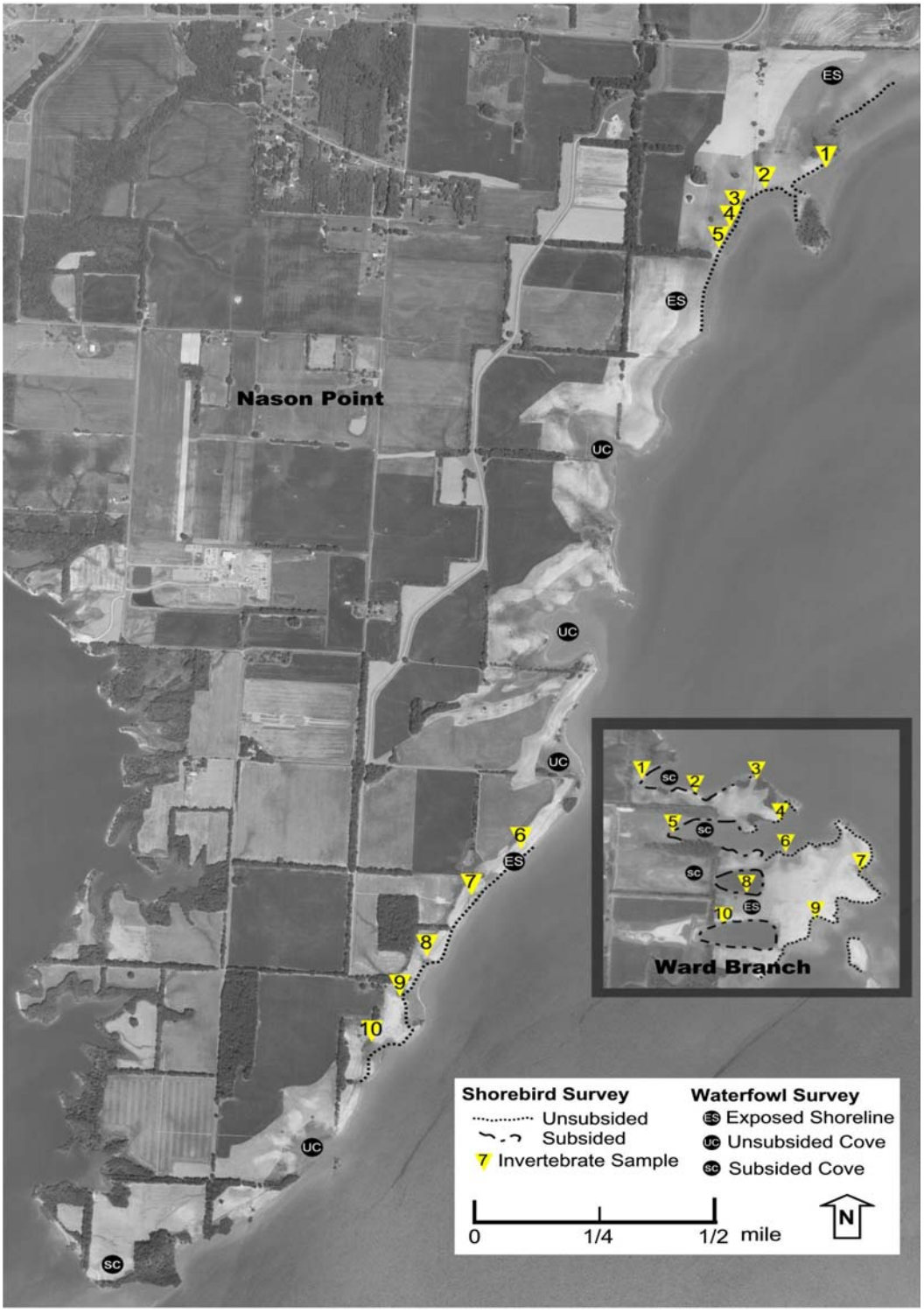

Figure 4. Nason Point and Ward Branch (inset photo) study areas at Rend Lake Il.

October 2001. Sediment core samples were preserved in 9% formalin solution, stained with phloxine blue, and transported to the lab for processing. Samples were washed with a number 35 standard sieve (500 μm) to facilitate sorting, identification, and counting. Samples were dried (50-60° C) for 24 hours, cooled in a desiccator for 24 hours and weighed to the nearest mg to determine biomass.

Results

Shorebirds

Fall migration surveys conducted during 2000 and 2001 enumerated more than 10,000 shorebirds using the Nason Point peninsula (hereafter referred to as Nason Point) and Ward Branch study areas (Table 1). More than 6,000 shorebirds were surveyed at both areas in 2001 compared to less than 4,000 individuals during the fall 2000 surveys (Fig. 5). The Ward Branch study area accounted for more than 2,300 shorebirds in 2000 compared to approximately 1,400 shorebirds surveyed at the Nason Point study area. However, in 2001, 40 percent more shorebirds were observed at the Nason Point study area.

Subsidence basins associated with the Ward Branch study area represented approximately 22% (5.1 ha; 12.8 Ac) of the 23.2 ha (57.2 Ac) complex of subsidence wetlands and unsubsided mudflats included in the total area surveyed. Therefore, an adjustment (~5x) of shorebird survey results to reflect relative area, indicates an approximately equal utilization of the subsided and unsubsided portions of Ward Branch during 2000, and a 40% decrease in use of subsided areas in 2002. Decreased water levels (~406 ft) in 2001 compared to water levels in 2000 (407.5 ft) may have contributed to a shift in shorebird utilization from the more inland subsidence wetland basins to the broader expanse of exposed offshore unsubsided mudflats.

Kildeer (*Charadrius vociferous*) and pectoral sandpipers (*Calidris melanotos*) accounted for the majority of shorebirds identified during both survey years (Fig. 5). Semipalmated sandpipers (*C. pusilla*) and least sandpipers (*C. minutilla*) were also abundant along the shallowly inundated wetland margins and moist substrates of recently exposed mudflats. Although selected initially by the RET as an indicator species for the WHAG habitat assessment model, lesser yellowlegs (*Tringa flavipes*)

were only a minor contributor to the migrant shorebird community utilizing either the subsided or unsubsided wetland habitats of the Nason Point and Ward Branch study areas (Fig. 5).

Table 1. Total shorebirds observed during Rend Lake, IL shoreline surveys in 2000 and 2001. Totals for Ward Branch and the northern and southern portions of Nason Point are the sum of 16 ground surveys in 2000 and 18 in 2001. Totals for areas of Nason Point, other than the northern and southern sections, are summed from four kayak surveys in 2000 and three in 2001.

	Nason Point				Ward Branch			Total
Year	Northern	Southern	Other Areas	Subtotal	Subsided	Unsubsided	Subtotal	
2000	1,092	151	144	1,387	445	1,948	2,393	3,780
2001	3,065	470	538	4,073	175	2,134	2,309	6,382
Total	4,157	621	682	5,460	620	4,082	4,702	10,162

Waterfowl

Spring surveys conducted at the Ward Branch and Nason Point study areas identified a total of 82,655 waterfowl in 2001 and 46,881 in 2002 (Table 2). Geese represented the most abundant waterfowl group recorded during both 2000 and 2001. Inclusion of large flocks of snow geese (*Chen caerulescens*) loafing ≥4,400 m offshore during the spring 2001 survey greatly increased survey results. Dabbling ducks utilizing Nason Point during 2001 were equally abundant as diving ducks (Table 2). However, during the spring 2002 survey of Nason Point, the numbers of dabbling ducks increased by ~75 percent. Total number of waterfowl observed at the Ward Branch study area during both 2001 and 2002 comprised less than 10% of the combined total for both study areas (Table 2). However, the influence of 61,000 geese recorded at Nason Point greatly affected survey results. Dabbling duck utilization of Ward Branch during 2001 and 2002 may represent a more realistic picture of wetland habitat associated with the subsidence wetland basins. Shoreline survey area of Nason Point was ~2x (@ 410 ft lake elevation) to ~3x (@ 408 ft lake level) greater than the survey area associated with Ward Branch. Therefore, if adjusted for survey area, waterfowl survey results for dabbling ducks observed at Ward Branch during spring 2001 and 2002 surveys were comparable to Nason Point. For example: 4,000 to 6,000 dabbling ducks could be an estimate for Ward Branch

utilization in 2001 and 16,000 to 24,000 dabbling ducks would represent a comparable estimate adjusted for survey area size in 2002.

Table 2. Total waterfowl observed during Nason Point and Ward Branch spring surveys conducted at Rend Lake, IL in 2001 and 2002.

	Ward Branch	Nason Point	Total
2001			
Dabbling Ducks	2,060	9,485	11,545
Diving Ducks	4	9,898	9,902
Mergansers	7	77	84
Geese	0	61,124[1]	61,124
Total	2,071	80,584	82,655
2002			
Dabbling Ducks	8,366	16,950	25,316
Diving Ducks	67	393	460
Mergansers	17	418	435
Geese	179[2]	20,665	
Swans	0	5	5
Total	8,629	38,252	46,881

[1] Includes snow geese ≥ 1/4 mile offshore east of Nason Point.

[2] Winter wheat planted on Ward Branch unsubsided mudflat during late fall 2001 was grazed extensively by geese during spring 2002.

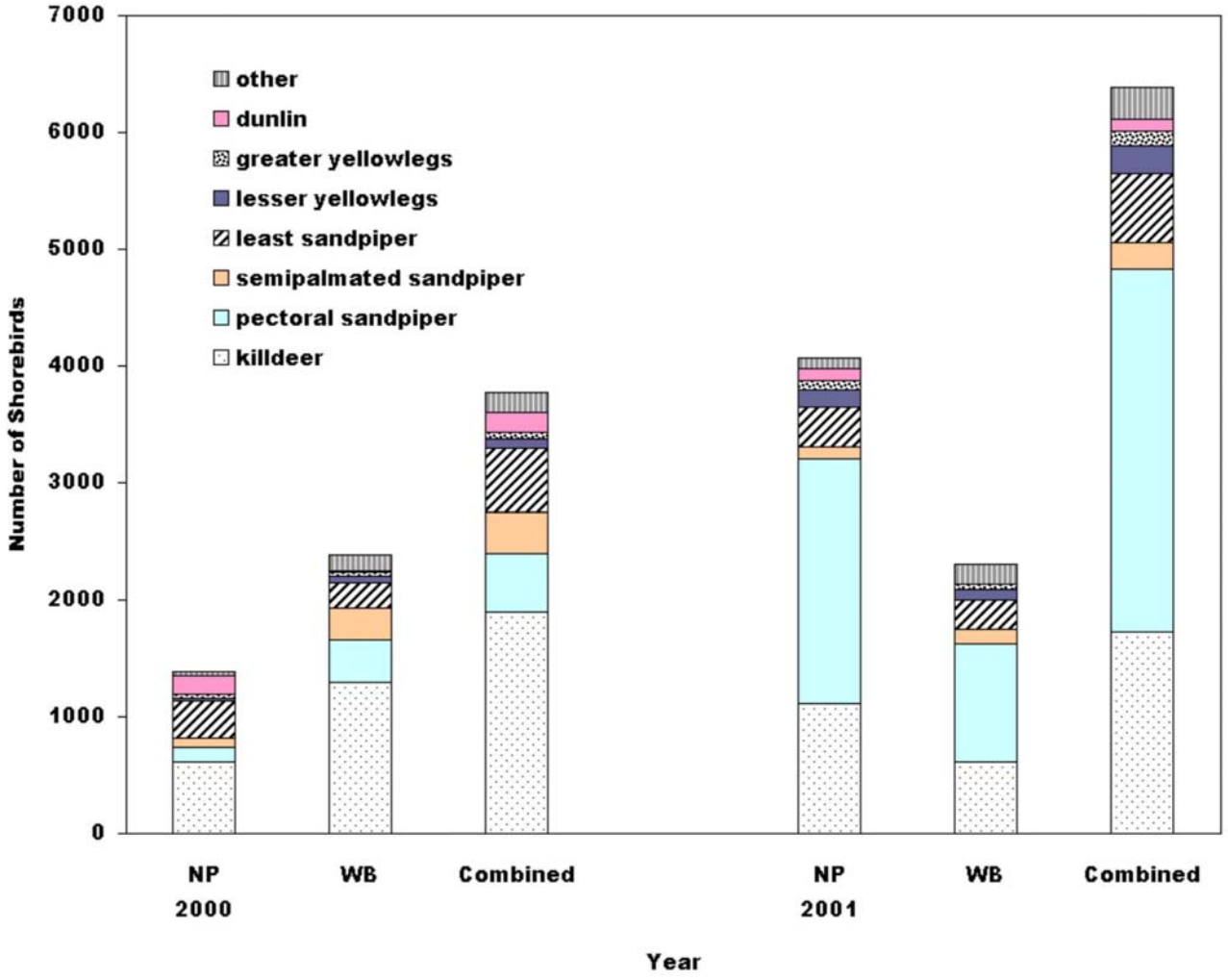

Figure 5. Total number of shorebirds counted during weekly surveys at Ward Branch and Nason Point combined, during fall migration 2000 and 2001, Rend Lake, IL. Species that represented <1.5% of the annual total were included in the portion of the bar labeled "other".

Macroinvertebrates

Core sampling (n=280) of benthic invertebrates during September - October 2000 and August - October 2001 for both the Nason Point and Ward Branch study areas yielded density values ranging from 0-1,096,880 invertebrates/m^2 (median=26,096). Biomass values ranged from 0-62.3 gm/m^2

(median=2.40 gm/m^2). Oligochaeta were the most frequently encountered taxa (100% - n=40), followed by Nematoda (82.5%), Chironomidae (62.5%), Ceratopogonidae (27.5%), and Nematomorpha (25.0%). Oligochaeta were also the most abundant taxa, averaging 76.5% of individuals in each sample. The next most abundant taxa were Nematoda (13.3%) and Chironomidae (5.7%). Invertebrate density (invertebrates/m^2) was higher at Ward Branch ($\bar{X}$=126,719) than Nason Point ($\bar{X}$=27,085) in fall 2000 samples. However, in fall 2001, invertebrate density was only marginally greater at Ward Branch ($\bar{X}$=45,191) than Nason Point ($\bar{X}$=38,613). Invertebrate biomass (g DM/m^2) was also greater at Ward Branch ($\bar{X}$=8.4) than Nason Point ($\bar{X}$=3.2) in 2000. However, in 2001 biomass values were relatively similar for both study areas (Ward Branch $\bar{X}$=5.2, Nason Point $\bar{X}$=3.4). No site differences were observed for invertebrate biomass in 2001. Within the Ward Branch study area, invertebrate density was greater (median=46,600 invertebrates/m^2) in subsided wetland basins than the unsubsided portions of the study area (median=39,565 invertebrate/m^2) for core data from 2000 and 2001 combined. However, biomass exhibited only minor differences between subsided (median=3.0 gm/m^2) and unsubsided portions of the study area (median=2.8 gm/m^2). Compared to other shorebird migration habitats, Rend Lake study areas (both Nason Point and Ward Branch) supported invertebrate densities that were equal to, or exceeded, recently documented values (~47,000 invertebrates/m^2) for two freshwater habitats in western Tennessee (Augustin et al. 1999).

Vegetation

Fall 2001 vegetation assessments documented a total of 21 genera occurring at subsided and unsubsided habitats of the Ward Branch and Nason Point study areas (Table 3). Percent cover was not significantly different for any genera recorded at the primary habitats (exposed shoreline, unsubsided cove, subsided cove). The Sørensen coefficient (Sørensen 1978) was used to assess community similarity. The coefficient of community similarity (CC_S) is derived from the formula:

$$CC_S = 2c/({}_S1 + {}_S2)$$

where c is the number of species found in both communities and s is the total number of species found in each community. Based on genera only, unsubsided and subsided coves are the most similar and exposed shorelines and subsided coves are the least similar (Table 4).

Table 3. Vegetative cover (percent) recorded during September 2001 within 0.25m^2 sample quadrats located equidistantly within each of eight transects at Nason Point peninsula (1 subsided cove, 4 unsubsided cove, 3 exposed shoreline) and four transects at Ward Branch (3 subsided cove, 1 exposed shoreline) study areas Rend Lake, IL.

Genus/species	Exposed shoreline	Unsubsided cove	Subsided cove
Ammania sp.	10.0	13.5	7.0
Cyperus spp.	11.0	3.0	17.0
Echinochloa sp.	–	0.5	1.0
Eclipta sp.	–	6.5	1.5
Eleocharis spp.	21.5	30.5	44.0
Eragrostis spp.	32.5	33.0	21.0
Euphorbia sp.	2.5	–	0.5
Heteranthera sp.	–	–	4.0
Leersia oryzoides	–	0.5	11.0
Lemna sp.	–	–	4.5
Leptochloa sp.	–	–	1.5
Ludwigia palustris	–	4.5	3.5
Panicum spp.	2.5	13.0	8.5
Paspalum sp.	–	–	1.5
Phyla lanceolata	0.5	–	–
Polygonum spp.	20.5	10.5	12.5
Rotala sp.	8.5	1.5	4.0
Sagittaria spp.	2.0	6.5	8.5
Salix nigra	0.5	2.5	–
Scirpus paludosus	–	1.0	–
Xanthium strumarium	3.5	15.0	24.0
Total	12.0	15.0	18.0

Table 4. Sørensen Community Coefficients (%) for vegetation surveyed along transects at exposed shorelines, unsubsided coves, and subsided coves during September 2001 at Rend Lake, Illinois.

Habitat type	Number of genera	Sørensen Community Coefficient
Exposed shoreline	12	66.7[a], 74.1[b]
Unsubsided cove	15	78.8[c]
Subsided cove	18	

[a] = coefficient with subsided cove
[b] = coefficient with unsubsided cove
[c] = coefficient with subsided cove

Summary and Recommendations

The recent assessments of the Ward Branch and Nason Point study areas provided baseline data for shorebird, waterbird, and macroinvertebrate components of unsubsided and subsided habitats. Long-term successional trends of wetland habitats associated with the Ward Branch study area indicated that the hydroperiod and resultant plant community composition and structure provides diverse wetland habitats for migratory waterfowl and resident wading birds. Macroinvertebrate abundance and density of the subsided wetlands can also provide important food resources for migrant shorebirds. Wetland area values for pre- and post-subsidence habitats have generally remained equal. However, pre-subsidence shoreline habitats included broader exposed mudflats adjacent to upland crop fields and open water littoral zones. Subsidence wetland configuration included narrow bands of shallowly inundated foraging habitat and immediately adjacent vegetated moist soil zones (upslope) and permanently inundated open water zones (downslope).

Mitigation alternatives can address the configuration of subsidence wetland basins relative to their contribution to a focal waterbird group. For example, an emergent/moist soil wetland zone can be extremely desirable for migrant spring and fall waterfowl use; and, resident wading birds. However, maximum shorebird benefits occur during gradual drawdowns that extend well into the more sparsely vegetated moist substrates. Therefore, subsidence mitigation planning can and should address multi-species benefits that can be derived by wetland configurations that provide both diverse hydroperiods

(natural and managed) and wetland and moist soil plant communities established on shallowly inundated substrates.

Acknowledgments

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