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ABSTRACT — A census of breeding bird populations was taken in a 40-hectare wetland near Biwabik, Minnesota, prior to the use of this wetland for phosphorus removal from treated wastewater. The wetland was comprised of four distinct habitat types: shrub swamp, black ash (*Fraxinus nigra*) forest, open coniferous forest, and closed coniferous forest. We used a line transect (about 4 km in length) to document species composition, relative species abundance, and habitat associations of the bird community. A total of 816 individuals (mean = 204) and 45 species (mean = 34) were observed during four censuses in June and July, 1985. Two distinct bird communities were present in this wetland: those associated with minerotrophic habitats (shrub swamp and ash forest) and those present in ombrotrophic habitats (open and closed coniferous forest). The Nashville warbler (*Vermivora ruficapilla*) was the most common species in the wetland and also the only species that occurred in both minerotrophic and ombrotrophic habitats. The pre-impact data collected will allow assessment of the relative impact of adding sewage effluent to this wetland and the subsequent effect on bird species and populations.

Introduction

Plans are underway to use a 40-hectare wetland near Biwabik, Minnesota, to remove phosphorus from treated wastewater prior to its entry into Embarass Lake (1). Wetlands are particularly sensitive to changes in water chemistry and these changes will probably affect the vegetation present in the wetland. Changes in vegetation may then affect species composition of the wetland fauna. Because birds are good indicators of environmental changes (e.g., vegetation changes), they are often used to assess the effects of an environmental perturbation in an area (2, 3). Our objective was to survey breeding bird populations in this wetland before its use as a sewage treatment area. Specifically, we documented bird species composition, relative species abundance, and habitat associations of bird species in the wetland.

Materials and Methods

The proposed wetland treatment site is located about one kilometer south of Biwabik, Minnesota between State Highway 135 and St. Louis County Highway 4 (Figure 1). The wetland is comprised of four distinct habitat types: shrub swamp, ash forest, open coniferous forest, and closed coniferous forest (Figure 1). The shrub portion of the wetland was 4 hectares in area and the most common species were speckled alder (*Alnus rugosa*) and willow (*Salix* spp.). The shrub wetland gradually changed to an ash swamp to the south. This habitat type was 6 hectares in area and the understory vegetation contained alder, willow, cattail (*Typha latifolia*), wild calla (*Calla palustris*), and wild iris (*Iris versicolor*). The main portion of the wetland was 28 hectares and was a closed spruce and tamarack (*Picea mariana* and *Larix laricina*) forest. A 2-hectare open spruce and tamarack forest was present in the middle of the wetland. Common understory vegetation in the open areas was leatherleaf (*Chamaedaphne calyculata*), bog laurel (*Kalmia polifolia*), small cranberry (*Oxycoccus microcarpa*), and cotton grass (*Eriophorum* spp.) Labrador tea (*Ledum groenlandicum*), three-leaved false Solomon's seal (*Smilicina trifolia*), and sedges (*Carex* spp.) were common in the closed canopy areas. The distinction between the open and closed forest was due to differences in density and height of trees.

The shrub swamp and ash forest were classified as minerotrophic habitats. In minerotrophic habitats, the water table is above the peat surface and these areas receive nutrients from adjacent and underlying mineral soil. The coniferous forest habitats were ombrotrophic habitats. In ombrotrophic habitats, the water table is below the peat surface and water is drained from these areas. In these habitats, the primary source of minerals is rainfall. Consequently, nutrient levels are much higher in minerotrophic as compared with ombrotrophic habitats within a wetland complex (4). The nutrient level also affects the type of plant species that occur. Broad-leaved deciduous species are more common in minerotrophic habitats and narrow-leaved evergreen species are prevalent in ombrotrophic habitats.

Four censuses of the wetland were taken during the breeding season (June to early July) using line transects (5). Census data were collected during early morning hours (0445-0930 central daylight savings time) and on mornings with winds less than 10 km/hour and with no precipitation. The observer walked a pre-determined route of 4 km through the wetland on a route planned to traverse all habitat types. The number of birds of each species was recorded as well as the approximate distance of each kind from the transect. The habitat affinity of

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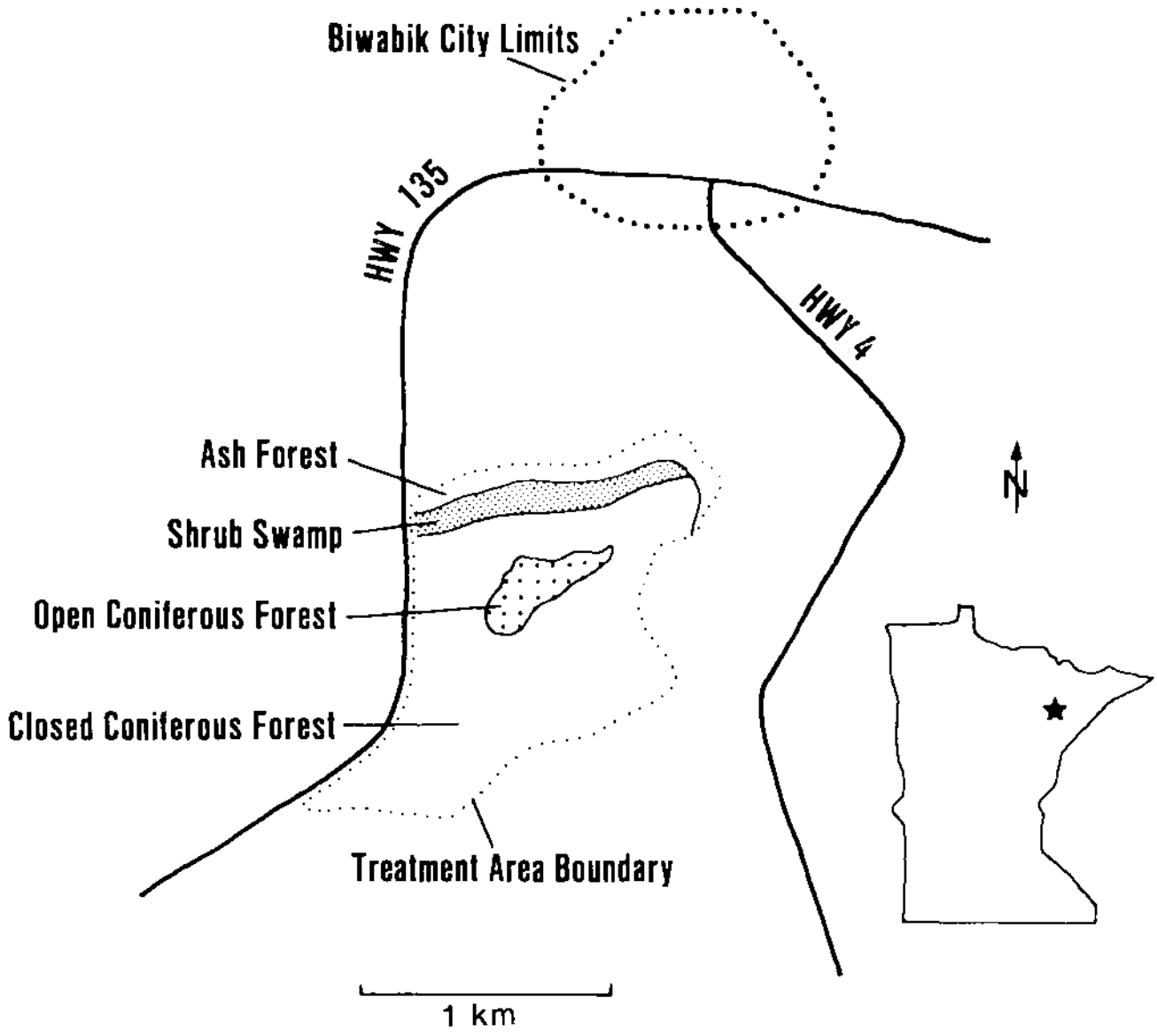

Figure 1. Location of study area near Biwabik, Minnesota

each bird species was also noted. The size (ha) of each habitat type was obtained from aerial photographs.

Results and Discussion

Bird density and habitat affinity

A total of 816 individuals were counted during the four censuses for a mean of 204 individuals/census. A low of 152 individuals was observed on June 13 and a high of 225 individuals on July 1 (Table 1). The total number of species observed was 45 with a high of 38 species on July 3 and a low of 30 species on June 28 (Table 1). Twice as many individuals were observed in minerotrophic as compared with ombrotrophic habitats (8.0 and 4.1 individuals/hectare respectively). This pattern was similar to what has been found in other northern Minnesota wetlands and is, presumably, due to the trophic status and consequent productivity of the habitats (6).

The most abundant species in the wetland was the Nashville warbler [*Vermivora ruficapilla* (40.8 individuals/census)]. It was also the only species that occurred in both minerotrophic (ash forest) and ombrotrophic (closed coniferous forest) habitats. Most northern Minnesota wetland species occur within either minerotrophic or ombrotrophic habitats (6). In previous studies, only one other species, the Savannah sparrow (*Passerculus sandwichensis*) was associated with both trophic peatland types (7, 8). However, these two species occur over a wide range of habitats during the breeding season; therefore, it is not unusual that they occupy both trophic types. For example, the Nashville warbler breeds along edges of habitats, in mixed deciduous coniferous uplands, and in shrub wetlands (7, 9, 10).

Other common species (those with a mean of > 5 individuals/census) in the wetland were: yellow-bellied flycatcher (*Empidonax flaviventris*), veery (*Catharus fuscescens*), her-

Table 1. Total and mean number of individuals observed for each species and each date and their habitat affinity in the proposed Biwabik wetland treatment site, 1985. Habitat codes are represented by letters; ash swamp (A), closed conifer forest (C), open conifer forest (O), and shrub wetland (S).

		Date				
		June		July		
Species	Habitat	13	28	1	3	Mean
Mallard	A	2	—	—	2	1.0
Sharp-shinned hawk	C	1	2	—	—	0.8
Black-billed cuckoo	S	—	—	—	3	0.8
Black-backed woodpecker	C	1	2	—	—	0.8
Northern flicker	A	1	—	1	—	0.5
Olive-sided flycatcher	C	—	—	—	1	0.3
Yellow-bellied flycatcher	C	12	9	7	5	8.3
Alder flycatcher	S	5	3	5	6	4.8
Least flycatcher	A	—	—	2	1	0.8
Eastern kingbird	O	—	2	—	1	0.8
Gray jay	C	3	3	2	1	2.3
Blue jay	C	1	—	4	3	2.0
American crow	C	3	3	7	4	4.3
Black-capped chickadee	C	—	2	—	3	1.3
Boreal chickadee	C	2	—	2	—	1.0
Red-breasted nuthatch	C	—	—	1	—	0.3
Sedge wren	S	—	2	1	8	2.8
Golden-crowned kinglet	C	6	2	1	1	2.5
Ruby-crowned kinglet	C	2	1	1	1	1.3
Veery	A,S	4	9	5	7	6.3
Hermit thrush	C	7	5	9	10	7.8
Gray catbird	S	—	—	1	2	0.8
Solitary vireo	C	—	—	2	2	1.0
Red-eyed vireo	A	8	8	6	7	7.3
Nashville warbler	C,S	22	58	49	34	40.8
Yellow warbler	S	—	2	4	6	3.0
Chestnut-sided warbler	A	1	2	1	1	1.3
Yellow-rumped warbler	C	8	9	11	6	8.5
Blackburnian warbler	C	1	—	—	—	0.3
Palm warbler	C,O	10	11	11	7	9.8
Black-and-white warbler	A	5	1	1	2	2.3
American redstart	A	2	—	4	4	2.5
Connecticut warbler	C	8	14	8	7	9.3
Common yellowthroat	A,S	6	12	16	17	12.8
Rose-breasted grosbeak	A	2	5	5	4	4.0
Chipping sparrow	C	6	4	6	1	4.3
Clay-colored sparrow	S	1	—	3	10	3.5
Song sparrow	S	1	4	9	4	4.5
Lincoln's sparrow	O	2	7	7	6	5.5
Swamp sparrow	A,S	7	9	9	16	10.3
White-throated sparrow	C	6	23	12	13	13.5
Dark-eyed junco	C	2	7	5	6	5.0
Red-winged blackbird	S	—	—	2	2	1.0
Brown-headed cowbird	C,A	3	1	5	3	3.0
Purple finch	A	1	—	—	—	0.3
Total (Individuals)		152	222	225	217	203.8
Total (Species)		34	30	36	38	45
Number of species in ash swamp habitat	14					
Number of species in closed spruce habitat	23					
Number of species in open spruce habitat	3					
Number of species in shrub habitat	11					

mit thrush (*Catharus guttatus*), red-eyed vireo (*Vireo olivaceus*), yellow-rumped warbler (*Dendroica coronata*), palm warbler (*D. palmarum*), Connecticut warbler (*Oporornis agilis*), common yellowthroat (*Geothlypis trichas*), swamp sparrow (*Melospiza georgiana*), white-throated sparrow (*Zonotrichia albicollis*), and dark-eyed junco (*Junco hyemalis*). These species were also the most common in similar wetland habitats in northern Minnesota (7, 8).

Species richness

As expected, a direct relationship exists between the number of species present and the size of the habitat. The most species (23) were associated with the most common habitat type (closed coniferous forest) and fewest species (3) were found in the habitat (open coniferous forest) that occupied the smallest area (Table 1). More species were associated with the ombrotrophic (26 species) as compared with the minerotrophic habitats (22 species), but this was probably because the area of ombrotrophic habitat types sampled was larger. Higher species richness observed in larger sized habitats is due to a species/area effect. That is, the number of species observed in a habitat is proportional to the size of area sampled. To control for this effect, we used the rarefaction procedure (11). This allowed us to simulate a census of same-sized habitats by calculating the number of species expected if the same unit of area had been used. Rarefaction results for the Biwabik wetland indicated that we would expect to count seven species in the ash forest, the shrub swamp, and the closed coniferous forest and three species in the open coniferous forest if we censused the same amount of each habitat (2 ha). These results are similar to what we have found in other northern Minnesota wetlands (7, 8).

Bird community responses to added wastewater.

Previous investigators who have studied bird communities in wastewater treatment areas have reported mixed results. Kadlec (12) reported that no major shifts in avian species abundance or composition occurred at a wetland treatment area near Houghton Lake, Michigan. However, a significant increase in bird diversity was reported for a treatment area in a Florida cypress dome (13). Fuller and Glue (14) suggested that sewage treatment facilities, especially lagoons, served as important feeding sites for passerine species and that this type of treatment site (surface irrigation) would support the most diverse bird communities. However, the physiological effect on individuals that use these areas as feeding sites during breeding or migration have not been assessed and the long-term effects are still unknown (13).

The addition of wastewater to this northern Minnesota wetland will probably increase the amount of nutrients and the water depth and subsequently increase the area of minerotrophic habitat types. Therefore, densities of species associated with the closed and open coniferous forests would probably decrease. Also, we would expect a decrease in species found in ombrotrophic habitats. These changes would be a result of either the addition or loss of a particular habitat type or an increase or reduction in size of existing habitat types.

In this study we have gathered information on several bird species, including densities and habitat affinities, in the proposed wetland treatment area. This information will allow us to examine the relative changes in species composition and changes in their habitat affinity following the addition of treated wastewater beginning in the fall of 1986. However, because of the high annual variation in bird populations, data collected for only one breeding season may be inadequate to assess changes in the *density* of all species after wastewater is added to the wetland, especially the less common species. The "best" pre-impact studies are those that are done over a number of years, but such studies are exceptions rather than the rule (15, 16). Although data presented here are valuable as

baseline information, we emphasize that a longer pre-impact data base is needed to improve our assessment of the effects of disturbances on ecological systems. Furthermore, using wetland systems like bogs for phosphorus retention needs critical evaluation since it is questionable whether these wetlands are useful for this purpose (17).

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