EFFECTS OF MANAGEMENT PRACTICES ON WETLAND BIRDS:

EARED GREBE

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This report is one in a series of literature syntheses on North American wetland birds. The need for these reports was identified by the Prairie Pothole Joint Venture (PPJV), a part of the North American Waterfowl Management Plan. The PPJV adopted a goal to stabilize or increase populations of declining grassland- and wetland-associated wildlife species in the Prairie Pothole Region. To further that objective, it is essential to understand the habitat needs of birds other than waterfowl, and how management practices affect their habitats. The focus of these reports is on management of breeding habitat, particularly in the northern Great Plains.

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Species for which syntheses are available or are in preparation:

Eared Grebe
American Bittern
Virginia Rail
Sora
Yellow Rail
American Avocet
Willet
Long-billed Curlew
Marbled Godwit
Wilson's Phalarope
Black Tern
Marsh Wren
Sedge Wren
Le Conte's Sparrow
Nelson's Sharp-tailed Sparrow

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EARED GREBE

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ORGANIZATION AND FEATURES OF THIS SPECIES ACCOUNT

Information on the habitat requirements and effects of habitat management on wetland birds were summarized from information in more than 500 published and unpublished papers. A ***range map*** is provided to indicate the relative densities of the species in North America, based on Breeding Bird Survey (BBS) data. Although the BBS may not capture the presence of elusive waterbird species, the BBS is a standardized survey and the range maps, in many cases, represent the most consistent information available on species' distributions. Although birds frequently are observed outside the breeding range indicated, the maps are intended to show areas where managers might concentrate their attention. It may be ineffectual to manage habitat at a site for a species that rarely occurs in an area. The species account begins with a brief ***capsule statement***, which provides the fundamental components or keys to management for the species. A section on ***breeding range*** outlines the current breeding distribution of the species in North America, including areas that could not be mapped using BBS data. The ***suitable habitat*** section describes the breeding habitat and occasionally microhabitat characteristics of the species, especially those habitats that occur in the Great Plains. Details on habitat and microhabitat requirements often provide clues to how a species will respond to a particular management practice. A ***table*** near the end of the account complements the section on suitable habitat, and lists the specific habitat characteristics for the species by individual studies. The ***area requirements*** section provides details on territory and home range sizes, minimum area requirements, and the effects of patch size, edges, and other landscape and habitat features on abundance and productivity. It may be futile to manage a small block of suitable habitat for a species that has minimum area requirements that are larger than the area being managed. The section on ***brood parasitism*** summarizes information on intra- and interspecific parasitism, host responses to parasitism, and factors that influence parasitism, such as nest concealment and host density. The impact of management depends, in part, upon a species' nesting phenology and biology. The section on ***breeding-season phenology and site fidelity*** includes details on spring arrival and fall departure for migratory populations in the Great Plains, peak breeding periods, the tendency to renest after nest failure or success, and the propensity to return to a previous breeding site. The duration and timing of breeding varies among regions and years. ***Species' response to management*** summarizes the current knowledge and major findings in the literature on the effects of different management practices on the species. The section on ***management recommendations*** complements the previous section and summarizes recommendations for habitat management provided in the literature. The ***literature cited*** contains references to published and unpublished literature on the management effects and habitat requirements of the species. This section is not meant to be a complete bibliography; a searchable, annotated bibliography of published and unpublished papers dealing with habitat needs of wetland birds and their responses to habitat management is posted at the Web site mentioned below.

Eared Grebe
(*Podiceps nigricollis*)

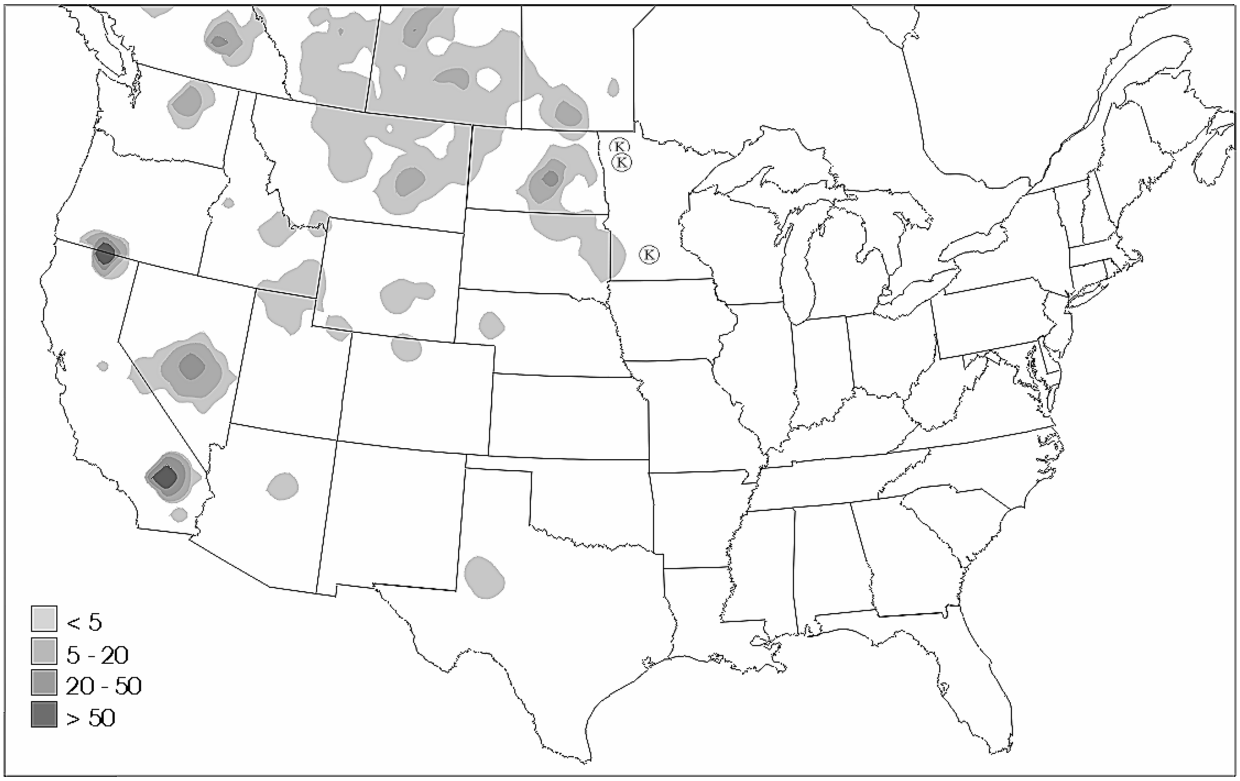

Figure. Breeding distribution of Eared Grebes in the United States and southern Canada, based on Breeding Bird Survey data, 1985-1991. Scale represents average number of individuals detected per route per year. Map from Price, J., S. Droege, and A. Price. 1995. The summer atlas of North American birds. Academic Press, London, England. 364 pages. Circles indicate other locations with known breeding populations (K). Information courtesy of Janet S. Boe.

Keys to management include maintaining wetlands with few trees around the perimeter and >70% open water interspersed with areas of emergent or floating, submergent vegetation.

Breeding Range:

Eared Grebes breed from eastcentral British Columbia through southern Alberta, Saskatchewan, and Manitoba, south to eastern Washington, eastcentral Oregon, to southeastern California, and east to northern Arizona and New Mexico, westcentral Texas, northcentral Colorado, westcentral Nebraska, northwestern Iowa, and western Minnesota (National Geographic Society 1999). (See figure for the relative densities of Eared Grebes in the United States and southern Canada, based on Breeding Bird Survey data.)

Suitable habitat:

Wetlands with areas of open water and beds of submergent aquatic plants appear to be critical components of suitable habitat (Bent 1963, Stewart 1975). Open water may be important because grebes congregate in open water when disturbed from their nests, and also because they need a running start before taking flight (Boe 1992). Submergent vegetation may be important for lessening the impact of turbulent water on nests, for harboring large populations of invertebrates, and for providing material for nest construction (Boe 1992). In Nebraska, a high degree of interspersion of open water and vegetation was required to provide foraging habitat for adults and young (Faanes and Lingle 1995). In Iowa, adult grebes moved their young about 180 m to open water (Friley and Hendrickson 1937). Eared Grebes use wetlands with large beds of submerged aquatic plants such as algal mats (Chlorophyceae and Cyanophyceae), muskgrass (*Chara* spp.), sago pondweed (*Stuckenia pectinatus*), claspingleaf pondweed (*Potamogeton richardsonii*), widgeon grass (*Ruppia maritima*), and common watermilfoil (*Myriophyllum heterophyllum*) (Stewart 1975, Boe 1993), and emergent plants such as hardstem bulrush (*Schoenoplectus acutus*) (Faanes and Lingle 1995) and reeds (*Phragmites*) (Salt and Salt 1976). Suitable habitat includes freshwater and saline seasonal, semipermanent, and permanent wetlands and lakes, shallow river impoundments, stock ponds, and sewage lagoons (Stewart 1975, Krapu and Green 1978, Knodel 1979, Johnsgard 1980, Uresk and Severson 1988, Boe 1992, Faanes and Lingle 1995, Baylor 1998, Cullen et al. 1999).

Wetland preference by breeding Eared Grebes was examined in western and southern Minnesota (Boe 1991, 1992). Twenty-four wetlands used for nesting were compared to a random sample of 26 unused wetlands in the same or adjacent counties. Wetlands were classified as fresh and shallow (about 15 cm deep), fresh and deep (about 15-91 cm deep), or fresh and open (water usually <3 m deep and fringed with emergent vegetation). Eared Grebes preferred fresh wetlands with maximum depths ≤3 m, >70% open water, abundant submergent vegetation, perimeters that were partially composed of trees, and wetlands without designated public access and little or no fishing or motorboating (Boe 1991, 1992). Wetlands with buildings along the wetland perimeter were not occupied by Eared Grebes. No differences were found between used and unused wetlands for percentage of wetland composed of open water (water generally was >50% open) or emergent fringe, or for percentage of wetland perimeter with nearby road or highway within 0.2 km. Wetlands used by Eared Grebes were generally composed of 78% open water and 60% emergent fringe, and included a perimeter of which 32% was composed of trees and 27% was composed of a road or highway within 0.2 km. Unused wetlands were generally composed of 68% open water and 38% emergent fringe, and included a perimeter in which 65% was composed of trees and 30% was composed of a road or highway within 0.2 km. In northwestern North Dakota, wetland size and vegetation cover appeared to be more important factors affecting selection of wetlands by Eared Grebes than wetland type (Faaborg 1976). Eared Grebes preferred large (>7.3 ha) wetlands over small (≤7.3 ha) wetlands, and preferred wetlands with large expanses of open water (≥95% open water) to wetlands with large areas of emergent vegetation (not defined). They were found in seasonal and semipermanent wetlands and in lakes. In the prairie pothole region of North Dakota, the highest densities of Eared Grebes were in seasonal wetlands, followed by semipermanent and permanent wetlands (Kantrud and Stewart 1984). The species was not found in ephemeral, temporary, alkaline, fen, or tilled wetlands. In central North Dakota, Eared Grebes were found in ephemeral, temporary, seasonal, semipermanent, permanent, and alkaline wetlands; highest densities occurred on permanent wetlands (Faanes 1982). In British Columbia, the best predictor of use of a wetland for breeding was area of emergent vegetation, not total wetland area, area of open water, or mean depth of wetland (Cullen 1998).

Nests are platforms of decaying and live vegetation obtained from the water column or from the bottom of wetlands, and are anchored to submergent vegetation, dead and living emergent vegetation, or floating mats in 10-123 cm of open water or among emergent vegetation (Goss 1883, Smith 1890, Abbott 1902, Rockwell 1910, Roberts 1932, McAllister 1958, Stewart 1975, Bryant 1983, Ray and Kruse 1989, Boe 1993, Lyon and Everding 1996). Vegetation such as algae, dead cattail (*Typha* spp.), cottonwood (*Populus deltoides*)/willow (*Salix amygdaloides*, *S. interior*), common bladderwort (*Utricularia vulgaris*), coontail (*Ceratophyllum demersum*), sago pondweed, goosefoot (*Chenopodium rubrum*), or hardstem bulrush are used as nest material (Bryant 1983, See et al. 1992, Boe 1993, Hill et al. 1997). Nests may be anchored to emergent plants such as hardstem bulrush, alkali bulrush (*Scirpus maritimus*), sprangletop (*Scolochloa festucacea*), and golden dock (*Rumex maritimus*), or built on dense, floating mats of submergent vegetation or algae (Friley and Hendrickson 1937, Stewart 1975, See et al. 1992, Boe 1993). Nests also may be attached to Franklin's Gull (*Larus pipixcan*) nests (Roberts 1932; Burger and Gochfeld 1995; J. S. Brice, University of North Dakota, Grand Forks, North Dakota, pers. comm.). In North Dakota, nests were generally in semi-open stands of emergent vegetation or in moderately dense cover within a few meters of open water (Stewart 1975). Distance from nests to open water ranged from 0 to 50 m (Boe 1991). Distance from nest to shore ranged from 15 to 1500 m (Smith 1890, Friley and Hendrickson 1937, Stewart 1975, Boe 1993). In Minnesota, nests that were built on dead or live emergent vegetation were initiated significantly earlier (about 1 mo) than nests built on floating mats (Boe 1993).

Eared Grebes nest in colonies that range in size from a dozen to several thousand nests, and rarely nest singly (Goss 1883; Smith 1890; Job 1902; Judd 1917; Roberts 1932; Friley and Hendrickson 1937; Buresh 1971; Stewart 1975; Faaborg 1976; Bryant 1983; Ray and Kruse 1989; Baylor 1998; Breault 1990; Boe 1994; Cullen et al. 1999; J. S. Brice, pers. comm.). Eared Grebes may locate colonies near open water or wetland channels (Boe 1993). First nests in a colony form a nucleus for future nests (Friley and Hendrickson 1937, McAllister 1958, Boe 1994). More than one colony may be formed on a body of water; for example, in British Columbia, two colonies were 200 m apart (Lyon and Everding 1996). Distances between nests within a colony have been reported as 0 to 9.5 m, and depend on habitat conditions (Job 1902, Friley and Hendrickson 1937, McAllister 1958, Buresh 1971, Ray and Kruse 1989, Lyon and Everding 1996, Hill et al. 1997). Hill et al. (1997) reported that nests in a low-density colony were farther apart (3.3 versus 1.4 m, respectively) than in a high-density colony (numbers of nests within low- and high-density colonies were not given). Depredation rate was higher in the low-density colony than in the high-density colony. Aggression rates, time spent in aggressive activities, egg loss due to conspecific interference, and intraspecific brood parasitism were higher in the high-density colony than in the low-density colony. No differences in clutch size or egg volume were detected between high- and low-density colonies. Boe (1994) found that distances to the nearest neighbor were shorter for colonies built in dense, green emergent vegetation than colonies built in sparser, more open, dead emergent vegetation or on open surface mats. As colonies developed, distances tended to decrease, possibly because aggression abated as the breeding season progressed. The colony with the greatest emergent stem density had the greatest nest density and the shortest distance to the nearest neighbor. Distance from shore to colony sites was significantly and positively associated with wetland area and was significantly farther than for random points; distance from shore may represent a compromise between reducing depredation by terrestrial predators and minimizing destruction of nests by high waves near the center of wetlands (Boe 1991, 1993).

In addition to Franklin's Gulls, Eared Grebes may nest among, although not attached to nests, of other colony-nesting species, such as Western Grebes (*Aechmophorus occidentalis*), and Forster's Terns (*Sterna forsteri*) (Abbott 1902, Boe 1993, Cullen et al. 1999). They also may nest in proximity to Horned Grebes (*Podiceps auritus*), Pied-billed Grebes (*Podilymbus podiceps*), Ruddy Ducks (*Oxyura jamaicensis*), American Coots (*Fulica americana*), or Black Terns (*Chlidonias niger*) (Abbott 1902, Roberts 1932, Bent 1963, Valadka 1988). Pied-billed Grebes may harass Eared Grebes, although young Pied-billed Grebes may associate with postbreeding Eared Grebes without aggression (Cullen et al. 1999). American Coots may depredate Eared Grebe nests (Breault 1990, Boe 1994, Hill et al. 1997). A table near the end of the account lists the specific habitat characteristics for Eared Grebes by study.

Area requirements:

Eared Grebes nest in wetlands ranging widely in size. In Minnesota, wetlands used for breeding were 33-3785 ha, compared to 36-5793 ha for unused wetlands (Boe 1992). However, small wetlands are uncommon in Minnesota due to drainage for agricultural purposes. Among wetlands with colonies, larger wetlands tended to have larger colonies. In North Dakota, three of 221 nests were in small (<3 ha) wetlands with ≥95% open water, and 218 nests were on large (≥7.3 ha) wetlands with open water (Faaborg 1976). Stewart (1975) indicated that Eared Grebes breed on lakes or wetlands ≥4 ha (no upper limit was given), whereas Daub (1993) found Eared Grebes on wetlands 1-19.3 ha. Daub sampled wetlands ranging from <1 to 19.3 ha. During a drought year in Minnesota, Eared Grebes were observed on small (<300 ha) wetlands in May and early June that were dry later in the summer; after early June, two of the largest colonies recorded in the state were found on large (>3000 ha) wetlands (Boe 1992).

Brood parasitism:

Eared Grebes are conspecific brood parasites (Lyon and Everding 1996) and may lay eggs in other Eared Grebe nests (Gollop 1958, Bent 1963). Lyon and Everding (1996) determined that 38% of 47 nests in two colonies experienced brood parasitism. Five nests were multiply parasitized, and most cases of multiple laying were by different females. Of 21 conspecific brood parasitism events reported by Hill et al. (1997), three nests each contained two parasitic eggs and 18 nests each contained one parasitic egg. No records of brood parasitism by Brown-headed Cowbirds (*Molothrus ater*) are known.

Breeding-season phenology and site fidelity:

In the southern Great Plains, Eared Grebes arrive on the breeding grounds as early as mid-February, continue to arrive through May, and depart for the wintering grounds from late August through November (Rockwell 1910, Johnsgard 1980, Thompson and Ely 1989). In the northern Great Plains, Eared Grebes arrive from early April through May and depart for the wintering grounds in September and October (Judd 1917, Roberts 1932, Bent 1963, Maher 1974, Stewart 1975, Salt and Salt 1976, Knapton 1979, Faanes 1981, Janssen 1987, South Dakota Ornithologists' Union 1991, See et al. 1992).

Eared Grebes are known to renest after destruction of the initial nest (Rockwell 1910, Boe 1993, Lyon and Everding 1996). Double-broodedness has not been documented (Bent 1963, Cullen et al. 1999). Eared Grebes may exhibit site fidelity. In British Columbia, six of 14 adults that had broods the previous year returned to the same breeding colony, compared to eight of 46 adults without broods (Breault 1990). In another British Columbia study, three of 26 males and three of 21 females captured the previous year returned to breed on the same wetland the following year (Cullen 1998). Two males and one female returned to breed in the study area but not on the same wetland. Five males and six females that bred in the study area during the first year were resighted the second year, but did not stay to breed. Also in British Columbia, an Eared Grebe was recaptured four years later in the same general area in which it was banded (Clapp et al. 1982). Based on North American banding records from several sources, of 1052 banded Eared Grebes, 1.2% were recovered 1-4 yr later in the breeding areas where they had been banded (Jehl and Yochem 1986).

Species' response to management:

Little is known about the effects of burning, mowing, or grazing on Eared Grebes. Eared Grebes are negatively impacted by wetland drainage, by diversion of water for agricultural purposes, and by maintenance of high water levels for recreational activities (Koonz and Rakowski 1985, Boe 1992, Faanes and Lingle 1995). In response to yearly fluctuations of water levels and subsequent changes in vegetation, Eared Grebes use different wetlands, different locations within wetlands, and different types of wetlands from year to year (Boe 1992). Maintaining a complex of wetland sizes and types is important, even if an individual wetland is not used every year. Eared Grebes may abandon nests when water levels drop, depending on depth of remaining water (Boe 1994).

High concentrations of selenium in eggs may cause embryotoxicity, that is, embryo deformity or death (Skorupa and Ohlendorf 1991). Irrigation over soils that have a high selenium content causes leaching of selenium from the soil to the groundwater (See et al. 1992). Selenium often is present in evaporation ponds that receive subsurface agricultural drainage water; these ponds often attract large numbers of waterbirds (Skorupa and Ohlendorf 1991). Skorupa and Ohlendorf (1991) investigated the level of selenium that represented a significant threshold of toxicity to waterbirds. Median selenium concentration from 74 sample means (sample means based on samples of two to nine eggs) from wild birds in nonmarine wetlands was 1.9 per million (ppm) dry weight. The interquartile range was 1.4 to 2.4 ppm. The authors suggested that >3 ppm mean egg selenium indicated avian contamination in nonmarine environments. Avian contamination was defined as mean selenium in eggs (mean egg selenium) above normal (background) concentrations. In the Tulare Basin, California, avian contamination of >3 ppm was associated with evaporation ponds that contained 1-3 parts per billion (ppb) waterborne selenium (Skorupa and Ohlendorf 1991). Mean egg selenium ranging from 8 to 37 ppm indicated various levels of embryotoxicity.

In California, an exposure-response relationship existed between selenium concentration in Black-necked Stilt (*Himantopus mexicanus*) and American Avocet (*Recurvirostra americana*) eggs and incidence of embryo deformity (Robinson et al. 1997, Skorupa 1998). Eggs with selenium concentrations of ≤40 ppm dry weight had 0% incidence (486 eggs) of deformed embryos; eggs with 41-60 ppm selenium had 5% (of 26 eggs) deformity, eggs with 61-80 ppm selenium had 8.3% (14 eggs) deformity, and eggs with 81-110 ppm had 25% (15 eggs) deformity. Percentages were calculated by weighting results for each 5-ppm interval equally. Embryotoxicity of >24 ppm mean egg selenium was associated with evaporation ponds that contained 10-20 ppb waterborne selenium.

However, for Eared Grebes in particular, avian contamination of 3 ppm was associated with waterborne selenium levels as low as <1 ppb (Skorupa and Ohlendorf 1991). Unlike other waterbirds that use more than one wetland for foraging, Eared Grebes often remain on the wetland in which their nesting colony is located, foraging on aquatic invertebrates within that wetland. Because of the tendency to remain on one wetland, Eared Grebes may reflect a one-to-one relationship between levels of waterborne selenium in a wetland and actual bioaccumulation of selenium.

In Wyoming, selenium levels in lakes of 38 to 54 ppb were associated with high selenium levels in eggs (>8 ppm) and livers (>30 ppm) of adult Eared Grebes (both live and dead birds) (See et al. 1992, Skorupa 1998). Of 151 Eared Grebe eggs, selenium concentrations ranged from 39.4 to 121 ppm dry weight and averaged 75.1 ppm dry weight. Mean egg concentrations of >13 ppm dry weight were associated with embryo deformities. Of 50 embryos, 10% were malformed. Crossed bills and malformed legs and feet were the most common types of deformities. Mean concentrations of >8 ppm dry weight were associated with impaired egg hatchability. Cause of selenium embryotoxicity was irrigation over soils derived from Cody shale, which tended to have a high selenium content. Selenium discharge from sub-basins was related to irrigation intensity (measured by the area of irrigated land) and the concentrations of selenium in groundwater.

At Freezout Lake Wildlife Management Area and Benton Lake National Wildlife Refuge in westcentral Montana, elevated levels of selenium were found in Eared Grebe embryos and livers (Nimick et al. 1996). Water sources for both lakes were irrigation return flow, surface runoff, and direct precipitation. At Freezout Lake, based on 20 embryos, geometric mean selenium concentration ranged from 10 to 18 ppm and averaged 14 ppm. Livers from 10 Eared Grebes contained selenium concentrations ranging from 8.3 to 27 ppm and averaging 14 ppm. At Benton Lake, based on 13 embryos, geometric mean selenium concentration ranged from 6.3 to 20 ppm and averaged 12 ppm. Livers from 31 Eared Grebes contained selenium concentrations ranging from 3.6 to 74 ppm and averaged 22 ppm.

At a lake in southwestern North Dakota, 45 of 46 eggs had selenium concentrations >3.2 ppm dry weight and averaged 4.5 ppm (Olson and Welsh 1993). At a selenium-contaminated site in California, mean selenium concentration in 18 Eared Grebe eggs was 69.7 ppm dry weight (Ohlendorf et al. 1986). Of 141 nests, 116 (82%) nests hatched at least one normal chick, 84 (60%) nests contained one or more dead embryos, and 22 (16%) nests contained one or more deformed embryos or chicks.

Fences, power lines, and television towers placed near, over, or through wetlands may cause mortality if Eared Grebes collide with the structures (Avery and Clement 1972, McKenna 1976, Malcolm 1982, Faanes 1987, Allen and Ramirez 1990). Oil spills and loss of waterproofing ability of feathers caused by detergent in water (a condition that may occur in sewage lagoons) also may cause mortality (Lincoln 1939, Nero 1968).

Management Recommendations:

Few species-specific management recommendations were found for Eared Grebe. The management recommendations that follow are based on the species' habitat requirements or apply to the community of wetland bird species as a whole. Eared Grebes require areas of emergent or submergent vegetation and the presence of an open-water zone. The ratio of emergent vegetation to open water can be controlled through periodic flooding of wetlands (Weller and Fredrickson 1973). Periodic drawdowns of wetlands followed by reflooding may increase invertebrate supply for Eared Grebes (Boe 1991).

In response to wetland suitability and availability with respect to yearly fluctuation of water levels, and thus also to changes in vegetation, Eared Grebes may use the same or different wetlands, different locations within wetlands, or different types of wetlands from year to year (Boe 1992, Cullen 1998). Therefore, maintaining a complex of wetland sizes and types is important, even if an individual wetland is not used every year (Boe 1992). The ideal management strategy for waterbirds is to maintain wetland complexes and large wetlands or lakes (Weller 1999). Because of variation in water levels over seasons or years, wetland complexes are more likely to have at least some wetlands with water and plant regimes favorable to a particular species, thus ensuring diverse species' representation in a geographical area. Wetlands should not be managed as isolated units (Cullen 1998). Whereas wetlands used every year may lead to regional persistence of Eared Grebe populations, wetlands used infrequently may allow entry of first-time breeders into a population. Eared Grebes may stay in a region based on local availability of wetlands. Individuals may decide to move to a new wetland based on the condition of another wetland in the region. Maximizing the availability of wetlands would therefore decrease the risk of regional extinction.

Eared Grebes avoid wetlands with high human disturbance, such as wetlands with designated public access, summer fishing, or motorboating (Boe 1992). The long-term protection of wetlands can be achieved through conservation easements and purchases of wetland basins (VanRees-Siewert 1993, VanRees-Siewert and Dinsmore 1996), and relocation of proposed housing developments (Koonz and Rakowski 1985). Additions to existing wetland complexes should be acquired whenever possible so that complexes become large enough to include different stages of vegetative development (Brown and Dinsmore 1986, Fredrickson and Reid 1986).

Wetland drainage, wetland diversion, and maintenance of high water levels for recreation (such as conversion into fishing lakes) are incompatible with use for breeding by Eared Grebes (Boe 1992, Faanes and Lingle 1995). Water levels should not be maintained at consistent levels (Koonz and Rakowski 1985). Wetland drainage can be addressed by enacting and enforcing anti-drainage legislation (Boe 1992).

To reduce risk of avian contamination and toxicity due to drainage water, either the amount of contaminants in drainage water should be reduced, or avian use of contaminated ponds should be reduced (Skorupa and Ohlendorf 1991, Skorupa 1998). To prevent avian toxicity but not avian contamination, drainage water should be purified to <10 ppb waterborne selenium. To minimize avian contamination, drainage water should be purified to <2.3 ppb waterborne selenium. However, as these standards cannot be met with current technology, deterring avian use of contaminated drainage water may be the only option. Drainage water containing 3-20 ppb selenium should be considered potentially hazardous to waterbirds, whereas >20 ppb selenium should be considered definitely hazardous to waterbirds.

Mortality due to fences can be prevented by reviewing fence construction and modifying plans for proposed management projects (Allen and Ramirez 1990). Fences placed through wetlands should be replaced or marked to make them conspicuous and to decrease likelihood of bird/fence collisions. Power lines should not be constructed through or within 1 km of known historical high-water marks of wetlands, through dry basins known to hold water intermittently, or through heavily used waterbird migration routes (Malcolm 1982). In cases where power lines must cross flyways, an attempt should be made to mask the lines with structures such as bridges (McKenna 1976). Power lines should be buried where possible and corridors established where power lines can be congregated to reduce their proliferation (McKenna 1976).

Table. Eared Grebe habitat characteristics.

Author(s)	**Location**	**Habitat(s) Studied**	**Species-specific Habitat Characteristics**
Abbott 1902	North Dakota	Wetland	Nested in water 0.76-1.2 m deep
Baylor 1998	South Dakota	Impoundment	Nested in open, shallow water on a 20-ha impoundment
Boe 1991	Minnesota	Sewage lagoon, wetland	Used wetlands were characterized by 78% open water, 60% emergent fringe, 32% treed perimeter, and 27% of wetland perimeter with a road within 0.2 km; unused wetlands were characterized by 68% open water, 38% emergent fringe, 65% treed perimeter, and 30% of wetland perimeter with a road within 0.2 km; colonies were found in stands of willow (*Salix amygdaloides*, *S. interior*) and cottonwood (*Populus deltoides*) without any submerged macrophytes, and on mats of submergent vegetation in sewage lagoons; during the drought year of 1988, used smaller (<300 ha) wetlands in May and June, but moved to larger (>3000 ha) wetlands after that time
Boe 1992	Minnesota	Wetland	Used wetlands >30 ha (range 33 to 3785 ha) for breeding, compared to 36 to 5793 ha for unused wetlands; however, small wetlands were scarce in the area; large wetlands supported large nesting colonies during drought years; colony size was positively correlated with wetland size; preferred deep, fresh wetlands over shallow, fresh wetlands and open, fresh wetlands fringed by emergent vegetation; used wetlands were negatively associated with deep (>3 m) water, designated public access, summer fishing and motorboating, and treed wetland perimeters; wetlands with buildings along the wetland perimeter were not used; no difference was found

			between used and unused wetlands for percent open water (>50% open), percent of wetland perimeter with emergent fringe, or percent of perimeter with nearby road or highway
Boe 1993	Minnesota	Wetland	All 12 colonies that were studied were near open water or channels; nests built on live or dead emergent vegetation were initiated significantly earlier than nests built on floating mats; nesting substrates were algal (Chlorophyceae and Cyanophpyceae) mats, dead cattails (*Typha* spp.), sago pondweed (*Stuckenia pectinatus*) mats, hardstem bulrush (*Schoenoplectus acutus*) islands, bulrush/pondweed mats, cottonwood/willow, cattail/coontail (*Ceratophyllum demersum*) mats, bladderwort (*Utricularia vulgaris*)/algal mats, and dead goosefoot (*Chenopodium rubrum*); mean water depth at 12 colony sites ranged from 0.5 to 1.2 m, with an overall mean of 0.88 m; distance from shore to colony sites ranged from 90 to 1500 m, with a mean of 380 m, and was significantly and positively associated with wetland area
Boe 1994	Minnesota	Wetland	Nests built in green emergent vegetation had shorter distances to the nearest neighbor than nests built in dead emergent vegetation or on surface mats; as colonies developed, distances decreased; the colony with the greatest emergent stem density had the greatest nest density and the shortest distance to the nearest neighbor
Breault 1990	British Columbia	Wetland	Wetlands used for breeding were alkaline (pH of 8.3), shallow (1-3-m deep), and ranged in size from 0.7 to 716 ha; mean water depth at 19 nest sites was 0.9 m; in a comparison of ten wetlands with nesting areas close (≤5 m) to shore with 16 wetlands with nesting areas far (>5 m) from shore, the number of breeding pairs was significantly lower on wetlands

			with nesting areas close to shore than on wetlands with nesting areas far from shore; nests close to shore were more concealed but were more susceptible to nest depredation, whereas nests far from shore were less concealed but were less affected by nest depredation
J. S. Brice, pers. comm.	North Dakota	Wetland	Colonies composed solely of Eared Grebe nests contained from 9 to 466 nests; colonies composed of Eared Grebe and Franklin's Gull nests contained up to 8890 grebe nests
Bryant 1983	Kansas	Wetland	Nested in 0.46 m of open water on floating platforms of coontail and sago pondweed
Buresh 1971	North Dakota	Wetland	Fifty-five nests were within an area of about 0.2 ha; nests were 0.61-0.91 m apart
Burger and Gochfeld 1995	Minnesota	Wetland	As many as seven grebe nests were attached to one Franklin's Gull (*Larus pipixcan*) nest, although the usual number was 1-3 grebe nests per gull nest; compared to random points, nests were placed in areas with higher percent floating vegetation and more live hardstem bulrush stems within 1 m of the nest; 32 grebe nests were characterized by an average of 20.8 cm distance to nearest vegetation, 37.9% floating vegetation cover around nest, and four live hardstem bulrush stems around nest
Cullen 1998	British Columbia	Wetland	Best predictor of use of a wetland for breeding was area of emergent vegetation, not total wetland area, area of open water, or mean depth of wetland
Daub 1993	Manitoba	Wetland	Nested in wetlands $\geq$1 ha in size
Faaborg 1976	North Dakota	Wetland	Nested colonially, only four of 222 nests were solitary; of

			221 nests, three were in small (<3 ha) wetlands with $\geq$95% open water and 218 were on large ($\geq$7.3 ha) wetlands with open water
Faanes 1982	North Dakota	Wetland	Occurred in all wetland classes (ephemeral, temporary, seasonal, semipermanent, permanent, and alkali), but highest densities occurred on permanent wetlands
Faanes and Lingle 1995	Nebraska	Sewage lagoon, wetland	Required dense stands of emergent aquatic vegetation such as hardstem bulrush for nesting and a high degree of vegetation/open water interspersion for foraging habitat for adults and young; occurred on sewage lagoons
Friley and Hendrickson 1937	Iowa	Wetland	Nested about 113 m from the east shore of a wetland in a thin stand of hardstem bulrush; nests were made of live vegetation pulled from the bottom of the wetland, were 1.5-9.5 m apart, and appeared to be arranged in semicircles around a center nest; after hatching, grebes moved about 180 m to more open water
Goss 1883	North Dakota	Lake	Nested colonially; nests were built of live or dead vegetation in water 0.91 m deep
Hill et al. 1997	Oregon	Lake	Nests were constructed of goosefoot or hardstem bulrush; nests were significantly closer (0.68 m apart) to one another at one of the study lakes than at the other study lake (1.55 m); distances between nests within two colonies in the same lake also differed significantly; nests in the low-density colony were 2.5 times farther apart than in the high-density colony
Johnsgard 1980	Nebraska	Impoundment, wetland	Breeding occurred in wetlands and shallow river impoundments with an abundance of submerged aquatic plants

Kantrud and Stewart 1984	North Dakota	Wetland complex	Highest density occurred in seasonal wetlands, followed by semipermanent and permanent wetlands; did not occur in ephemeral, temporary, alkaline, fen, or tilled wetlands
McAllister 1958	British Columbia	Wetland	Colonies were built in dense reedbeds or in the open; nests were 0.3-0.91 m apart and in water 0.3-1.07 m deep and were constructed of live or dead vegetation; first nests in a colony formed a nucleus for future nests
Ray and Kruse 1989	South Dakota	Wetland	Nests were constructed of floating aquatic vegetation, were in water 0.61-0.91 m deep, and were 0.9-6 m apart; colony was in an area composed of half water and half cattail
Roberts 1932	Minnesota	Wetland	Nested in colonies; nests were frail and floated in 0.15-0.3 m of water, among grasses and rushes, and were constructed of decaying vegetation and green vegetation from the bottom of the water
Rockwell 1910	Colorado	Wetland	Built flimsy, unconcealed nests on slight platforms of vegetative stems floating in open water or in sparse growths of cattail
Salt and Salt 1976	Alberta	Wetland	Nested on a floating mass of aquatic vegetation in reeds (*Phragmites*)
See et al. 1992	Wyoming	Wetland	Nested on floating platforms made of sago pondweed and anchored to bulrush (*Schoenoplectus* spp.)
Smith 1890	Colorado	Wetland	Nested on heaped masses of water moss anchored to beds of rushes about 15 m from shore in an alkali wetland where water was about 0.46 m deep
Stewart 1975	North Dakota	Impoundment, lake,	Occurred in slightly brackish, moderately brackish, brackish,

		sewage lagoon, wetland	and subsaline seasonal, semipermanent, and permanent wetlands and lakes that had large expanses of open water, and were also found in large stock ponds, sewage lagoons, or shallow river impoundments; nested on lakes or wetlands ≥4 ha characterized by large beds of submerged aquatic plants such as muskgrass (*Chara* spp.), sago pondweed, claspingleaf pondweed (*Potamogeton richardsonii*), widgeon grass (*Ruppia maritima*), and common watermilfoil (*Myriophyllum heterophyllum*); nested on floating structures composed of matted vegetation of submerged aquatic plant species, generally located ≤90 m from shore in open water, in semi-open stands of emergent vegetation, or in moderately dense cover within a few meters of open water, and with inter-nest distances ≤3 m; emergent plants used for nesting cover were hardstem bulrush, alkali bulrush (*Scirpus maritimus*), sprangletop (*Scolochloa festucacea*), and golden dock (*Rumex maritimus*)

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Effects of Management Practices on Wetland Birds: Bibliography on Survey Methods for Eared Grebe

Note: Few sources were found that explained detailed methods for conducting population surveys specific to Eared Grebes (but see Daub 1993, and Koonz and Rakowski 1985). Most methods involved finding nests or colonies, or recording vegetation measurements. A few articles dealt with capturing grebes. Some sources of methods were not reviewed. They are listed at the end of the annotated bibliography.

Annotated articles

Boe, J. S. 1991. Breeding habitat selection by Eared Grebes in Minnesota. Ph.D. dissertation. North Dakota State University, Fargo, North Dakota. 242 pages.

Habitat selection of the Eared Grebe at the three levels of wetland, colony, and nest site were examined in Minnesota. Individual chapters of the dissertation were devoted to each level and written in manuscript form. Preceding these chapters was a literature review that contained information on avian coloniality, habitat selection, and ecology of Eared Grebes. The study occurred in western and southern Minnesota from 1986 to 1989.

<u>Paper 1: Wetland selection</u>

The characteristics of 24 wetlands used by nesting Eared Grebes were compared to 26 wetlands not used by nesting grebes. Unused wetlands were chosen by means of a stratified random sample of unused wetlands in the same or adjacent counties. Wetlands were stratified by size within wetland classes Types 3-5 (Shaw and Fredine 1971). Type 3 wetlands are shallow, fresh marshes. Type 4 wetlands are deep, fresh marshes. Type 5 wetlands are open, freshwater wetlands that may be fringed with a border of emergent vegetation.

<u>Paper 2: Colony site selection</u>

Twelve colonies within nine wetlands were surveyed. Conditions on wetlands were documented as close as possible to the time the colony was established by using aerial photography. Colonies were photographed in June and July at a mean height of 1475 m using 35 mm photography. Height at which the plane flew was determined by the size of the wetland. On resulting photographs, vegetation types and water depths were marked using marking pens. After nest abandonment, nests were photographed from the air. Characteristics of random sites on wetlands were compared to colony sites. The colony was represented by a single point that was placed at the site of the earliest nest.

Measured wetland characteristics were maximum depth, public access, wetland recreational use, percent open water, submergent vegetation, wetland type, percent emergent fringe, percent treed perimeter, number of buildings within 0.2 km of the wetland, shoreline irregularity (shoreline length / 2 multiplied by the square root of lake area in km^2 times pi), and percent of perimeter with road or highway within 0.2 km. A coefficient of community (2w/a+b; a = # bird spp. present on used wetlands, b = # spp. on unused wetlands, and w = # species present on both) measured degree of similarity of avian species using the two groups of wetlands.

Measured variables were distance from shore, distance to open water, and vegetation composition. Water depth and number of dead cattail stems were measured at 10 randomly selected unused points and at the colony site at one Lake (West Toqua Lake) during the drought year of 1988. Effects of mats of submergent vegetation on wave mediation was measured. A calibrated stick was used to measure wave height in the mat and at points windward and leeward of the mat at Swan Lake. Measurements were taken on 8 June 1988 when wind speed was 34 km/h.

Paper 3: Nest site selection

Eleven colonies on nine wetlands were observed for information on nesting synchrony, nearest-neighbor distances, vegetation, exposure, and nest success. Eggs were floated to determine stage of incubation and color was recorded. Length and breadth of eggs were measured with calipers. Egg volume was estimated. Clutch size was determined. A successful nest was defined as one in which shells without membranes were present or if at least one egg was in a late stage of incubation during the last nest check. Nests were defined as early, peak, or late nests and perimeter nests were located. Perimeter nests were those in which no other nest was located within a 120 degree arc around the nest. Colonies were defined as large if there were $\geq$50 nests; large colonies were then divided into edge, intermediate, and center nests. In small colonies (<50 nests) and the one large, linear colony, only edge and center nests were defined. Emergent stem densities were measured at some sites by counting stems within a 0.25 m x 0.75 m quadrat placed regularly at 0.75 m intervals along N-S and E-W transects. At one wetland with two colonies, nest placement in relation to dead cattails was examined by comparing percent cover of dead cattail debris in a 5-m diameter around the nests and in a similar circle at random points within the colony boundary.

Nesting synchrony was measured by two estimates of span. Span was the number of days between initiation of the first nest and initiation of the last nest in the colony. The second estimate, 50% span, was the minimum number of days during the peak nesting period in which 50% + 1 nests were established.

Breault, A. M. 1990. Breeding distribution, habitat selection and factors affecting coloniality in Eared Grebes in British Columbia. M.S. thesis. University of British Columbia, Vancouver, British Columbia. 143 pages.

Past and current breeding distribution and abundance of Eared Grebes in British Columbia were reviewed using historical records. Surveys of 421 lakes (36 lakes for which there were historical records and 385 new lakes) were conducted in 1985 and 1986. Counts of adults and chicks were conducted using binoculars and spotting scopes from shore. Counts were conducted twice on lakes <26 ha; the maximum count was recorded. On larger lakes, adults were counted once. Age and number of chicks were documented on audio tapes. Aging was determined using Gollop and Marshall's (Gollop, J. B. and W. H. Marshall. 1954. A guide for aging duck broods in the field. Mississippi Flyway Council Technical Section. 14 pages.) system of plumage development in waterfowl. Birds were not flushed from emergent vegetation, so counts represented minimum estimates. In cases where chicks were feeding, several consecutive counts were conducted and the highest count recorded. Nests were tallied while walking through emergent vegetation. Active nests, defined as nests containing eggs or indicating signs of hatching such as membranes and shells, were recorded separately from empty platforms. Number of eggs within each nest was recorded.

Up to three estimates of the number of breeding pairs per lake were determined. For adult birds, the estimate was derived from the maximum number of adults seen during April-August divided by two. For nest counts, the minimum number of breeding pairs per lake was obtained from taking the highest number of active nests during each season. For chick counts, the observed number of chicks of a given age were divided by the mean number of chicks per pair surviving to that age. Three periods of chick development were determined: hatching to 2 wks, 2 wks to 1 mo, and 1 mo. to fledging.

Maximum nest counts were used as an overall estimate of abundance of breeding pairs. However, when nest counts were not available or when estimates based on incomplete nest counts were lower than estimates based on chick counts, breeding pair abundance was based on chick counts. Regional estimates of breeding abundance were determined by adding minimum (from nests) and maximum (from adult surveys) estimates from each lake.

Burger, J., and M. Gochfeld. 1995. Nest site selection by Eared Grebes in a Franklin's Gull colony: structural stability parasites. Condor 97:577-580.

The adaptive significance of Eared Grebes nesting in a Franklin’s Gull colony was examined at Agassiz National Wildlife Refuge in northwestern Minnesota in 1994. Nest site selection was examined at one of two Eared Grebe colonies in which the grebes were nesting with Franklin’s Gulls. Nest site characteristics were gathered at 32 grebe nests, 32 gull nests, and 32 matched points in the center of the grebe colony. Matched points were selected by using random numbers from which to get a compass direction from a grebe nest. Characteristics of the matched point were taken 1 m from the edge of the grebe nest in the random direction. Measured characteristics at nests were number of eggs, nest width at widest diameter, and percent of eggs covered by vegetation. At nests and random points, distance to edge of nearest gull nest and to nearest gull clutch (to indicate distance between sitting birds), distance to nearest vegetation, percent emergent cover within 1 m of the nest, distance to nearest emergent vegetation that extended above the water, percent surface covered with floating vegetation within 1 m of the nest, total number of live *Scirpus* stems around the nest, and whether the nest was anchored to a gull nest.

Cullen, S. A. 1998. Population biology of Eared Grebes in naturally fragmented habitat. M.S. thesis. Simon Fraser University, Burnaby, British Columbia. 89 pages.

Sex ratio, population structure, site fidelity, and movements of breeding Eared Grebes were examined at Becher’s Prairie, British Columbia, from 1995 through 1997. Eared Grebes were captured with gill nets and fitted with nasal tags made of darvic plastic in early May 1995 and 1996 and in mid-July 1995 and 1996. Some birds were implanted with radio transmitters. Wetlands were surveyed with spotting telescopes on a 3-day rotation until mid-June 1995 [initiation of surveys not given]. After mid-June, surveys included all of the 47 permanent wetlands. Wetlands were surveyed on a 4-day rotation during 1996. Pond number and presence and age of chicks were recorded for each bird sighting. Marked birds also were recorded. Two other ponds outside of Becher's Prairie were surveyed. From May through July in 1996, number of birds that an individual associated with also was recorded. Resighting data was gathered in 1997.

Daub, B. C. 1993. Effects of marsh area and characteristics on avian diversity and nesting success. M.S. thesis. University of Michigan, Ann Arbor, Michigan. 37 pages.

Daub examined the relationship between marsh area, species richness, and nesting success in 20 marshes located near Minnedosa, Manitoba, from 1991-1992. Avian censuses were conducted along the perimeter of marshes by placing a randomly chosen, 100 m x 15 m transect, along which nest-searching also occurred. The 15 m portion of the transect included 5 m of emergent vegetation and 10 m of open water. Each transect was walked for 45 min. Each marsh was surveyed three times during the breeding season, about every two weeks. Playback calls were used to elicit responses from American Bittern, Virginia Rail, Yellow Rail, and Sora at the beginning, middle, and end of each transect during every survey. Nesting success was determined using the Mayfield method. Measured marsh characteristics were water depth, vegetative composition (line-intercept technique), and width of vegetation growing in standing water.

Faaborg, J. 1976. Habitat selection and territorial behavior of the small grebes of North Dakota. Wilson Bulletin 88:390-399.

Habitat selection, territorial behavior, and nest dispersion of Horned, Eared, and Pied-billed grebes were studied in Ward County, North Dakota, in the 1970's. The author surveyed over 500 wetlands. Wetlands were classified according to permanence (e.g., seasonal, temporary, semipermanent, permanent), as determined by aquatic plant composition (following Stewart, R. E., and H. A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. Resource Publication 92. U.S. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife. 57 pages.). Wetland cover was categorized between a rating of 1-4, with 1 indicating 95% or more of wetland area covered emergent vegetation and 4 indicating 95% or more open water.

On each wetland, number of pairs of grebes were recorded. Nests were found if possible. Size of wetland was determined through cover-mapping or use of aerial photographs. Area of defended territories was noted.

Hill, W. L., K. J. Jones, C. L. Hardenbergh, and M. Browne. 1997. Nest distance mediates the costs of coloniality in Eared Grebes. Colonial Waterbirds 20:470-477.

The effect of nest density on behavior and reproduction of Eared Grebes was examined at Malheur National Wildlife Refuge in Oregon in 1993 and 1994. In 1993, two colonies from different lakes that had different nearest-neighbor distances were used. In 1994, two colonies from the same lake that had different nearest-neighbor distances were used.

Distances between nests were measured from the center of a focal nest to the center of the nearest nest. In 1994, distance to the second nearest nest also was measured. Nests were checked daily or every two days. Eggs were marked to identify laying sequence. Length and width of eggs were measured. Egg loss was categorized as conspecific competing (single, floating eggs or with peck marks), predation (all eggs missing or partially eaten remains found), or infanticide (dead chicks). Intraspecific brood parasitism occurred if more than one egg was laid in a nest per day or a new egg appeared in a nest after a delay in egg-laying of 3 days. Nest success was defined by the number of eggs that hatched.

Colonies were observed from a floating blind, from a canoe, or from a truck. Focal observations followed the focal animal continuous sampling method. Instantaneous sampling also was used.

Jehl, J. R., Jr., and P. K. Yochem. 1986. Movements of Eared Grebes indicated by banding recoveries. Journal of Field Ornithology 57:208-212.

Banding data from North America were analyzed to elucidate route of fall migration, winter range, and site tenacity for Eared Grebe. Banding data for 1955-1984 came from the Bird-banding Lab of the U.S. Fish and Wildlife Service. Additional data for previous years came from Clapp et al. 1982 (Longevity records of North American birds: gaviidae through alcidae. Journal of Field Ornithology 5381-124.).

Jehl, J. R., Jr., and P. K. Yochem. 1987. A technique for capturing Eared Grebes (*Podiceps nigricollis*). Journal of Field Ornithology 58:231-233.

Use of dip nets aided in the capture of 469 Eared Grebes during their flightless period at the fall molting and staging area of Mono Lake, California in 1985 and 1986. A small (4.5 m) boat with a 20 or 25 horsepower motor trailed grebes that were swimming underwater. A 0.5 m diameter fishing net attached to a 2.8 m pole was used to capture grebes when they surfaced for air. The authors report on grebe's underwater behavior when pursued. Capture rates varied from 4-6 to 10-12 grebes per hour. The dip-net method also worked on Horned Grebe, Western Grebe, Pied-billed Grebe, Gadwall, Mallard, Northern Shoveler, Ruddy Duck, and American Coot. Yellow collars were placed on grebes, but caused mortality, so their usage was discontinued.

Koonz, W. H., and P. W. Rakowski. 1985. Status of colonial waterbirds nesting in southern Manitoba. Canadian Field-Naturalist 99:19-29.

Estimates of colonial waterbird numbers were compared between historic data and data measured in 1979. Aerial waterbird censuses were conducted on all major Manitoba lakes south of 54E10'N during June 1979. Islands known to have contained colonial nesting waterbirds were checked at a height of 200-300 m. Active colonies were censused at an altitude of 150 m. Where time permitted, ground counts were made at the active colonies to ground-truth aerial information. Information was presented as number of colonies observed, number of total nests counted, and number of nests found within individual colonies.

Breeding distribution, not only in Manitoba but also the northern Great Plains, and number of recorded colonies in southern Manitoba were given for Eared Grebe, Western Grebe, American White Pelican, Double-crested Cormorant, Great Blue Heron, Black-crowned Night-Heron, Franklin's Gull, Ring-billed Gull, Herring Gull, Caspian Tern, Common Tern, and Forster's Tern.

Lyon, B. E., and S. Everding. 1996. High frequency of conspecific brood parasitism in a colonial waterbird, the Eared Grebe, *Podiceps nigricollis*. Journal of Avian Biology 27:238-244.

The occurrence of conspecific brood parasitism in Eared Grebes was examined in two nesting colonies in 1988 in British Columbia. Nests were checked daily at both colonies. Parasitism was determined in three ways: 1) appearance of two or more eggs on the same day, 2) appearance of new eggs after completion of a clutch, and/or 3) disappearance of a marked egg with the simultaneous replacement of an unmarked egg.

The following sources may provide more information on methods.

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