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NESTING ECOLOGY OF WATERBIRDS AT GRAYS LAKE, IDAHO

Jane E. Austin¹ and William H. Pyle^{2,3}

ABSTRACT.—Montane wetlands provide valuable habitat for nesting waterfowl and other waterbirds in the western United States, but relatively little information is available about the nesting ecology of their waterbird communities. We describe the general nesting ecology of breeding waterbirds at a large, shallow, montane wetland in southeastern Idaho during 1997–2000. Habitats include upland grasslands and intermittently to semipermanently flooded wetland habitats. We located a total of 1207 nests of 23 bird species: Eared Grebe (*Podiceps nigricollis*), Canada Goose (*Branta canadensis*), Mallard (*Anas platyrhynchos*), Gadwall (*A. strepera*), American Wigeon (*A. americana*), Green-winged Teal (*A. crecca*), Blue-winged Teal (*A. discors*), Cinnamon Teal (*A. cyanoptera*), Northern Shoveler (*A. clypeata*), Northern Pintail (*A. acuta*), Redhead (*Aythya americana*), Canvasback (*A. valisineria*), Lesser Scaup (*A. affinis*), Ruddy Duck (*Oxyura jamaicensis*), Northern Harrier (*Circus cyaneus*), American Coot (*Fulica americana*), Virginia Rail (*Rallus limicola*), Greater Sandhill Crane (*Grus canadensis tabida*), American Avocet (*Recurvirostra americana*), Long-billed Curlew (*Numenius americanus*), Wilson's Snipe (*Gallinago delicata*), Wilson's Phalarope (*Phalaropus tricolor*), and Short-eared Owl (*Asio flammeus*). Most nests were initiated in May–early June and were terminated (hatched or destroyed) by the 3rd week of June. Mean daily survival rate (DSR) for Canada Goose nests was 0.954 ± 0.005 ($s_{\bar{x}}$; $n = 127$ nests), equivalent to Mayfield nest success of 21%. Mean DSR for dabbling duck nests over all 4 years was 0.938 ± 0.006 ($n = 41$), equivalent to Mayfield nest success of 11%. For all other species where we found >10 nests each year (Eared Grebe, Redhead, Canvasback, Coot, Sandhill Crane, American Avocet, and Wilson's Snipe), >50% of nests found hatched at least 1 young. Success rates for geese, cranes, and ducks were lower than reported for Grays Lake during 1949–1951 and lower than most other wetlands in the region.

Key words: American Avocet, American Coot, Canada Goose, dabbling ducks, habitat management, Idaho, montane wetland, nesting ecology, Sandhill Crane, waterbirds.

Montane wetland systems provide valuable habitat for nesting waterfowl and other waterbirds in the western United States (Ringelman 1992). Although these wetlands have communities of breeding waterbirds similar to those found in the Prairie Pothole region (Kantrud et al. 1989), montane wetlands generally have shorter growing seasons, cooler and less predictable summer temperatures, and different predator communities (Windell et al. 1986, Ringelman 1992, Sanders 1997). Montane wetlands also tend to have experienced fewer impacts from agriculture and invasive species. Montane sites have higher annual precipitation, snowfall, and persistence of snowcover than wetlands at low elevations, and they tend not to support robust grasses such as basin wildrye (*Elymus cinereus*) and intermediate wheatgrass (*Agropyron intermedium*) that can withstand compaction from heavy snow accumulations. Characteristics of individual montane wetlands, however, can be highly variable,

depending on elevation, aspect, hydrology, underlying geology, and human influences. Therefore, information from a variety of montane wetlands is needed to understand variations and commonalities in the communities and ecology of breeding waterbirds and to adapt habitat management practices to local conditions.

Grays Lake, located in southeastern Idaho, is a large (15,000 ha), montane wetland that hosts a diversity of breeding waterbirds. Of the nearly 199 species of birds that occur there, 44 species nest in wetland habitats (U.S. Fish and Wildlife Service 1995). The area has long been recognized for its breeding populations of ducks, Great Basin Canada Geese (*Branta canadensis moffitti*), and Greater Sandhill Cranes (*Grus canadensis tabida*; Sperry and Martin 1929, Steel et al. 1956, 1957, Drewien 1973). A large proportion of the wetland habitat of Grays Lake is encompassed within Grays Lake National Wildlife Refuge (GLNWR or

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Refuge), established in 1965 to protect and restore habitat for waterfowl production, Sandhill Cranes, and other wildlife. Habitat management focuses on the upland and wetland habitats that border the central cattail (*Typha latifolia*)-bulrush (*Scirpus* spp.) marsh. These "lakeshore" habitats include upland grasslands and intermittently to semipermanently flooded wetlands. During 1997–2000 we studied the general nesting ecology of Canada Geese, Sandhill Cranes, ducks, and other waterbirds on lakeshore habitats. Here we describe the nesting bird community and provide information on nesting phenology, clutch size, nest site characteristics, and nest success of these species. We compare nesting phenology and current rates of nest success for Canada Geese, ducks, and Sandhill Cranes with those reported for Grays Lake historically (Steel 1952, Steel et al. 1956, 1957, Drewien 1973) and for other wetlands in the region.

STUDY AREA

Grays Lake lies within the Caribou Range of the Rocky Mountains in southeastern Idaho, at the western edge of the Greater Yellowstone Ecosystem. The central portion of this montane wetland is a large, contiguous area of semipermanently flooded wetland dominated by bulrush and lesser amounts of cattail (8153 ha; hereafter interior marsh). The lakeshore habitats surrounding the interior marsh are a mosaic of seasonally (1264 ha) and temporarily (914 ha) flooded habitats, dominated by Baltic rush (*Juncus balticus*), tufted hairgrass (*Deschampsia caespitosa*), Kentucky bluegrass (*Poa pratensis*), brome (*Bromus* spp.), mat muhly (*Muhlenbergia richardsonis*), spikerush (*Eleocharis* spp.), and sedges (*Carex* spp.). Because of its high elevation (1946 m), the valley is subject to severe and prolonged winters with snow accumulations often exceeding 200 cm. Temperatures vary from -45°C during winter to 35°C during summer, but freezing temperatures can occur during any month. Henry, Idaho, located 13 km southwest of Grays Lake and at 1869 m elevation, had an average annual precipitation of 53.5 cm and average annual snow accumulation of 219 ± 29 cm (1971–2000; Western Region Climate Center 2002).

The water level of Grays Lake is determined by precipitation, evaporation/transpiration, and water-level management at 2 outflows. During

spring the lake level is high enough to flood surrounding lakeshore habitats. The lake is typically drawn down to a standard level from late June to September to supply water for irrigation downstream, leaving surface water only in the interior marsh. Only in very wet years is standing water available in the margins between Baltic rush–sedge habitat and the interior marsh during summer months.

Ranching (cattle, sheep, and hay production) has been the predominant land use in the valley since the late 1800s. Currently, cattle grazing of upland and wetland areas occurs from June through early November. The GLNWR contains most of the interior marsh as well as large areas of lakeshore habitats; relatively small amounts of sagebrush grassland are included within the Refuge. Based on data from the National Wetland Inventory, lakeshore fields under USFWS control are dominated by seasonally flooded (45%), temporarily flooded (23%), and semipermanently flooded (21%) wetland, with small amounts of upland (11%) and permanently flooded wetland (<1%). Lakeshore habitats are managed by USFWS for nesting and foraging waterbirds using summer and fall grazing, fall burning, and haying; some fields are idled for 1 year or several years.

For our study we selected 12 (776 ha total) of 22 fields that were within lakeshore habitats and managed by GLNWR. Wetland composition of selected lakeshore fields was very similar to that of all lakeshore habitat under USFWS control: 55% seasonally flooded (422 ha), 20% temporarily flooded (153 ha), 18% semipermanently flooded (138 ha), and <1% permanently flooded (<3 ha) wetland, and 7% upland (54 ha). In 1996 all 12 fields were left idle to allow their vegetation stature to become more similar before the study began, and they remained idle during 1997 and 1998, the first 2 years of data collection. Grazing and burning treatments were applied to 9 fields in late summer–fall 1998, and fall grazing was again applied in fall 1999; three of the 12 fields remained idle through summer 2000. These treatments were similar to those applied to other USFWS lakeshore fields not included in this study and are part of normal refuge management activities. While areas searched for nests within each field included stands of cattail-bulrush, we did not extend our searches more than 100 m into contiguous interior marsh, which was considered the outer boundary of

the defined field. For a more complete description of plant communities and hydrology, see Austin et al. (2002).

METHODS

We conducted the 1st systematic searches for nests of Sandhill Cranes and Canada Geese, which initiated nesting 2–4 weeks before other waterbirds, beginning the 1st week of May. Because residual vegetation was minimal in early spring and these nesting birds were very visible, we systematically scanned each unit for nesting Sandhill Cranes and Canada Geese from vantage points. Often a 2nd such search was conducted during the 2nd week of May, before systematic searches were started for ducks and other waterbirds.

We conducted systematic searches for all ground-nesting waterbirds on each unit at approximately 21-day intervals 3 times each year, beginning in the 3rd week of May, 1st week of June, and last week of June. In 1999 four systematic searches were conducted within the specified time frame because earlier searches went quickly and biologists suspected the late spring conditions delayed nesting of some species. However, final search dates in that year were similar to final search dates in 1997 and 1998. Any crane and goose nests found during searches were mapped, and field crews attempted to minimize disturbance near all crane and goose nests.

We used several methods to search for nests. Unflooded areas were searched using a 61-m, 0.8-cm-diameter chain drag pulled between 2 all-terrain vehicles (ATVs), using procedures similar to those of Higgins et al. (1969). In areas that were flooded, where the substrate was too soft to use ATVs without damage to substrate or vegetation, or where access by ATVs was otherwise restricted, searching was done by 1–2 people on foot using a 30-m rope drag or hand-held poles. To minimize disturbance to crane and goose nests, searchers maintained a distance of ≥ 30 m from the nests unless directly checking the nest status. Locations of all nests found were plotted on an aerial photo.

Information recorded at nests followed procedures recommended by Klett et al. (1986). We marked nests with willow stakes labeled with a nest number to facilitate their relocation. In the first 2 years, colored flagging was

tied to the willows; however, concerns about detection of marked nests by American Crows (*Corvus brachyrhynchos*) and Common Ravens (*C. corax*) that are common in the area (Greenwood and Sargeant 1995) caused us to abandon that practice in 1999 and 2000. All nests were checked every 10–21 days and their status monitored until terminated (hatched, destroyed, abandoned). We used eggshell fragments to determine nest fate (Mabee 1997, Sargeant et al. 1998). During the 1st visit we recorded nest site vegetation (unvegetated, annual crops, upland graminoids, upland forbs, low shrubs [< 1 m], tall shrubs [> 1 m], trees [> 6 m], floating hydrophytes, and short [0.5 m], medium [0.5–1.0 m], and tall [> 1.0 m] hydrophytes) and nest site type (not special, nest structure, natural island, artificial island, other). Information recorded during each subsequent visit included number of host and parasitic eggs, incubation stage, and water depth (cm) at the nest. Water depth was recorded as missing or “not applicable” if the nest was not in water when found. Because this variable did not capture information of nests not in water during laying or early incubation, we summarized the data with the assumption that water depth was 0 if water depth was recorded as missing. To best represent conditions at initiation, we report water depths only for those 1st nest visits that occurred during laying or early incubation.

Because sample sizes were limited for most species within years, we summarized data for all 4 years and did not conduct statistical tests. For those species with sufficient sample sizes, we compared final clutch sizes among years using 1-way analysis of variance (SAS Institute, Inc. 1999). We calculated annual and overall daily survival rates (DSRs) for nests of Canada Geese and dabbling ducks (species pooled) using the Mayfield method (Mayfield 1975), with modifications suggested by Johnson (1979, 1990). Nests found already hatched or destroyed and nests abandoned or destroyed due to investigator disturbance were excluded from analyses. Estimated exposure days for Canada Geese were based on a 28-day incubation period, 5-egg clutch, and 1 egg laid per day, with a day skipped between the 3rd and 4th eggs and between the 4th and 5th eggs (Bellrose 1980). For duck species we used incubation periods from Bellrose (1980) to estimate nest initiation and exposure dates. Data for

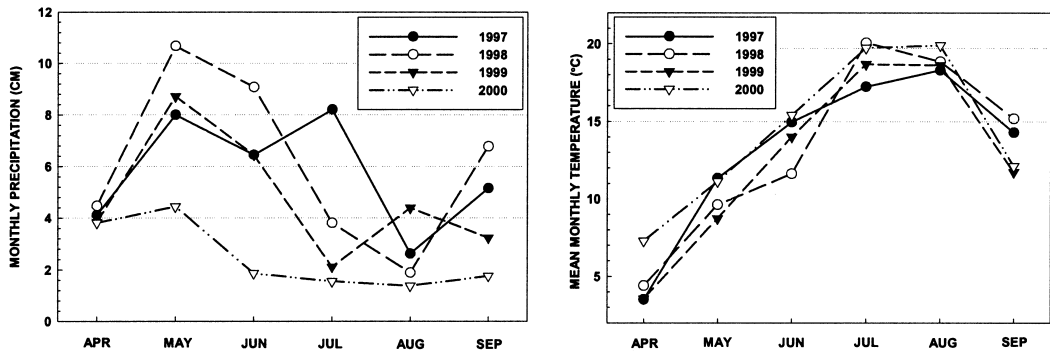


Fig. 1. Mean monthly precipitation and temperature reported for Swan Valley, Idaho, located 85 km north of Grays Lake, during 1997–2000 (Western Regional Climate Data Center unpublished data).

other species were usually insufficient to calculate DSRs; therefore, we report only apparent nest success rates (number of nests that hatched at least 1 egg divided by number of nests found).

RESULTS

Weather and Water Conditions

Weather conditions during the course of the nesting season varied annually, generally changing from wet conditions during the first 2 years to warm and dry conditions during 2000 (Fig. 1). Weather data for the Grays Lake valley were not available for the years of this study, so we report monthly weather data for Swan Valley, located 85 km north of Grays Lake and at 1710 m elevation (Western Region Climate Data Center unpublished data). Total annual precipitation was highest in 1997 (59.4 cm) and 1998 (62.3 cm) and declined to 48.6 cm in 1999 and 38.8 cm in 2000. The decline in precipitation in the latter 2 years was most apparent for the growing season (April–September), falling from a high of 36.7 cm in 1998 to 14.8 cm in 2000. Patterns of mean monthly temperatures also varied among years. In general, April was warmest in 2000; May was relatively cool during 1999 and warm during 1997; and June was coolest in 1998.

Water level records for Grays Lake have been collected since 1979 at Beavertail Point, at the southernmost end of the lake (GLNWR unpublished data). During April–May 1997–1999, water levels were above the long-term median (1979–2000; Fig. 2), with highest water levels occurring in 1997. In that year large

areas of lakeshore habitat were flooded in April and early May. During April–May 2000, water levels were near the long-term median. Continued summer precipitation during 1997 kept water levels above normal through July and August that year, whereas in the other years water levels fell to or below the lake bottom level by the 1st week of August.

Nesting Waterbird Community

We located 1207 nests of 23 bird species during the 4 years of this study, and ≥ 10 nests for each of 10 species (Table 1): Eared Grebe (*Podiceps nigricollis*), Canada Goose, Mallard (*Anas platyrhynchos*), Gadwall (*A. strepera*), American Wigeon (*A. americana*), Green-winged Teal (*A. crecca*), Blue-winged Teal (*A. discors*), Cinnamon Teal (*A. cyanoptera*), Northern Shoveler (*A. clypeata*), Northern Pintail (*A. acuta*), Redhead (*Aythya americana*), Canvasback (*A. valisineria*), Lesser Scaup (*A. affinis*), Ruddy Duck (*Oxyura jamaicensis*), Northern Harrier (*Circus cyaneus*), American Coot (*Fulica americana*), Virginia Rail (*Rallus limicola*), Greater Sandhill Crane, American Avocet (*Recurvirostra americana*), Long-billed Curlew (*Numenius americanus*), Wilson's Snipe (*Gallinago delicata*), Wilson's Phalarope (*Phalaropus tricolor*), and Short-eared Owl (*Asio flammeus*). Twelve nests of "unknown" species were also found in 1997 and 1998. American Coots were by far the most abundant nesting species (108 nests in 1997 to a high of 430 nests in 1999; total of 997 nests). We also found 134 Canada Goose nests and 234 Sandhill Crane nests. For ducks we found 162 dabbling duck nests (41% Mallard, 30% Cinnamon Teal, 17% Gadwall, and

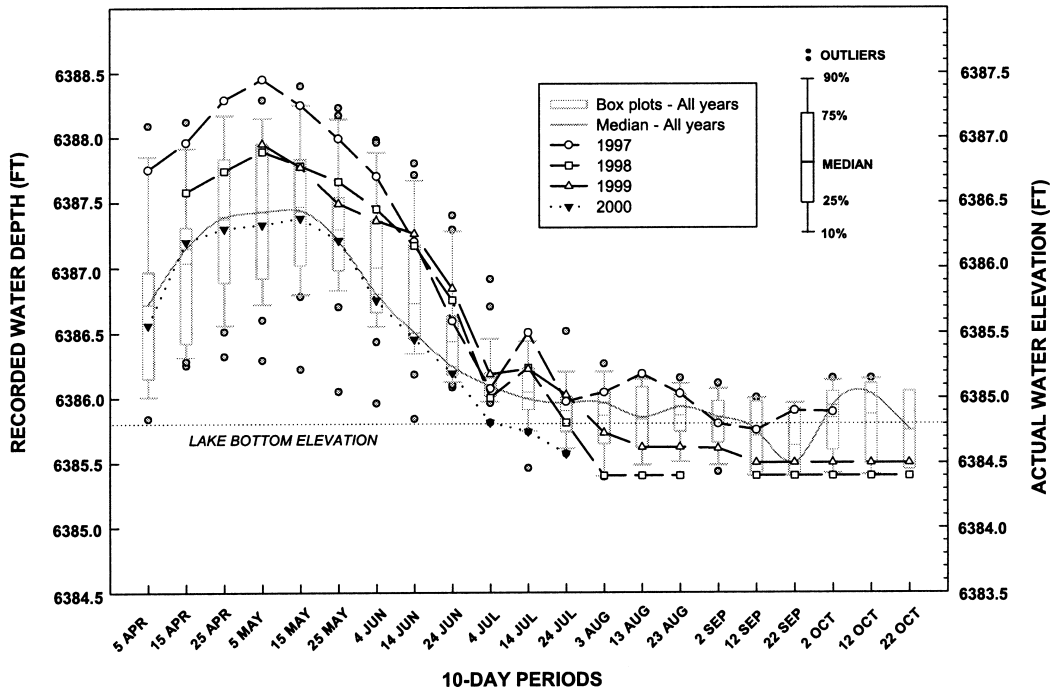


Fig. 2. Water levels recorded at Beavertail Point, located on the south end of Grays Lake for April–October, 1979–2000, summarized by 10-day periods. Right axis reflects gauge elevation correction (+0.95 feet) surveyed during 1998.

>1% each for other species) and 24 diving duck nests (42% Canvasback, 37% Ruddy Duck, 17% Redhead, and 4% Lesser Scaup).

Numbers of nests found for 3 species declined over the 4 years of the study. Nineteen Eared Grebe nests were found in 1997, but only 2–3 nests were found in subsequent years. Numbers of Canada Goose nests declined from 40 and 43 in the first 2 years to 27 and 24 in the latter 2 years. Numbers of American Avocet nests declined from 50 in 1997 to 29 in 1998, 14 in 1999, and 0 in 2000. We caution, however, that nest detection probabilities vary among species and could vary within a species among years (e.g., change in vegetative cover or distribution of nests to different cover). Therefore, numbers of nests do not necessarily reflect actual or relative abundances.

Nest Initiation and Termination Dates

The earliest nesting species was the Canada Goose, with almost 75% of nests initiated by the end of April; the Ruddy Duck was the latest nester (Fig. 3). Most nests of Redheads,

American Coots, American Avocets, Long-billed Curlews, and Short-eared Owls were initiated in May, whereas most nests of Gadwalls, Ruddy Ducks, Wilson's Phalaropes, and Wilson's Snipes were initiated in June. Most duck nests were initiated between mid-May and mid-June. Most nests were terminated (hatched or destroyed) by about the 3rd week of June, although some Ruddy Duck nests continued into August. When all species and years are considered together, most active nests occurred between early May and mid-July.

Sample sizes were large enough to allow graphical examination of annual differences in nest initiation dates for Canada Geese, Mallards, and American Avocets (Fig. 4). Median dates and dates of earliest nests for Canada Geese were earlier in 2000 than in other years, and 1st nests tended to be later in the season in 1999 than in other years. Earliest initiation dates for Sandhill Crane nests differed by only 4 days and median dates by only 7 days. Median nest initiation dates for the Mallard were similar among years, but initiation of the earliest nests tended to be later in

TABLE 1. Total number of nests found, apparent nest success (ANS), and clutch size (mean \pm $s_{\bar{x}}$) for 23 waterbird species nesting in 12 lakeshore fields at Grays Lake National Wildlife Refuge, Idaho, during 1997–2000. Total number of nests includes some nests that were later lost (i.e., no fate determined); apparent nest success was calculated based on nests of known fate.

Species	Acronym	Total number nests	ANS (%)	Clutch size			
				<i>n</i>	Mean	$s_{\bar{x}}$	Range
Eared Grebe	EAGR	26	73.7	23	4.5	0.5	2–8
Canada Goose	CAGO	134	43.4	117	4.7	0.1	1–7
Mallard	MALL	66	30.0	40	8.4	0.2	5–11
Gadwall	GADW	28	26.9	16	8.2	0.3	6–10
American Wigeon	AMWI	1	100.0	1	8.0	—	—
Cinnamon Teal	CITE	49	12.8	31	8.2	0.4	3–12
Green-winged Teal	GWTE	1	0	0	—	0	—
Blue-winged Teal	BWTE	3	33.3	3	9.0	0.0	9
Northern Shoveler	NOSH	3	66.7	3	9.3	1.2	7–11
Northern Pintail	NOPI	13	61.5	10	8.6	0.4	6–11
Canvasback	CANV	10	60.0	6	7.5	0.8	5–11
Redhead	REDH	4	75.0	2	7.0	1.0	6–8
Lesser Scaup	LESC	1	—	1	8.0	—	—
Ruddy Duck	RUDU	9	22.2	4	8.5	2.2	5–14
Northern Harrier	NOHA	1	100.0	1	5.0	—	—
American Coot	AMCO	998	71.9	882	7.8	0.1	1–16
Virginia Rail	VIRA	2	50.0	1	11.0	—	—
Sandhill Crane	SACR	234	51.8	207	1.8	0.1	1–2
American Avocet	AMAV	93	81.0	87	3.7	0.1	1–5
Long-billed Curlew	LBCU	6	33.3	6	3.8	0.2	3–4
Wilson's Snipe	WISN	12	50.0	7	3.5	0.2	3–4
Wilson's Phalarope	WIPH	6	20.0	5	3.8	0.2	3–4
Short-eared Owl	SEOW	5	60.0	3	6.3	0.7	5–7

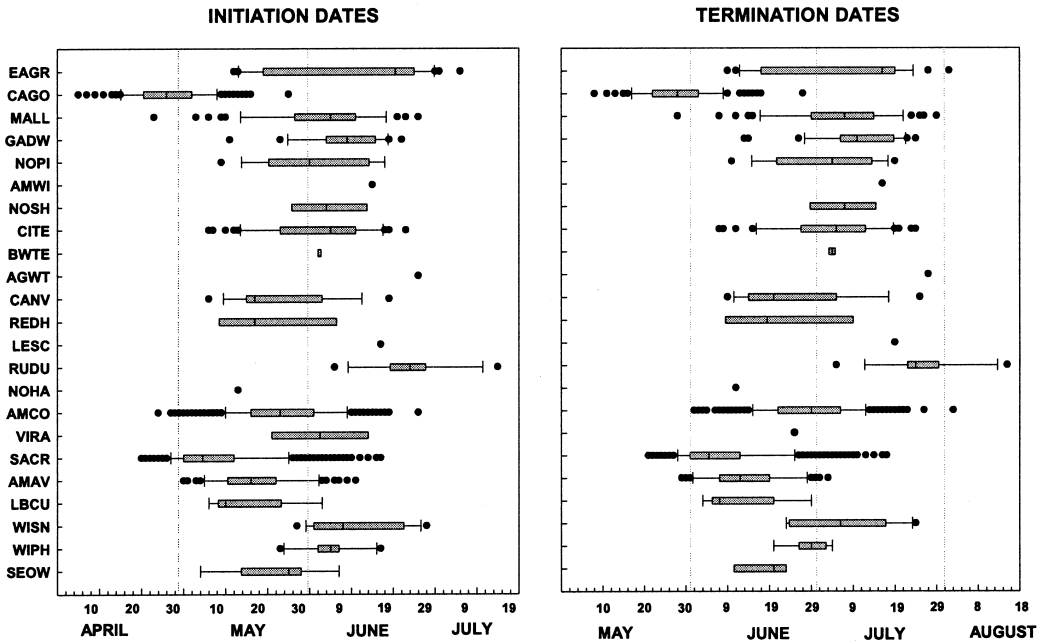


Fig. 3. Nest initiation and termination dates for 23 species nesting on 12 lakeshore fields at Grays Lake National Wildlife Refuge during 1997–2000. Box plots show median (vertical line in box), 25th and 75th percentiles (shaded box), 10th and 90th percentiles (bars with whiskers), and outliers (dots). Refer to Table 1 for acronym definitions.

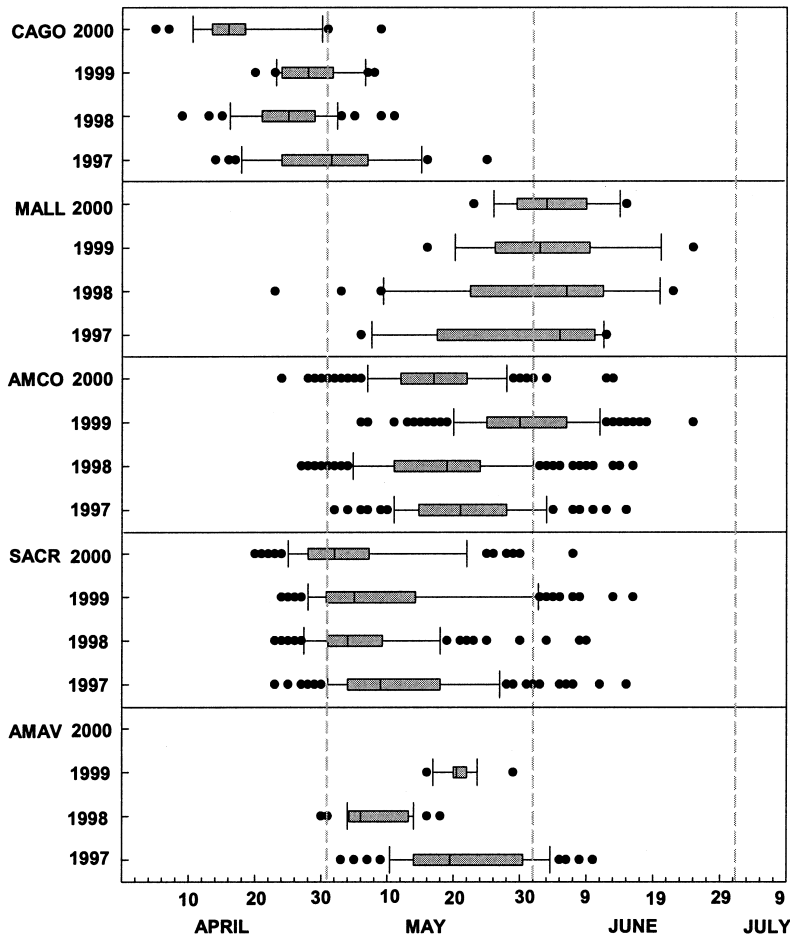


Fig. 4. Initiation dates by year for nests of Canada Geese (CAGO), Mallards (MALL), American Coots (AMCO), Sandhill Cranes (SACR), and American Avocets (AMAV) at Grays Lake National Wildlife Refuge, Idaho, during 1997–2000. Box plots show median (vertical line in box), 25th and 75th percentiles (shaded box), 10th and 90th percentiles (bars with whiskers), and outliers (dots).

the last 2 years of the study than in the first 2 years. The nest-initiation period for this species was markedly later and shorter in 2000 compared with other years, and longest and earliest in 1998. The American Avocet had a longer nest-initiation period in 1997 than in 1999; further consideration of annual variation in nesting phenology is limited by the few avocet nests found in 1999 and their absence in 2000.

Clutch Sizes

Mean clutch sizes are presented in Table 1 for each species. Sample sizes for nests of Canada Geese, American Coots, Sandhill Cranes, and American Avocets were large enough to examine for differences among

years (Table 2). Clutch sizes of geese, cranes, and avocets were similar among years ($P > 0.05$). Clutch size of coots varied among years ($F_{3,881} = 41.57, P < 0.001$), declining between 1997 and 1999.

Nest Site Characteristics

Most nests were located in hydrophytic vegetation or upland graminoids (Table 3). If the large numbers of coot nests are excluded, 62% of nests occurred in upland vegetation (upland graminoids, forbs, and low shrubs) and 36% in wetland (hydrophytic) vegetation. Nests of dabbling ducks occurred more often in upland graminoids than in hydrophytes, whereas all coot nests and all but 2 nests of

TABLE 2. Annual clutch size (mean \pm $s_{\bar{x}}$) for Canada Geese, American Coots, Sandhill Cranes, and American Avocets nesting in 12 lakeshore fields at Grays Lake National Wildlife Refuge, Idaho, during 1997–2000.

Year	Canada Goose			American Coot ^a			Sandhill Crane			American Avocet		
	<i>n</i>	Mean	$s_{\bar{x}}$	<i>n</i>	Mean	$s_{\bar{x}}$	<i>n</i>	Mean	$s_{\bar{x}}$	<i>n</i>	Mean	$s_{\bar{x}}$
1997	36	4.58	0.24	96	9.30	0.27	49	1.84	0.05	48	3.63	0.14
1998	39	4.59	0.25	202	8.69	0.15	62	1.92	0.03	26	3.81	0.12
1999	21	4.71	0.27	381	7.12	0.10	52	1.87	0.05	13	4.00	0.00
2000	21	4.90	0.31	203	7.67	0.14	44	1.95	0.03	0	—	—

^aClutch size differed among years ($P < 0.001$).

diving ducks were in hydrophytes, reflecting their use of overwater nest sites. Other species nesting in upland graminoids or other upland vegetation included Canada Goose, American Avocet, Wilson's Snipe, Long-billed Curlew, Wilson's Phalarope, and Short-eared Owl. Dabbling ducks and Canada Geese occasionally were found nesting in low shrubs, which were uncommon or absent in most fields. Canada Geese and ducks also were reported nesting on floating emergents, natural islands, and on man-made features such as berms or spoil piles. Eighteen nests of Canada Geese (13%) and 3 of Sandhill Cranes (1%) were found on muskrat lodges or mounds.

Nests of Eared Grebes, Virginia Rails, and Redheads were initiated in the deepest water (median >40 cm; Fig. 5). Many nests of Ruddy Ducks, coots, and Canvasbacks were in water 20–40 cm deep. Nests of coots, cranes, and geese occurred in a wide range of water depths (0–80 cm). Twelve of the 21 species nested on unflooded areas, including dabbling ducks, the remaining shorebird species, and the Short-eared Owl.

Nest Success

Mean DSR for Canada Goose nests during 1997–2000 was 0.954 ± 0.005 ($s_{\bar{x}}$; $n = 127$ nests), equivalent to Mayfield nest success of 21%. The mean DSR was lower in 1998 than in other years but all confidence intervals overlapped, indicating annual differences were not significant (Fig. 6).

Mean DSR for dabbling duck nests over all 4 years was 0.938 ± 0.006 ($n = 151$), equivalent to Mayfield nest success of 11%. The mean DSR was lower in 2000 compared to other years, but the wide confidence intervals indicate that differences among years were not significant (Fig. 6). Among dabbling ducks, nests of Mallards ($n = 60$), Cinnamon Teals ($n = 47$), and Gadwalls ($n = 24$) were the most common; other dabbling species included Northern Pintail ($n = 12$), Blue-winged Teal ($n = 3$), Northern Shoveler ($n = 3$), American Wigeon ($n = 1$), and Green-winged Teal ($n = 1$).

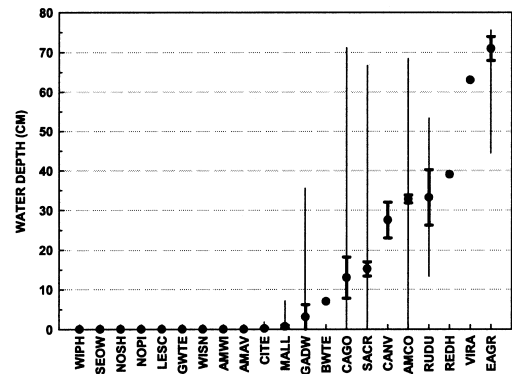


Fig. 5. Water depths (cm) at nests for 23 species, during laying or early incubation, in 12 lakeshore fields at Grays Lake National Wildlife Refuge, Idaho, during 1997–2000.

For all other species where we found >10 nests each year (Eared Grebe, Redhead, Canvasback, American Coot, Sandhill Crane, American Avocet, and Wilson's Snipe), apparent nest success was >50% (Table 1). We caution that apparent nest success rates, particularly for those species with low sample sizes, can overestimate actual nest success rates when nests are found relatively late in incubation (Klett et al. 1986). More detailed evaluation of nest success rates for Sandhill Cranes and coots will be reported elsewhere.

DISCUSSION

The meadow and wetland habitats at Grays Lake support a diversity of nesting wetland

TABLE 3. Proportion of nests occurring in each type of nest site vegetation for 23 species nesting in 12 lakeshore fields at Grays Lake National Wildlife Refuge, Idaho, during 1997–2000.

Species	n	Unvegetated	Annual crop	Upland graminoids	Upland forbs	Low shrubs (<1 m)	Floating	Medium			
								Short emergent hydrophytes (<0.5 m)	Medium emergent hydrophytes (0.5–1.0 m)	Tall emergent hydrophytes (>1.0 m)	
Eared Grebe	19								23.1		76.9
Canada Goose	134	6.7		60.4		3.0	0.7	16.4	6.0		6.7
Mallard	66	1.5	1.5	40.9	7.5	9.1		6.1	22.7		10.6
Gadwall	28			57.1	14.3	10.7			14.3		3.6
Northern Pintail	13			53.8	7.7	15.4			7.7		
American Wigeon	1			100.0							
Northern Shoveler	3			100.0							
Cinnamon Teal	49			57.1	4.1	6.1		10.2	20.4		2.0
Blue-winged Teal	3			66.7					33.3		
Green-winged Teal	1			100.0							
Canvasback	9								55.6		44.4
Redhead	4			25.0				25.0	50.0		
Lesser Scaup	1			100.0							
Ruddy Duck	9								11.1		88.9
Northern Harrier	1								100.0		
American Coot	998	0.1		0.2							
Virginia Rail	2										
Sandhill Crane	234	0.8	0.4	11.1	0.4	0.4	0.4		49.2		27.3
American Avocet	93			75.3	1.1				50.0		50.0
Long-billed Curlew	6			83.3	16.7				20.9		8.6
Wilson's Snipe	12			50.0	8.3				16.7		8.3
Wilson's Phalarope	6			66.7					16.7		
Short-eared Owl	5			100.0							
Overall	325	0.8	0.1	18.1	1.1	1.2	0.1	19.6	37.0		22.0

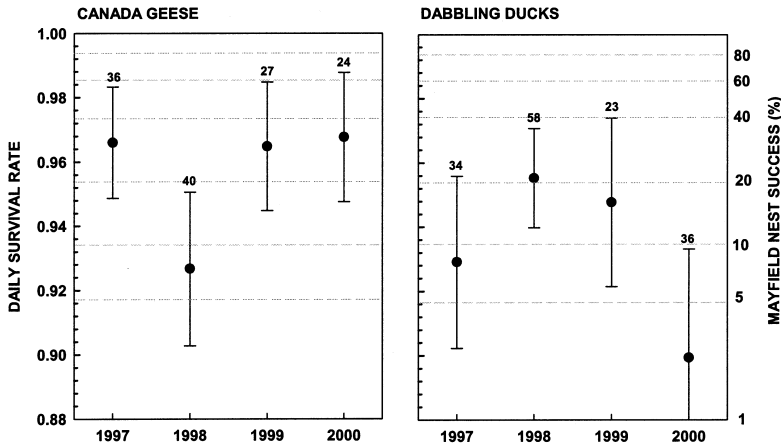


Fig. 6. Daily nest survival rates $\pm 95\%$ confidence intervals and Mayfield nest success rates for Canada Goose and dabbling duck nests on 12 lakeshore fields at Grays Lake National Wildlife Refuge, Idaho, during 1997–2000. Numbers above error bars represent number of nests in sample.

birds, including substantial numbers of American Coots, Sandhill Cranes, Canada Geese, dabbling ducks, and American Avocets. The dabbling duck group was dominated by Mallards and Cinnamon Teal, similar to waterfowl communities in other wetlands of the central Rocky Mountains (Williams and Marshall 1938, Frary 1954, Peterson and Low 1977, Thornton 1982, Gilbert et al. 1996, Sanders 1997). The American Avocet was the most numerous of the 4 species of nesting shorebirds present. Because the search area within each unit usually included relatively small areas of semipermanently and permanently flooded wetland (generally $<20\%$ of field area), this study cannot adequately represent the nesting community in these more permanently flooded habitats, particularly the extensive interior marsh. White-faced Ibis (*Plegadis chihi*), Franklin's Gull (*Larus pipixcan*), and Trumpeter Swan (*Cygnus buccinator*) are known to nest in the interior marsh and were recorded in the study fields during breeding bird surveys, but they do not nest in the lakeshore habitats.

Annual differences in nest numbers for some of the more common species reflect the spatial and temporal variability of waterbird nesting in this montane wetland. In particular, numbers of nests found of Eared Grebes, Canada Geese, and avocets declined over the 4 years of our study. Eared Grebes are largely a colonial nesting species (Cullen et al. 1999), and

we suspect the small grebe colony (19 nests) found in 1 field during 1997 moved into the interior marsh in later years; the few nests found in other years were solitary nesting pairs. Declines in numbers of American Avocet nests among years also are likely related to their semicolonial nesting habits (Sordahl 1996, Robinson et al. 1997, this study). Research activity might have affected avocet nest success within a year (1-egg nests were prone to abandonment) and might have contributed to declines in nesting activity in subsequent years (Robinson et al. 1997). However, density and occurrence of avocet colonies also are influenced by year and habitat conditions (Robinson et al. 1997, Hötter 2000). We surmise that the greater availability of temporary island or isolated habitats due to high water levels in 1997 provided attractive and more secure nesting habitat to avocets; lower water levels in 1999 and 2000 would have exposed these sites to more mammalian predator activity, and avocets may have shifted their nesting sites elsewhere.

We suspect the decline in number of Canada Goose nests is largely related to timing of nest searches. Many goose nests are initiated by mid-April (Steel et al. 1957, this study), 10–14 days before our 1st visual nest searches. Thus, we probably missed nests that were lost to predation early. We suspect such early nest predation was low during 1997 and 1998 when water levels were high and isolated many nests

from mammalian predation. In 2000, however, we found extensive evidence that low water levels allowed mammalian predators access to large areas of the wet meadow habitat and that many early goose nests were depredated before nest searching began in early May. Results of concurrent breeding bird surveys (Austin et al. 2002) indicate that goose densities are not influenced by year, unit, or treatment effects. Therefore, we believe the apparent decline in goose nest numbers during this study was due to depredation of many nests before searches started in 1999 and 2000. These changes in numbers of nests found highlight the need for multiyear studies and careful attention to nesting phenology relative to nest search efforts.

Comparative Nesting Phenology

Comparisons of nesting phenology between this and other studies conducted throughout the West suggest some trends of later nest initiation at higher elevations, but they also indicate that phenology often is influenced by annual variation in weather or habitat conditions. The most extensive data are available for Canada Geese, ducks, American Coots, and Sandhill Cranes; fewer data were found on nest-initiation dates for avocets, and very few were found for the other species considered here. For most species, dates of earliest nests seem quite variable within and among studies, which is likely related to annual variation in snowmelt, temperatures, and water conditions.

The nesting phenology of Canada Geese seems most clearly related to elevation (Krohn and Bizeau 1980:22, this study). Dates of peak nest initiation vary by about 4 weeks: earliest nesting (late March–1st week of April) occurs at elevations <1600 m, and latest nesting (2nd and 3rd weeks of April) occurs at elevations ≥ 1940 m. Krohn and Bizeau (1980) examined the week of peak nest initiation of western Canada Geese from 23 locations and found elevation accounted for 50% of observed variation (simple linear regression, $r^2 = 0.50$); unexplained variation was suspected to be related to annual variation in temperatures, such as that reported for Canada Geese nesting at Hanford, Washington (Hanson and Eberhardt 1971:20).

For other species evidence of elevational influence on nesting phenology is apparent only where data are available for multiple sites

of varying elevation within a state. In Arizona mean or median nesting dates of Mallards, Cinnamon Teal, and Gadwall at >2450 m are usually 2–3 weeks later than those nesting at lower elevations; annual variation within sites also is apparent and likely related to weather (Piest 1982, Gammonley 1996). Nesting phenology of coots seems to be influenced by both latitude and elevation. The earliest nests at Grays Lake, the northernmost area compared, were initiated later than early nests in Colorado (1442–2500 m; Gorenzal et al. 1981, 1982), Utah (1280 m; Ryder 1961), California (1230 m; Rienecker and Anderson 1960), or Washington (711 m; Hill 1988). In general, peak nesting for coots occurred earlier at sites <1600 m elevation (late April–mid-May) compared with nests at sites >1900 m elevation (last 3 weeks of May–early June). Nest-initiation dates for coots at Grays Lake were similar to those reported for Mountain Valley, Colorado (2425 m elevation; Gorenzal et al. 1982), but later than those at lower-elevation Plains (1446 m), Western (1634 m), and Beebe Marsh sites in Colorado (Gorenzal et al. 1981, 1982).

Limited data for avocets indicate that the earliest nests at Grays Lake occur later (very late April to mid-May) than at lower-elevation sites in Utah (1440 m, 14 April; Sordahl 1981) or Oregon (1270 m, 24 April; Gibson 1971). However, peak and median nesting dates were relatively similar among studies, during the 2nd and 3rd weeks of May (Oregon, Gibson 1971; Utah, Sordahl 1996; San Luis Valley, Colorado, M. Laubhan, USGS, Northern Prairie Wildlife Research Center, personal communication; this study).

Annual variation in nesting phenology apparent for all species is related to those influences affecting nest site conditions. Canada Geese and Sandhill Cranes are usually the earliest of the waterbirds species, generally arriving while the land is still snow- and ice-covered and initiating nests as soon as snow disappears from nesting areas (Dimmick 1968, Bellrose 1980, Ball et al. 2003, this study). Influences of elevation for these early species therefore would be closely related to snowpack and rapidity of spring melt. Influence of snowpack is most apparent for Greater Sandhill Cranes, which seem to have the most consistent initiation dates across study areas, elevations, and years. Earliest nests occur between 10 and 20 April, and peak nesting occurs during the last week

of April to mid-May for cranes nesting in Minnesota (Dimatteo 1992, Provost et al. 1992), Oregon (Littlefield and Ryder 1968, Stern et al. 1987, Littlefield 2001), and Grays Lake (this study). The earliest reported initiation dates occurred at Malheur National Wildlife Refuge (10 April; Littlefield and Ryder 1968) and Sycam Marsh, Oregon (5 April; Stern et al. 1987); in these areas snow accumulations are much lower than at Grays Lake or Minnesota and therefore nest sites would become snow-free earlier.

Temperature and precipitation influences on nesting phenology for ducks in the Intermountain West are probably similar to those described for ducks nesting in the Prairie Pothole region (Cowardin et al. 1985, Klett et al. 1988). At Grays Lake the nesting season of Mallards was later and shorter during 1999 and 2000, when water conditions were markedly lower than in 1997 and 1998. Species such as the Cinnamon Teal, Gadwall, and American Coot rely largely on new vegetative growth for nesting cover and thus would be affected by spring temperatures, through influence on vegetative growth. Precipitation or water levels may also influence nesting indirectly through effects on vegetative cover and secure nesting sites. Sordahl (1996) reported that the nesting season of avocets in northern Utah was 2 weeks later in 1977 than in 1978, most likely a response to drought and low-water conditions. Peak nesting of avocets there was during June 1977, and from the last week of April through May 1978. In comparison, the main nesting period for avocets at Grays Lake was mid- to late May 1997 (wettest year) and early May 1998, despite cooler April–May temperatures and continued good water conditions.

Comparative Clutch Size

Clutch sizes for most species were within the range reported in Bellrose (1980) or the various Birds of North America (BNA) species accounts (Birds of North America, Inc., Philadelphia, PA). Clutch size of Eared Grebes in this study was higher than that reported for 2 areas in British Columbia (3.4 eggs, McAllister 1958; 3.1–3.3 eggs, Breault 1990) and the general average cited in the BNA account (3.0 eggs; Cullen et al. 1999). Although our sample size was small ($n = 23$), apparently large clutch size invites further investigation into nesting ecology and productivity of this species at Grays Lake. Clutch size of Canada Geese in

this study (4.7 eggs) was somewhat lower than that cited for Grays Lake during 1949–1951 (5.2 eggs; Steel et al. 1957) and for other studies of western Canada Geese (5.1–8.5 eggs; Krohn and Bizeau 1980). Overall mean clutch size of American Coots in this study (7.8 eggs) was similar to that of coots breeding at high altitudes (>2000 m) in Colorado (7.5 ± 2.2 eggs; Gorenzel et al. 1982) and fit the pattern suggested there that clutch size declines with altitude.

Nest Site Characteristics

Dabbling ducks and shorebirds were most commonly found in upland habitats, and many of their nests were initiated on unflooded sites. Although one-third of Mallard and Cinnamon Teal nests were located in hydrophytic vegetation, most were unflooded; only Gadwall nests were found in water >10 cm deep. Similar to our findings for nest sites of dabbling ducks, Steel (1952) reported that 76% of dabbling ducks nested in upland habitats and about half of the Mallard nests occurred in cattail-bulrush habitat (overwater nests). During that earlier period (1949–1951), however, most nests of Canada Geese were found in marsh habitat or on muskrat houses, and only 1 was recorded as a “field” nest (Steel et al. 1957). Differences in nest sites between these 2 studies are due in part to the greater search effort in the interior marsh by Steel et al. (1957). However, geese may have shifted to greater use of upland nest sites as availability of muskrat houses declined; since 1949–50, muskrat populations at Grays Lake have declined from 8000 (Williams 1950) to <3000 today (GLNWR unpublished data).

Comparison of Nest Success Rates

The apparent nest success rates for Canada Geese in our study were lower than those reported for other breeding areas for western Canada Geese historically (average of 72% for 10 studies in marsh habitat; Krohn and Bizeau 1980) as well as more recently (69%, Fish Springs, UT, Stolley et al. 1999; 87%, Cutler Marsh, UT, U.S. Geological Survey unpublished data). Rates were about half that reported by Steel et al. (1957) for Grays Lake during 1949–1951 (43% vs. 68%). However, our data were limited to lakeshore habitats and did not include the interior marsh, unlike data in Steel et al. (1957); nests at Fish Springs and Cutler Marsh

also were largely in cattail-bulrush marshes or otherwise isolated by water. Decline in nest success at Grays Lake probably also reflects changes in nest site availability and the predator community (Austin et al. 2002). With fewer muskrat houses available for nest sites, as noted above, geese may have shifted to greater use of areas that are dry or temporarily flooded in spring, where they are more vulnerable to mammalian predation. Ground nests of Canada Geese are vulnerable to mammalian predators and have lower nest success rates than those nesting on platforms (51% vs. 86%; Stolley et al. 1999). At Grays Lake upland nest sites often were isolated from contiguous mainland by shallow flooding during April, but in 1999 and 2000 low-water conditions during early spring exposed many goose nests to increased access by mammalian predators, and many depredated nests were found during the 1st nest searches in 2000. Actual rates of nest success probably were substantially lower in 2000 than recorded.

Apparent nest success rates for dabbling ducks at Grays Lake during this study are lower than those reported in other studies in the Intermountain West (28% vs. 40%–50%; Steel et al. 1956, Ryder 1961, Enright 1971, Jarvis and Harris 1971, Clark 1977, Thornton 1982, Gilbert et al. 1996). Equivalent or lower nest success in other studies was often reported for 1 year of multiyear studies (Spencer 1953, Ryder 1961, Jarvis and Harris 1971, Thornton 1982). Moreover, duck nest success at Grays Lake has declined from 68% during 1949–1951 (Steel et al. 1956) to 28% (our study). Part of the decline may be attributable to differences in habitats searched because the earlier study included many nests in cattail-bulrush (overwater) habitats. More direct comparisons are possible for Cinnamon Teal and Gadwall nesting in upland and lakeshore habitats that were searched both by Steel et al. (1956) and this study; our study found substantially lower rates of apparent nest success (Cinnamon Teal, 13% vs. 58%; Gadwall, 27% vs. 80%). We believe the decline in nest success of dabbling ducks primarily relates to changes in the predator community (Austin et al. 2002), most notably in the introduction of red fox (*Vulpes vulpes*). This predator was first sighted in the valley during 1970 and was commonly observed in lakeshore habitats during our study.

Annual rates of apparent nest success for Sandhill Cranes during 1997–2000 ranged

from 51% to 78%. These rates are lower than apparent nest success rates reported for Grays Lake for 1949–1951 (90%; Steel 1952), 1970–71 (78%; Drewien 1973), and 1977–1989, a period of intensive predator control (94%; Drewien and Bizeau 1990). Water-level management at Grays Lake has not changed over this time period, and spring water levels during 1969–70 (GLNWR unpublished data) were very similar to those during 1998 and 1999, suggesting flooding conditions were generally similar. We have no evidence of marked change in habitat conditions. We suspect changes in the predator community have also contributed to the decline in nest success for Sandhill Cranes.

Apparent nest success rate for avocets at Grays Lake was >2 times higher than that found in Cache County, Utah, during 1977–78 (81% vs. 34.8–36.4%; Sordahl 1996) and in the San Luis Valley, Colorado (69%), during 1995–96 (M. Laubhan personal communication). Sordahl (1996) attributed 57% of nest losses to predation of the nest and an additional 11% to depredation of the incubating adult; suspected predators were similar to those present at Grays Lake (red fox, striped skunk [*Mephitis mephitis*], long-tailed weasel [*Mustela frenata*], larids, and corvids). Results from Sordahl (1996) and our study indicate that sparse vegetation and island-like conditions (i.e., isolation from contiguous upland by water) would provide the best habitat conditions for successful avocet nesting. Interestingly, we had higher nest densities in the experimental units during 1997–98, when all units were idled, and few or no nests in grazed or burned units even though the shorter vegetation conditions should have been more attractive in 1999–2000, after 9 of the 12 units were burned or grazed. This suggests water conditions are a key factor in attracting nesting avocets.

Regional Role of Grays Lake for Waterbird Production

Lakeshore habitats of GLNWR provide valuable habitat for nesting waterbirds in the northern Rocky Mountains, particularly for Canada Geese, ducks, Sandhill Cranes, and coots. In some years, these habitats also support substantial numbers of nesting avocets. Grays Lake is considered a significant breeding area for Canada Geese (Krohn and Bizeau 1980), Sandhill Cranes (Drewien and Bizeau 1974), and ducks (Steel et al. 1956). The value

of Grays Lake and its lakeshore habitats for other waterbirds is difficult to assess because comparable information for other breeding areas in the central Rocky Mountains is sparse. Moreover, within Grays Lake we have little good information about nesting in the interior marsh and no information on actual recruitment for any species other than Sandhill Cranes (Drewien 1973, Ball et al. 2003).

Relatively low abundance of nests and low to moderate nest success of Canada Geese and dabbling ducks suggest the lakeshore habitats at Grays Lake are not highly productive for waterfowl. Waterfowl production at Grays Lake may be sustained in part by higher success of overwater nests in the interior marsh, but only geese, Mallards, and diving ducks commonly nest in the interior marsh (M. Fisher, U.S. Fish and Wildlife Service, GLNWR, personal communication). We attribute the low abundance and nest success of dabbling duck nests in lakeshore habitats largely to the poor quality of nesting cover available in spring, which reduces the attractiveness of the areas to nesting females and the concealment of early nests from predators. Most graminoid vegetation in the lakeshore habitats is not robust enough to withstand the pressures of the heavy annual snowpack. By spring most residual vegetation is compacted into a dense, damp mat underlain by ice into which early-nesting birds would have to burrow to establish overhead cover at a nest site; only bulrush and cattail retain some standing cover. C. Mitchell (U.S. Fish and Wildlife Service, GLNWR, personal communication) reported similar conditions of nesting cover and similar low levels of nest abundance of upland-nesting ducks at Red Rocks NWR, a large, montane wetland system in southwest Montana. Moreover, structure of residual vegetation in fields that had been idled 3–7 years appears quite similar to that in fields that had been grazed or burned the previous year (personal observations), suggesting idling would yield little improvement for nesting ducks. Because grasslands and meadows around montane wetlands like Grays Lake and Red Rocks NWR in the northern Rocky Mountains often do not support an abundance of robust native grasses, attractiveness and productivity of upland and wet meadow habitats around montane wetlands for ducks may be limited until late spring, when new vegetation provides sufficient cover.

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