United States Department of Agriculture

Soil Conservation Service

517 Gold Avenue SW
Room 3301
Albuquerque, NM 87102

December 15, 1992

BIOLOGY TECHNICAL NOTE NO. NM-42

SUBJECT: "Ecology of Montane Wetlands" and "Ecology of Playa Lakes"

Purpose. To distribute current information on the ecology of montane and playa lake wetlands.

Effective Date. Effective when received.

Distribution is being made on two (2) Fish and Wildlife leaflets, #13.3.6, Ecology of Montane Wetlands, and 13.3.7, Ecology of Playa Lakes. This information will be useful for FSA wetland decisions and conservation planning. The information will also me useful in promoting the values of wetlands for the Chiefs Wetland Alliance Marketing Initiative.

Filing Instruction. File in the Biology Technical Note binder.

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13.3.6. Ecology of Montane Wetlands

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Most waterfowl managers envision typical waterfowl habitat as the undulating or flat terrain characteristic of the prairie pothole region of the north-central United States or the aspen parklands of Canada. However, several other habitats in North America provide valuable resources for breeding and migrating waterfowl. Among these is the Rocky Mountain region of the western United States, which stretches in a band 100–500 miles (160–800 km) wide and 1,240 miles (1,984 km) long from south-central New Mexico to northern Montana (Figure).

Some Rocky Mountain wetland complexes contain waterfowl breeding densities that equal or exceed those of prairie breeding habitat, and also serve as important staging, migratory, and wintering areas. To aid waterfowl management endeavors in this region, this leaflet summarizes aspects of wetland ecology and waterfowl biology in montane habitats. Although emphasis is placed on the Rocky Mountain region, many of the wetland characteristics and waterfowl relationships in this area are similar or identical to those found in other montane regions of the United States.

Comparisons with Prairie Wetlands

As in other regions, waterfowl that breed in montane habitats require suitable upland nesting areas coupled with a diverse wetland community, from which they obtain aquatic invertebrates, plant foods, and isolation from territorial birds of the same species. These wetland complexes also attract spring and fall migrants and, in some instances, wintering waterfowl.

Montane waterfowl habitats have several attributes that set them apart from their grassland counterparts. First, montane wetland communities are relatively intact compared with the widespread wetland degradation typical of the northern Great Plains. This more nearly pristine condition reflects the rugged topography and generally poor soils of the region, which favor ranching, timber harvest, and mining rather than farming. Additionally, some areas are afforded legal protection as wilderness areas or research natural areas. Second, except where locally affected by mining operations and ski areas, for example, upland plant communities are still dominated by native plant species despite some grazing and timber harvest. Third, although the magnitude of the snowpack and rainfall varies annually, precipitation is almost always sufficient to provide adequate spring water for ducks and geese. Thus, montane wetlands are relatively stable compared with those in the prairie states.

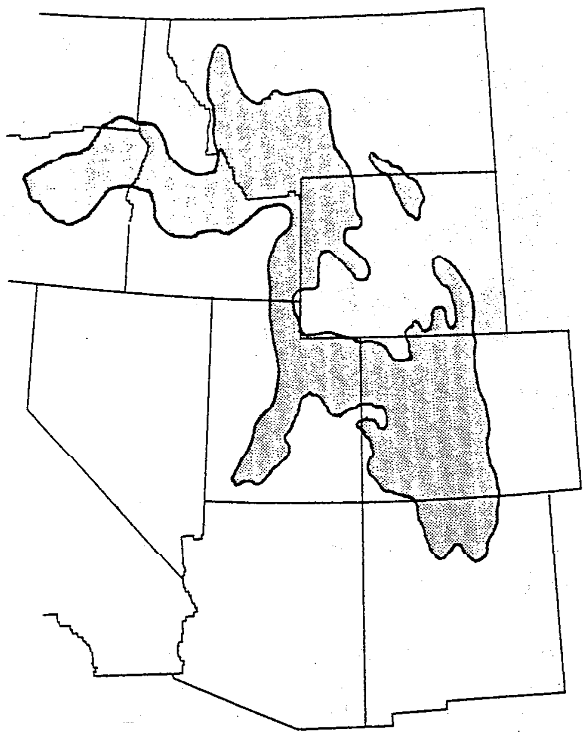

Figure. Distribution of montane wetlands (*shading*) in the Rocky Mountain region of western United States.

The geology and topography of montane regions create a greater diversity of wetland types than may be found in the prairies. Rocks weather slowly, and annual primary production decreases with elevation, so wetland succession proceeds much more slowly in montane wetlands than in low-elevation ponds. Elevational gradients interacting with precipitation patterns and growing season affect soil type, nutrient cycling, water chemistry, and associated plant and animal communities. Most high-elevation wetlands are slightly acidic to circumneutral and contain relatively small amounts of dissolved nutrients compared with typical prairie wetlands. Accordingly, only some types of montane wetlands are frequented by waterfowl, unlike their wide use of most prairie ponds. Recognition of the wetland types inhabited by waterfowl and an understanding of basic wetland function is therefore important to the success of any waterfowl management initiative in montane habitats.

Montane Wetlands Important to Waterfowl

Intermountain Basin Wetlands

The intermountain basins or "parks" of the western United States contain the most important habitats for montane waterfowl. The flat or rolling topography typical of mountain parks, which originated from tectonic and volcanic events during the formation of mountain ranges, is underlain by deep layers of alluvial material eroded from the surrounding mountains and transported to nearby basins by wind and water. Although relatively few in number—33 parks have been identified in the Rocky Mountain region—intermountain basins are often several hundred square miles in area. Many parks are considered cool deserts because of the low precipitation created by the rain shadow from surrounding mountains. The average frost-free period may be less than 2 months. Despite low seasonal temperatures, ratios of precipitation to evaporation are usually less than 1, causing the development of pedocal soils. Where alkali deposits occur in poorly drained areas, salt-tolerant plants such as black greasewood and saltgrasses are common. Less saline areas typically contain wheatgrasses, bluegrasses, sedges and rushes, or shrubs such as sagebrush and rabbitbrush. Ranching and hay cultivation are the most common land uses, but some grain crops and cold-weather vegetables are grown in more temperate parks.

Many intermountain basins contain few wetlands; some, such as the 5,000-square-mile (12,950-km^2) San Luis Valley in south-central Colorado, possess abundant wetlands. Wetlands are formed by spring runoff, which creates sheet water and recharges the persistently high water tables, and by artesian flows and impoundments. Lakes and reservoirs provide important migratory staging and molting habitats, and lake margins attract breeding waterfowl. Rivers and old oxbows are also frequented by waterfowl. Dissolved nutrients and high amounts of organic matter create some wetlands that rival prairie potholes in their fertility. High densities of aquatic invertebrates such as freshwater shrimp and the larvae of dragonflies, midges, flies, and mosquitos are common in intermountain basin wetlands.

Beaver Ponds

Beaver ponds most commonly occur in mid-elevation, montane valleys where slope is less than 15%. Because beaver ponds are often clustered in flowages along suitable lengths of streams and rivers, they provide a valuable wetland community well suited to the needs of breeding waterfowl. Densities of 3 to 6 ponds per mile (5–10 ponds per kilometer) of stream are common, increasing to as many as 26 ponds per mile (42 ponds per kilometer) in excellent habitat with high beaver populations. Wetlands created by beaver possess relatively stable water levels maintained by precipitation and runoff. However, beaver flowages themselves may be somewhat ephemeral in nature, and usually are abandoned within 10–30 years, after beaver deplete their food resources. Floods sometimes destroy beaver dams that are constructed in narrow valleys or on major streams or rivers.

Beaver ponds act as nutrient sinks by trapping sediments and organic matter that otherwise would be carried downstream. This function enhances wetland fertility and the plant and aquatic invertebrate communities exploited by waterfowl. Invertebrates typical of running water systems are replaced by pond organisms such as snails, freshwater shrimp, and the larvae and immature stages of caddisflies, dragonflies, flies, and mosquitos. Structural cover provided by flooded willows, alders, sedges, burreeds, and other emergents affords ideal habitat for waterfowl breeding pairs and broods.

Glacial Ponds

Glacial ponds include (1) small wetlands formed behind lateral and terminal moraines, and (2) kettle ponds created by the same glacial process that found the prairie potholes—large chunks of ice embedded in glacial outwash melt after a glacier retreats, forming depressions that later fill with water. Glacial wetlands most commonly occur in mountainous terrain. Often, these ponds are dependent solely on spring runoff and summer precipitation for water. Therefore, water levels recede during summer, while density and abundance of herbaceous, emergent vegetation increases. Despite dynamic water level fluctuation, natural succession is slow; peat accumulations indicate that some glacial ponds have persisted as wetlands for more than 7,000 years.

Northern mannagrass, sedges, and reedgrasses are common emergent plants in glacial ponds, as are submersed species such as pondweeds, watermilfoils, and cowlilies. Glacial ponds are often surrounded by forested uplands and rocky moraines. These physical features and the relatively small size of glacial ponds may restrict the types of waterfowl using them to dabbling duck species that can take off in confined areas. The shallow water depths typical of kettle ponds often are unsuitable for sustaining fish populations, which might otherwise compete with waterfowl for aquatic invertebrate foods. The absence of fish and the abundant underwater substrate provided by herbaceous vegetation promote a rich invertebrate fauna dominated by larvae or immature stages of caddisflies, dragonflies, beetles, and mosquitos.

Ecological Relations

Elevational changes result in ecosystem regions or life zones characterized by differences in precipitation, humidity, temperature, growing season, wind, exposure, and soil conditions. The four life zones recognized in the Rocky Mountain region—Lower Montane, Upper Montane, Subalpine, and Alpine—possess unique flora and fauna. Only the wetlands found in the first three zones are used extensively by waterfowl. Alpine wetlands receive occasional use by migrating and postbreeding waterfowl, but the duration of the ice-free period and growing season is too brief to enable waterfowl to breed.

Montane habitats separated by relatively small distances often vary markedly in annual precipitation. Much of this variation is attributable to altitude and slope. Western slopes usually receive more snowfall than eastern slopes or areas in the rain shadow of surrounding mountains. For example, portions of the San Luis Valley in south-central Colorado (8,200 feet or 2,500 m elevation) receive less than 7 inches (18 cm) of moisture per year, whereas the nearby western slopes of the San Juan Mountains at the same elevation receive over 40 inches (102 cm) per year. Accordingly, west- and north-facing slopes usually support different plant communities than southern and eastern slopes.

Snowmelt begins in late April and May in Lower and Upper Montane zones but occurs 3 to 4 weeks later in Subalpine areas. The shade provided by a forest canopy further delays snowmelt, thus providing wetlands in forested areas a more constant supply of water. However, the flora and fauna in such wetlands may develop more slowly than in ponds in open terrain. This delayed development is a result of the constant supply of cold snowmelt water, as well as shading from the forest canopy, which reduces sunlight penetration.

The effects of precipitation patterns and snowmelt on floristic and faunal development have important implications for breeding waterfowl. In prairie habitats, breeding waterfowl often use wetlands of different water permanencies to optimize their exploitation of aquatic invertebrates. Temporary prairie wetlands are heavily used in early spring because their invertebrate faunas develop quickly in the warm, shallow water. More permanent wetlands, in which development of invertebrates is delayed, receive increasing use in the spring and summer. In montane habitats, however, this temporal pattern of use in relation to water permanency is superimposed on a spatial component that includes exposure and time of runoff. Small, shallow snowmelt ponds, which are the counterparts of temporary ponds in the prairies, usually lack invertebrate faunas of value to waterfowl. Instead, the shallow margins of permanent wetlands are the areas in which the invertebrate fauna is richest in early spring.

The timing of snowmelt runoff is also critical to understanding waterfowl exploitation of montane habitats. Many species (e.g., mallards and green-winged teal) begin nesting long before runoff begins to fill wetlands in most intermountain basins. The early application of water in such areas by pumping or by releasing water from reservoirs is vital in providing habitat to attract and hold breeding pairs and for promoting development of aquatic invertebrates needed by prelaying female ducks. At higher elevations, where natural kettle ponds, lakes, and beaver flowages have retained water through winter into early spring, runoff often increases water levels through late spring and into early summer, increasing the amount of wetland habitat through the middle of the nesting period.

Nutrient availability is important in regulating wetland primary productivity, which in turn affects periphyton, invertebrate, and waterfowl abundance. Surface runoff is far more important than groundwater flow or direct precipitation in determining water level dynamics and nutrient input to montane wetlands. Thin, coarse soils on granite bedrock tend to be acidic and low in nutrients, whereas soils near limestone and shale outcroppings are more finely textured, higher in nutrients, and buffered by calcium carbonate. Wetlands fed by runoff from the latter soils tend to receive higher nutrient loads from runoff, and therefore have higher productivity than wetlands associated with granitic soils. Some common wetland plants such as alders and rushes host nitrogen-fixing bacteria that incorporate atmospheric nitrogen into wetlands, providing a supplemental source of nutrients. Waterfowl and beaver are the primary animal groups to import nutrients to montane wetlands, although defecation by large herbivores such as moose, elk, mule deer, bighorn sheep, cattle, and domestic sheep may also be important.

Waterfowl Resources

Waterfowl populations in montane habitats have not been well studied. Most research has been conducted at mid-latitude habitats between 7,000 and 10,000 feet (2,100–3,000 m) elevation. Despite the relatively harsh climate and infertility of montane wetlands, waterfowl are surprisingly abundant in these areas. Generally, peak waterfowl populations occur during spring and fall migration periods, particularly in intermountain basins. As prairie-nesting species migrate northward in spring, resident birds establish territories in preparation for breeding. In beaver pond and glacial wetland habitats, numbers of waterfowl decline as females proceed with incubation and males seek larger wetlands during the time of molting. Often, a molt migration occurs from higher elevation forested habitats to large lakes and reservoirs in intermountain basins. During fall, postfledging young birds also move toward lower-elevation staging areas in mountain parks. Most mid-latitude montane wetlands freeze during October, greatly reducing the amount of available wetland habitat. Some wetland areas, however, such as the San Luis Valley of south-central Colorado, retain open water reaches as a result of warmer flows from springs and artesian wells. Major river systems also afford winter habitat, particularly if cereal grain crops or other foods are located nearby.

Species composition of the waterfowl community varies seasonally and in relation to habitat type (Table 1). Mallards and green-winged teal are usually the most common nesting species in both intermountain parks and higher-elevation

Table 1. *Relative species abundance in different montane wetlands during spring and fall migration (M or m), breeding (B or b), and wintering (W or w) periods. Uppercase letters denote greater relative abundance than lowercase letters.*

Species	Montane wetland type: Intermountain basin	Beaver pond	Glacial wetland
American wigeon	M,B	b	b
Barrow's goldeneye	m	m,b	m,b
Blue-winged teal	m,b	—	—
Bufflehead	m,b	m,b	m,b
Canada goose	M,B,w	b	—
Cinnamon teal	m,B	—	—
Common merganser	m	m,b	m,b
Gadwall	M,B	b	b
Green-winged teal	M,B,w	m,B	m,b
Lesser scaup	M,B	—	—
Mallard	M,B,w	m,B	m,B
Northern pintail	M,B,w	—	—
Northern shoveler	M,B	—	—
Redhead	M,B	—	—
Ring-necked duck	m,b	M,B	M,B
Ruddy duck	m,b	—	—
Trumpeter swan	b[a]	—	—

[a] Primarily riverine habitats.

Montane and Subalpine zones. Gadwalls, northern pintails, American wigeon, cinnamon teal, northern shovelers, redheads, lesser scaup, and Canada geese are other common breeders in intermountain basins. Trumpeter swans are important year-round residents in the northern Rockies. In beaver and glacial ponds of the Upper Montane and Subalpine zones, ring-necked ducks, Barrow's goldeneyes, buffleheads, and gadwalls are common. The peak of nest initiation for early-nesting ducks (mallards and green-winged teal) varies from early May to early June, depending on snow conditions and wetland availability. Late-nesting species such as ring-necked ducks begin nesting nearly a month later than early-nesting species.

Breeding densities vary greatly among montane habitats (Table 2), largely as a function of wetland density and availability of open water to attract and hold spring migrants. Wetlands larger than 1 acre (0.405 ha) receive most of the use by breeding ducks, although much smaller wetlands are also frequented. Considerably larger wetlands are needed to attract molting birds and fall migrants. Some intensively managed habitats achieve remarkably high breeding densities. For example, the 22-square-mile (57-km^2) Monte Vista National Wildlife Refuge in the San Luis Valley of Colorado averaged 277 duck nests per square mile (107 duck nests per square kilometer) during a 27-year period, and some individual wetland units exceeded 3,000 nests per square mile (1,158 nests

Table 2. *Waterfowl breeding pair densities in montane habitats. Habitat type denotes either forested montane (FM) or intermountain basin (IB) study sites.*

Density: pairs/mi^2	Density: pairs/km^2	Area sampled: mi^2	Area sampled: km^2	Elevation: feet	Elevation: m	Location (habitat type)
1.6	0.62	36	93.2	7,500-10,000	2,285-3,047	Uinta Mountains, Utah (FM)
1.6	0.62	18	46.6	9,000-10,000	2,742-3,047	White River Plateau, Colo. (FM)
4.1	1.58	685	1,774.0	8,000-10,000	2,437-3,047	San Juan Mountains, Colo. (FM)
21.8	8.42	7	18.1	8,500-9,500	2,590-2,894	Park Range, Colo. (FM)
0.5	0.19	900	2,331.0	8,400-9,900	2,559-3,016	South Park, Colo. (IB)
5.2	2.01	5,000	12,950.0	7,400-8,000	2,255-2,437	San Luis Valley, Colo. (IB)
27.2	10.50	598	1,549.0	8,000-9,000	2,437-3,047	North Park, Colo. (IB)

per square kilometer) in some years. This compares favorably to nesting densities in the best prairie habitat, where, except in island nesting situations, 400–700 duck nests per square mile (150–270 duck nests per square kilometer) are typical. Moreover, nest success averaged 50%, a rate about four times as high as that in much of the northern Great Plains. The unfragmented habitat and balanced predator communities typical of many montane areas undoubtedly contribute to these high nest success rates. The combination of high nest success and potentially high breeding densities underscores the pronounced management potential of some montane habitats.

Waterfowl Habitat Management

Most waterfowl habitat management is directed at correcting problems caused by humans. Montane wetlands management is no exception, although the causes of habitat deficiencies are often different than those found in prairie habitats. In Upper Montane and Subalpine zones, logging activities may cause disturbance, reduce the amount of available nesting cover surrounding wetlands, and cause erosion and sediment deposition in ponds. Reseeding and stabilizing uplands may be necessary to promote the timely regrowth of grasses and forbs. Disturbance from recreationists can also become a problem in popular areas, and seasonal restrictions on activities in buffer zones surrounding wetlands may be necessary. Grazing by domestic livestock and native ungulates can have locally severe effects on riparian vegetation and surrounding uplands. Eliminating grazing, reducing stocking rates, and fencing portions of wetlands can reverse the habitat degradation. Mining activities often physically alter or destroy wetlands, and can create acid runoff that drastically alters water chemistry and devastates invertebrate communities. Reclamation of wetlands despoiled by mining activities, although technically possible, is often difficult and costly. Beaver, which create beneficial wetland habitat, can also become a nuisance if populations grow beyond carrying capacity and begin to degrade streamside vegetation. Control by trapping or transplanting may be warranted in such instances. Agricultural practices have affected plant communities and wetland abundance in several intermountain basins, as they have in the prairie states. In these instances, the conventional waterfowl management practices developed in the prairies can be successfully employed to improve waterfowl habitat.

Some human activities have caused irreversible damage to waterfowl habitat. Among these are residential developments along riparian corridors, and dams and water diversions that have either flooded former shallow wetland habitat or dewatered once productive wetlands. Fortunately, however, many montane habitats, particularly those in the Upper Montane and Subalpine zones, have been insulated sufficiently from human activities that no management activities are warranted. In these pristine habitats, actions are best directed toward habitat preservation rather than improvement. By conducting a biological reconnaissance of waterfowl populations and identifying limiting factors before initiating management actions, managers can avoid trying to fix something that isn't broken.

Selected Reading

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Appendix. Common and Scientific Names of Plants and Animals Named in Text.

Birds	
Northern pintail	*Anas acuta*
American wigeon	*Anas americana*
Northern shoveler	*Anas clypeata*
Green-winged teal	*Anas crecca*
Cinnamon teal	*Anas cyanoptera*
Blue-winged teal	*Anas discors*
Mallard	*Anas platyrhynchos*
Gadwall	*Anas strepera*
Lesser scaup	*Aythya affinis*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Canada goose	*Branta canadensis*
Bufflehead	*Bucephala albeola*
Barrow's goldeneye	*Bucephala islandica*
Trumpeter swan	*Cygnus buccinator*
Ruddy duck	*Oxyura jamaicensis*
Mammals	
Moose	*Alces alces*
Beaver	*Castor canadensis*
Elk	*Cervus elaphus*
Mule deer	*Odocoileus hemionus*
Bighorn sheep	*Ovis canadensis*
Invertebrates (orders)	
Freshwater shrimp	Decapoda
Beetles	Coleoptera
Flies	Diptera
Midges	Diptera
Mosquitos	Diptera
Dragonflies	Odonata
Caddisflies	Trichoptera
Plants	
Wheatgrass	*Agropyron* spp.
Alder	*Alnus* spp.
Sagebrush	*Artemisia* spp.
Sedge	*Carex* spp.
Rabbitbrush	*Chrysothamnus* spp.
Saltgrass	*Distichlis* spp.
Northern mannagrass	*Glyceria borealis*
Rush	*Juncus* spp.
Watermilfoil	*Myriophyllum* spp.
Cowlily	*Nuphar* spp.
Pondweed	*Potamogeton* spp.
Bluegrass	*Poa* spp.
Willow	*Salix* spp.
Greasewood	*Sarcobatus vermiculatus*
Burreed	*Sparganium* spp.

Note: Use of trade names does not imply U.S. Government endorsement of commercial products.

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Fish and Wildlife Leaflet 13
Washington, D.C. • 1992

13.3.7. Ecology of Playa Lakes

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Between 25,000 and 30,000 playa lakes are in the playa lakes region of the southern high plains (Fig. 1). Most playas are in west Texas (about 20,000), and fewer, in New Mexico, Oklahoma, Kansas, and Colorado. The playa lakes region is one of the most intensively cultivated areas of North America. Dominant crops range from cotton in southern areas to cereal grains in the north. Therefore, most of the native short-grass prairie is gone, replaced by crops and, recently, grasses of the Conservation Reserve Program. Playas are the predominant wetlands and major wildlife habitat of the region.

More than 115 bird species, including 20 species of waterfowl, and 10 mammal species have been documented in playas. Waterfowl nest in the area, producing up to 250,000 ducklings in wetter years. Dominant breeding and nesting species are mallards and blue-winged teals. During the very protracted breeding season, birds hatch from April through August. Several million shorebirds and waterfowl migrate through the area each spring and fall. More than 400,000 sandhill cranes migrate through and winter in the region, concentrating primarily on the larger saline lakes in the southern portion of the playa lakes region.

The primary importance of the playa lakes region to waterfowl is as a wintering area. Wintering waterfowl populations in the playa lakes region range from 1 to 3 million birds, depending on fall precipitation patterns that determine the number of flooded playas. The most common wintering ducks are mallards, northern pintails, green-winged teals, and American wigeons. About 500,000 Canada geese and 100,000 lesser snow geese winter in the playa lakes region, and numbers of geese have increased annually since the early 1980's. This chapter describes the physiography and ecology of playa lakes and their attributes that benefit waterfowl.

Origin, Physiography, and Climate

Playas are shallow (generally less than 1 m deep), circular basins averaging 6.3 ha in surface

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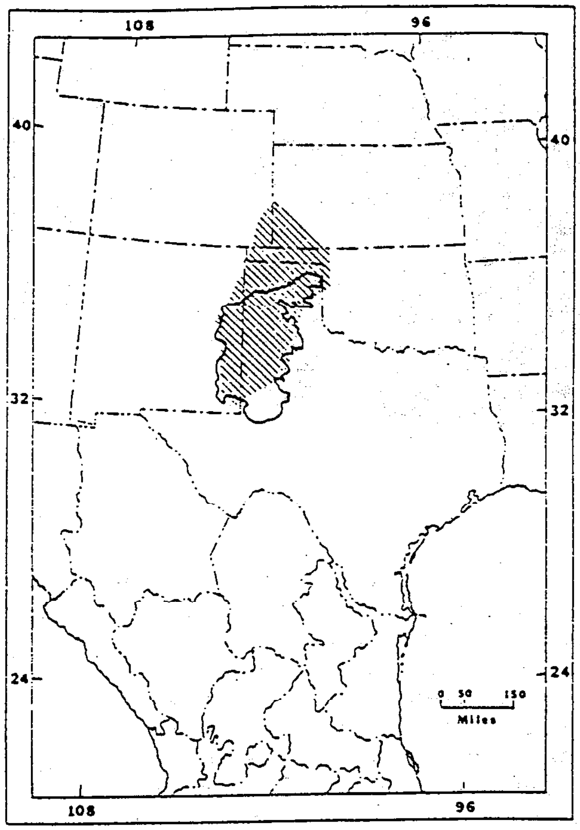

Fig. 1. The playa lakes region of the southern great plains (*hatched* area); most playas are on the southern high plains (*outlined* area).

area; 87% are smaller than 12 ha. Watershed size averages 55.5 ha and ranges from 0.8 to 267 ha. Where it is high (central Texas panhandle), the density of playas is 0.4/km^2. Playas provide more than 160,000 ha of wetland habitat.

Several theories have been proposed for the formation of playas. The most recent theory proposes that playa basins form and expand as a result of hydrologic and geomorphic processes when water collects in depressions on the prairie. As the ponded water percolates into the subsoil, carbonic acid forms from the oxidation of organic material. The acid dissolves the underlying carbonate material (caliche). Loss of caliche leads to enhanced permeability of surface water that increases downward transport of solutes, particulate rock, and organic matter and expands the basin in a circular fashion from a central point. Land subsides from loss of caliche and the basin deepens.

Theoretically, a playa can form whenever a depression develops on the prairie. A few lakes are documented as having formed from depressions created during highway construction in the 1940's. Potentially, existing playas can continually expand. Decaying vegetation provides a constant source of organic matter. However, the maximum size of a playa is limited by the size of its watershed, which determines the amount of runoff into the basin.

Playas are the primary recharge areas for the Ogallala aquifer of the southern high plains. Groundwater recharge is primarily along edges of playas. Infiltration in the center of the playa is limited because of pore filling when clays and organic matter percolate downward during basin formation. Historically, people assumed that water in playas was lost only by evaporation and transpiration. Although evaporation and transpiration are still considered a major loss of water in playas, the lack of increasing salt content in the water and soil of playas during declining water levels indicates some water loss from percolation.

Unlike most wetlands, floors of playas are not rounded, but plate-like (Fig. 2). As a result, water depth is relatively constant throughout much of the basin. Soils of the playa floor are predominantly clays, differing from the loams and sandy loams of the surrounding uplands. Therefore, locations of playas are easily recognized from soil maps.

The climate of the playa lakes region is semi-arid in the west to warm temperate in the east. In the Texas panhandle, mean temperature ranges from 1 to 3° C during winter and from 25 to 28° C in summer. Precipitation is mainly from localized thunderstorms during May and June and again during September and October. Precipitation averages 33 to 45 cm and is lowest in the southwest and highest in the northeast of the region. However, the entire region is rarely subject to average precipitation. Usually, rainfall is well above or below average and dependent on location. Average annual evaporation is 200–250 cm.

Because very few are directly associated with groundwater, playas can fill from only precipitation

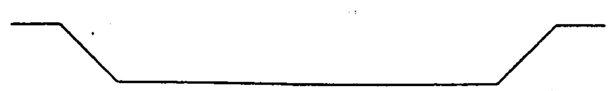

Fig. 2. A typical plate-like floor of a playa lake.

and irrigation runoff. Most playas are dry during one or more periods of each year, usually late winter, early spring, and late summer. Several wet-dry cycles during one year are not uncommon for a playa and depend on precipitation and irrigation patterns.

Importance of Playa Lakes to Crop Irrigation

Most playas (>70%) greater than 4 ha were modified for inclusion in crop irrigation systems. A pit or ditch was dug in these playas to concentrate and recirculate onto surrounding cropland any water collected in playas from precipitation and irrigation runoff. Using water from playas to irrigate crops is less expensive than pumping aquifer water. Furthermore, water from playas for irrigation reduces demand on the Ogallala aquifer. Therefore, many landowners depend on the water in their playas to maintain profitable farming.

Extensive irrigation of crops in the playa lakes region since the mid-1940's has resulted in a net loss of water from the aquifer. Consequently, dominance of dryland agriculture is predicted in the area by the early 21st century. High water-use plants, such as corn, may be grown less frequently in the playa lakes region. Because corn is an important food for wintering waterfowl, increases in another crop (e.g., grain sorghum) or native food plants will have to compensate for its loss.

Playa Lake Vegetation

Establishment of vegetation depends on the existing moisture regime of the playa when other environmental conditions are suitable (i.e., temperature, photoperiod). Vegetation in dry playas resembles upland vegetation and includes species such as summer cypress, ragweed, and various prairie grasses. Moist and flooded conditions in playas favor vegetation representative of other North American wetlands; barnyard grass, smartweeds, bulrush, cattail, spikerush, arrowhead, toothcup, and dock.

Specifically, 14 physiognomic types of vegetation by moisture regime (frequency and longevity of flooding) and crop irrigation or other physical disturbance (grazing, cultivation, irrigation modifications) were identified in playas. The two most common types are broad-leaved emergent and wet meadow, which are dominated in varying proportions by willow and pink smartweed and barnyard grass.

Unlike most other North American wetlands, playa lakes are dominated by annuals. This is a response to the unpredictable, rapidly changing moisture regime in a playa during the growing season. Water loss from percolation, evaporation, transpiration, and irrigation and runoff from rainfall and irrigation can alter the moisture regime of a playa daily. Annual species are capable of responding to changing moisture regimes by rapidly germinating, maturing, and setting seed. Furthermore, the lack of a depth gradient throughout playas, combined with the dominance by annuals, limits the development of concentric bands of monotypic vegetation characteristic of northern glacial wetlands.

Native vegetation in playas is important to wintering waterfowl. The cover of native vegetation reduces stress during harsh winter conditions, and seeds of native species provide forage. Recent studies revealed ducks prefer seeds from native vegetation over agricultural grains. Seeds preferred by waterfowl wintering in the playa lakes region are from plants such as barnyard grass, smartweeds, and dock that germinate in moist-soil conditions (mudflats; saturated, exposed soil).

Recent research revealed that survival of wintering ducks in playas is higher and body condition is better during wet years (above-average rainfall) than during dry years (below-average rainfall). This is so because during wet years the abundance of preferred native food and cover (e.g., smartweeds and barnyard grass) is greater and readily available without energy expenditure for flights to agricultural fields. Therefore, management of playas should emulate conditions that favor development of vegetation communities (broad-leaved emergent and wet meadow) in playas during wet years.

Invertebrates in Playas

The influence of invertebrates on waterfowl use of playas is poorly understood. However, invertebrates are always in the diet of ducks in playas. Although playas have a wide variety of invertebrates (Table 1), life histories of most species are unknown. Invertebrate diversity is influenced by time and space. The composition of invertebrate communities changes profoundly, as yet unpredictably, as a function of the length of

Table 1. *Orders and families of insects in playa lakes.*

Order	Families
Ephemeroptera	Baetidae, Caenidae
Odonata	Gomphidae, Aeshnidae, Libellulidae, Coenagrionidae, Lestidae
Orthoptera	Tetrigidae, Tridactylidae
Hemiptera	Belostomatidae, Corixidae, Gelastocoridaeridae, Notonectidae, Mesoveliidae, Hebridae, Veliidae, Gerridae, Saldidae
Trichoptera	Leptoceridae
Coleoptera	Dytiscidae, Gyrinidae, Hydrophilidae, Heteroceridae, Curculionidae, Carabidae, Haliplidae
Diptera	Tipulidae, Culicidae, Ceratopogonidae, Chironomidae, Tabanidae, Stratiomyidae, Ephydridae

time a playa is flooded. Additionally, invertebrate community structure seems to be playa-specific (R. W. Sites, University of Missouri, Columbia, personal communication). Such changes in invertebrate structure may influence future management of playas because certain communities of invertebrates may be more desirable than others for waterfowl.

Diseases of Waterfowl in Playas

Disease is a major source of nonhunting mortality of waterfowl wintering in the playa lakes region. During any year, avian cholera and botulism can kill thousands of waterfowl in playas. Avian cholera was first documented in North America in the playa lakes region. With high densities of waterfowl concentrations on small quantities of water, such as during drought, the potential exists for major dieoffs of waterfowl. However, currently, location and timing of disease outbreaks in the playa lakes region cannot be predicted.

Management of Playas for Waterfowl

Almost all playas are in private ownership (>99%) and, therefore, the key to long-term management of these wetlands rests on incentives for private landowners. Because playas are not interconnected by courses of surface water, each playa lake and its watershed are an independent system and should be managed as such. We tested and confirmed the usefulness of management of playas that focuses on producing forage (seeds) and on increasing cover for wintering ducks.

Vegetation in playas has adapted to unpredictable wet–dry cycles. Indeed, a playa is most productive when its moisture regime fluctuates from dry to wet a few times during the growing season. Therefore, managing playas by stabilizing water levels results in less than maximum production of vegetation.

Because of the unpredictability of rainfall in the playa lakes region, all management plans for wintering waterfowl include options for flooding playas during winter. This aspect cannot be overemphasized; the cost of management must incorporate the expense of maintaining a flooded playa to satisfy management objectives (e.g., hunting season, migratory periods, wintering populations). Whether a playa will receive enough runoff from fall rains to be flooded when necessary cannot be predicted and managers must be prepared to pump water from other sources (e.g., aquifer, irrigation pit) to maintain water in a playa during desired periods of the year.

During construction of irrigation pits, landowners can terrace one or more sides of the excavation in a stair-step manner, which allows a littoral zone to be present at all times during fluctuations of water levels. These artificial littoral zones produce more vegetation, seeds, and invertebrates than standard steep-sided irrigation pits. Although it is a successful approach to using previously unproductive pit areas, such management has several drawbacks.

Usually, landowners already constructed all the pits that they want and very few playas remain in which pits can be built. Managing pits only affects a small amount of habitat, generally less than 1 ha. Longevity of the terraces and the cost of long-term maintenance are unknown. Furthermore, given the current permit requirements on modification of wetlands, such construction may not be approved.

Moist-soil management, common in other reas, has proved successful in playas. Moist-soil management involves drawdown or irrigation of wetlands for creation of saturated, exposed soil to promote germination and growth of mudflat species. In playas, prominent mudflat species are smartweeds and barnyard grass. Specific drawdown and irrigation schedules promote mudflat vegetation communities that are typical of playas during wet years (Table 2).

The cost of moist-soil management is less than 10% of the cost of winter flooding alone. However, playas that are managed for production of native foods can carry 10–20 times more ducks than playas managed for winter flooding. Therefore, landowners who flood their playas for wintering ducks should manage their lake for moist-soil vegetation during the growing season to receive a better return on their investment.

Moist-soil management favors establishment of smartweeds and barnyard grass, which are preferred for their greater total seed production and better nutritional characteristics than other species in playas (Tables 3 and 4). Because these species are in most playas, about 15,000 playas are vailable for moist-soil management. The increase ı native food and cover from moist-soil management should increase the number of wintering ducks leaving the playa lakes region.

Moist-soil management allows landowners to continue using water collected in playas for irrigation of crops because recommended periods of creating moist-soil conditions correspond with irrigation schedules. Therefore, landowners can create moist-soil conditions in their playas by drawing down a flooded playa and irrigating crops or directing irrigation runoff into specific areas of a dry playa. By allowing the farmer to continue the use of water collected in playas for irrigation during the growing season, moist-soil management is made simple and more cooperation from landowners can be expected.

When vegetation is established from moist-soil management, managers have several options to achieve a variety of management goals. Migratory ducks could be supported by flooding managed playas during fall and late winter. A wintering population of ducks can be maintained by managing a complex of playas and implementing a flooding schedule to ensure a constant supply of native food. Depth and timing of flooding will influence shorebird use of managed playas. Maintaining a few centimeters of water in managed playas during shorebird migration allows use by shorebirds. However, the effects of moist-soil management on the invertebrate food source for shorebirds in playas are unknown.

Current moist-soil management in playas was tested for seed-producing annuals and the presence of ducks but not geese. Therefore, current management of geese in playas revolves around providing roosting and foraging areas. Protecting large, open-water playas, which geese use for roosting, is important. Encouraging farmers to leave crop stubble and waste grain in the field provides foraging areas throughout winter for geese.

Few data are available for the management of breeding ducks in the playa lakes region. Maintenance of upland cover near a permanent water source, such as a large irrigation pit, meets most requirements of breeding and nesting ducks. Methods to encourage nesting in uplands rather than in playas, which often results in flooded nests, must be included in the management of breeding birds. Large-scale use of nesting structures is not recommended until the effectiveness of such structures can be determined for playas.

Table 2. *Recommended schedule for moist-soil management of playa lakes.*

Date	Activity	Purpose
Early April	Draw down or flood playa to create moist-soil conditions	Create conditions for desired plants to germinate and grow
Mid-late June	Draw down or flood playa to create moist-soil conditions	Reestablish plants lost to spring flooding
August	Draw down or flood playa to create moist-soil conditions	Maximize seed production for duck food
›vember–January	Flood and maintain 1 foot (30.5 cm) of water in playa	Create site for ducks to rest and feed

Table 3. *Frequency (%) and seed production (kg/ha) of common plant species from moist-soil managed and unmanaged playa lakes (Haukos, unpublished data).*

	Frequency		Production	
Species	Managed	Unmanaged	Managed	Unmanaged
Barnyard grass	20	4	346	45
Willow smartweed	38	3	730	55
Pink smartweed	22	2	532	105
Dock	3	3	1,233	703
Spikerush	15	35	66	28

Table 4. *Chemical constituents (%) of common plant species from playa lakes (Haukos, unpublished data).*

	Constituent							
Species	Ash	Nonstructural carbohydrates	Crude protein	Crude fat	Hemicellulose	Lignin	Cellulose	Cutin/ suberin
Barnyard grass	6.1	12.6	9.4	7.7	32.5	10.3	27.7	5.1
Willow smartweed	4.7	12.2	9.9	7.1	20.4	14.3	11.9	20.9
Pink smartweed	5.8	14.3	11.5	8.1	16.8	16.2	10.4	17.4
Dock	6.8	12.2	9.1	7.1	16.3	23.4	20.9	14.7
Spikerush	13.2	9.5	6.4	8.4	22.9	7.5	15.9	28.9

Future Research Needs

Most studies involving playas have focused on wildlife or the use of playas for irrigation. Few basic ecological studies have been initiated on playas. Studies relating to the basic functions and structure of playas, as have been conducted of the prairie potholes, would yield immediate benefits by providing a foundation for future studies and management. Future studies of wildlife should focus on using natural forces (i.e., water-level fluctuations, fire) to improve wildlife habitat. These studies should be designed for land in private ownership to elicit the interest and cooperation of owners.

Suggested Reading

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Osterkamp, W. R., and W. W. Wood. 1987. Playa-lake basins on the southern high plains of Texas and New Mexico: I. hydrologic, geomorphic, and geologic evidence for their development. Geological Society of America Bulletin 99:215–223.

Appendix. Common and Scientific Names of the Plants and Birds Named in the Text.

Common name	Scientific name
Plants	
Ragweed	*Ambrosia* sp.
Toothcup	*Ammannia* sp.
Barnyard grass	*Echinochloa crusgalli*
Spikerush	*Eleocharis* sp.
Summer cypress	*Kochia scoparia*
Willow smartweed	*Persicaria (Polygonum) lapathifolia*
Pink smartweed	*Persicaria (Polygonum) pensylvanica*
Dock	*Rumex crispus*
Arrowhead	*Sagittaria longiloba*
Bulrush	*Scirpus* sp.
Cattail	*Typha* sp.
Birds	
Northern pintail	*Anas acuta*
American wigeon	*Anas americana*
Green-winged teal	*Anas crecca*
Blue-winged teal	*Anas discors*
Mallard	*Anas platyrhynchos*
Canada goose	*Branta canadensis*
Lesser snow goose	*Chen caerulescens*
Sandhill crane	*Grus canadensis*

Note: Use of trade names does not imply U.S. Government endorsement of commercial products.

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Fish and Wildlife Leaflet 13
Washington, D.C. • 1992