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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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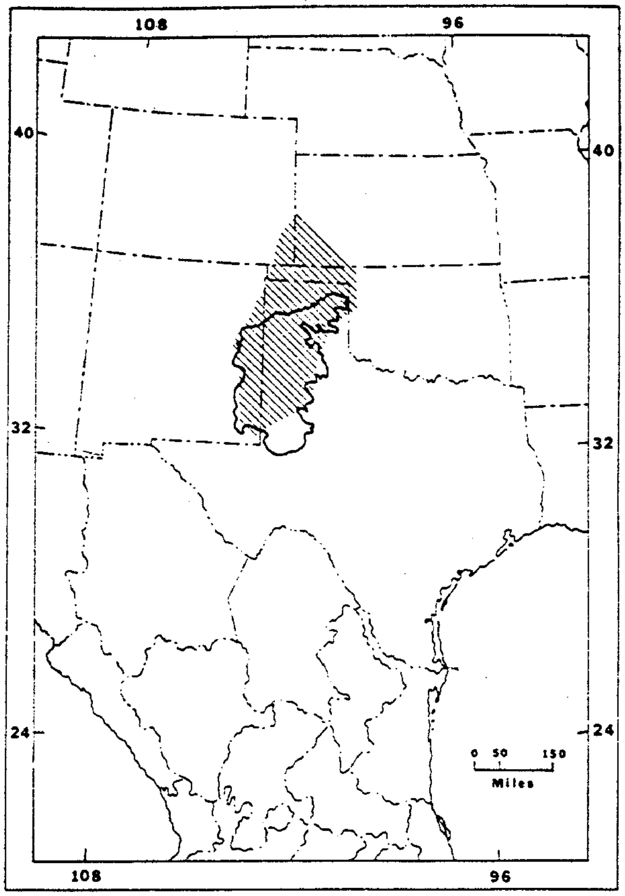

Fig. 1. The playa lakes region of the southern great plains (*hatched* area); most playas are on the southern high plains (*outlined* area).

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.*

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

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 areas, 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 available for moist-soil management. The increase in 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
November–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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Appendix. Common and Scientific Names of the Plants and Birds Named in the Text.

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*

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