Gulf Coast Joint Venture:

Laguna Madre Initiative

North American Waterfowl Management Plan

2002

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This is one of six reports that address initiative plans for the entire North American Waterfowl Management Plan, Gulf Coast Joint Venture: the Chenier Plain Initiative, the Laguna Madre (Texas) Initiative, the Texas Mid-Coast Initiative, the Mississippi River Coastal Wetlands Initiative (southeast Louisiana), the Coastal Mississippi Wetlands Initiative, and the Mobile Bay Initiative.

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Introduction

North American Waterfowl Management Plan

Faced with continuing wetland destruction and rapidly declining waterfowl populations, the Canadian and U.S. governments signed the North American Waterfowl Management Plan (NAWMP) in 1986, undertaking an intense effort to protect and restore North America's waterfowl populations and their habitats. Updated in 1994 and 1998 with Mexico as a signatory, the NAWMP recognizes that the recovery and perpetuation of waterfowl populations observed in the 1970's, which is the baseline reference for duck population objectives under the plan, depends on restoring wetlands and associated ecosystems throughout the continent. The purpose of the NAWMP is to achieve waterfowl conservation while maintaining or enhancing associated ecological values in harmony with human needs. The benefits of such habitat conservation were recognized to be applicable to a wide array of other species as well. Six priority waterfowl habitat ranges, including the western U.S. Gulf of Mexico Coast (hereafter Gulf Coast), were identified in the 1986 document and targeted as areas to begin implementation of the NAWMP.

Transforming the goals of the NAWMP into actions requires a cooperative approach to conservation. The implementing mechanisms of the NAWMP are regional partnerships called joint ventures. A joint venture is composed of individuals, corporations, small businesses, sportsmen's groups, conservation organizations, and local, state, provincial, and federal agencies that are concerned with conserving migratory birds and their habitats in a particular physiographic region such as the Gulf Coast. These partners come together under the NAWMP to pool resources and accomplish collectively what is often difficult or impossible to do individually.

Gulf Coast Joint Venture

The Gulf Coast is the terminus of the Central and Mississippi Flyways and is therefore one of the most important waterfowl areas in North America, providing both wintering and migration habitat for significant numbers of the continental duck and goose populations that use both flyways. The coastal marshes of Louisiana, Alabama, and Mississippi regularly hold half of the wintering duck population of the Mississippi Flyway. Coastal wetlands of Texas are the primary wintering site for ducks using the Central Flyway, wintering more than half of the Central Flyway waterfowl population. The greatest contribution of the Gulf Coast Joint Venture (GCJV) region (Fig. 1) in fulfilling the goals of the NAWMP is as a wintering ground for waterfowl.

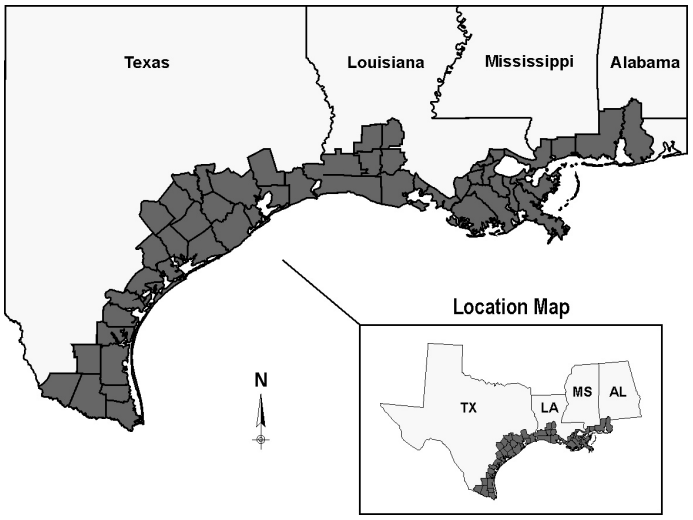


Figure 1. Location of the Gulf Coast Joint Venture region.

The GCJV area also provides year-round habitat for over 90% of the continental population of mottled ducks and serves as a key breeding area for whistling ducks. In addition, hundreds of thousands of waterfowl use the Gulf Coast as stopover habitat while migrating to and from Mexico and Central and South America. The GCJV region is the primary wintering range for several species of ducks and geese, and is a major wintering area for every other North American duck except wood ducks, black ducks, cinnamon teal, and some sea ducks (Tribe Mergini).

Through its wetlands conservation accomplishments, the GCJV is contributing to the conservation of biological diversity. While providing habitat for waterfowl, especially ducks, continues to be the major focus of the GCJV, a great diversity of birds, mammals, fish, and amphibians also rely on the wetlands of the Gulf Coast for part of their life cycles. Numerous species of shorebirds, wading birds, raptors, and songbirds can be found along the Gulf Coast. Of the 650 species of birds known to occur in the United States, nearly 400 species are found in the GCJV area. Muskrats and nutria have historically been important commercial fur species of the Gulf Coast. Many species of fish, shellfish, and other marine organisms also depend on the gulf coastal ecosystem. Almost all of the commercial fish and shellfish harvested in the Gulf of Mexico are dependent on the area's estuaries and wetlands that are an integral part of coastal ecosystems. The American alligator is an important Gulf Coast region species and is sought commercially and recreationally for its hide and meat.

Gulf Coast Joint Venture Objectives

Conserving Gulf Coast habitats is critical to the overall success of the NAWMP because the area provides extensive wetlands that are vitally important to traditional wintering waterfowl concentrations. The primary goal of the GCJV is to provide habitat for waterfowl in winter and ensure that they survive and return to the breeding grounds in good condition, but not exceeding levels commensurate with breeding habitat capacity as is the case with midcontinent lesser snow geese and Ross' geese. A secondary goal is to provide ample breeding and postbreeding habitat for resident waterfowl. Actions that will achieve and maintain healthy wetland ecosystems that are essential to waterfowl will be pursued. Wetland conservation actions that will provide benefits to species of fish and wildlife, in addition to waterfowl, will also be supported.

The emergence of the U.S. Shorebird Conservation Plan, Partners In Flight physiographic plans, and the Waterbird Conservation Plan, which address conservation of other North American migratory birds, presents opportunities to broaden and strengthen joint venture partnerships for wetland conservation. As definitive population data and habitat needs are developed for the migratory birds represented in these emerging strategies, areas of mutual concern in wetland ecosystems can be identified. These wetland areas of overlapping interest in the GCJV will be candidate priority sites for the integrated design and delivery of habitat conservation efforts. Although wetland conservation projects cannot be designed to provide maximum benefits for all concerned species, they can be designed to maximize the overlap of benefits between the species groups. This joint venture will strive to balance its focus on waterfowl and wetlands with the need to expand coordination and cooperation with existing conservation initiatives that promote common purposes, strategies, or habitats of interest.

The GCJV is divided geographically into six initiative areas, each with a different mix of habitats, management opportunities, and species priorities. This document deals with planning efforts for the Laguna Madre Initiative area of south Texas (Fig. 2). The goal of the Laguna Madre Initiative is to provide wintering and migration habitat for significant numbers of redhead ducks, greater and lesser scaup, Northern pintails, and other dabbling ducks, as well as year-round habitat for mottled ducks (Table 1).

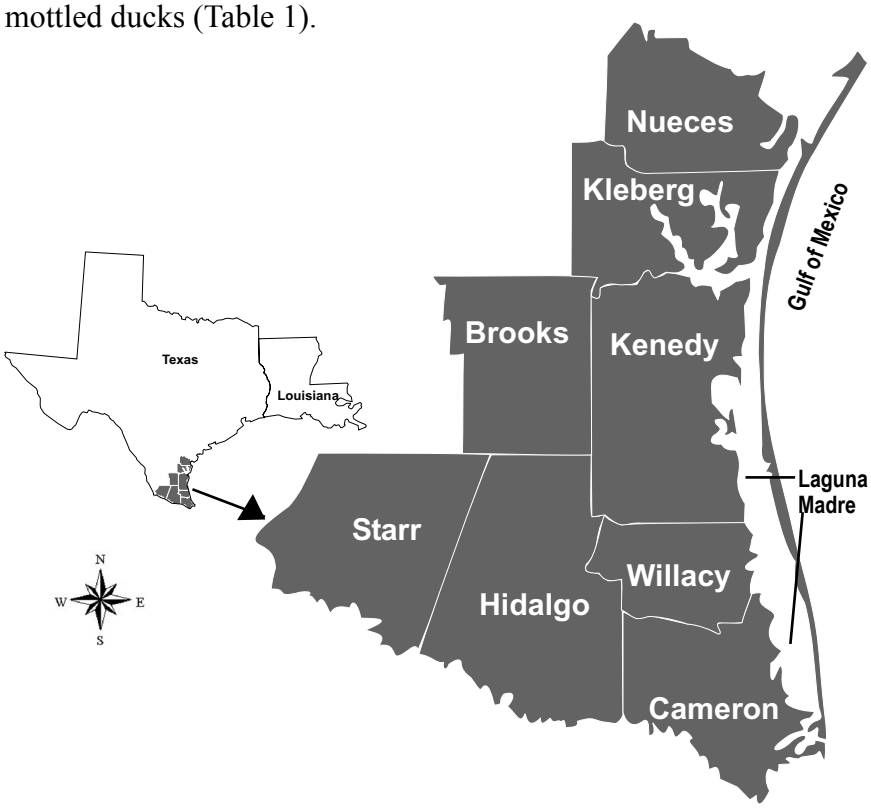


Figure 2. Location of the Laguna Madre Initiative area.

Table 1. Midwinter population objectives[1,2] for initiative areas of the GCJV. (See Derivation of GCJV Waterfowl Objectives and Migration Patterns section of this plan, p. 23, for information about the methods used to develop these goals.)

	Laguna Madre	Texas Mid-Coast	Texas Chenier Plain	Louisiana Chenier Plain	Mississippi River Coastal Wetlands	Coastal Mississippi Wetlands	Mobile Bay	Total
Mallard	13,530	72,819	44,632	515,895	249,257	619	451	897,203
Northern pintail	173,355	775,755	124,193	396,313	99,967	0	1,236	1,570,819
Gadwall	46,200	224,926	84,039	888,456	714,356	268	2,286	1,960,531
American wigeon	100,377	93,841	29,147	423,845	264,119	191	1,711	913,231
Green-winged teal	35,160	293,574	650,395	951,853	537,313	413	2,544	2,471,250
Blue-winged teal	1,707	23,941	147,053	378,953	723,140	1,738	1,156	1,277,689
Northern shoveler	10,136	127,599	42,988	330,612	103,221	84	0	614,639
Mottled duck[3]	6,595	161,326	89,961	169,544	217,642	397	601	646,067
Canvasback	4,311	33,638	0	23,585	7,516	174	3,025	72,249
Redhead	392,650	92,944	402	0	13,731	0	0	499,727
Ring-necked duck	6,067	11,345	3,331	186,917	41,450	5,999	782	255,890
Greater & lesser scaup[4]	454,727	47,402	40,707	245,746	1,722,858	13,836	3,294	2,528,570
Total ducks	1,244,816	1,959,109	1,256,847	4,511,720	4,694,568	23,719	17,086	13,707,864
Lesser snow geese[3]	30,967	609,879	100,214	279,157	51,614			1,071,831
	25,766	737,403	117,555	437,841	72,250			1,390,815
Greater white-fronted geese[3]	7,759	97,636	7,457	62,529	0			175,381
	13,819	102,790	10,235	77,821	1,233			205,898
Canada geese[3]	6,155	63,043	996	2,000[5]	0			72,194
	430	12,768	957	1,052[5]	0			15,207
Total geese[3]	44,881	770,558	108,667	343,686	51,614	0	0	1,319,406
	40,015	852,961	128,747	516,714	73,483	0	0	1,611,920

[1] Objectives for ducks are based on 1970's winter distributions and breeding populations.
[2] Objectives for geese are based on 1982-88 averages of December Goose Surveys.
[3] Shaded values are "expected" numbers from 1994-97 (mottled ducks) or 1995-97 (geese) estimates.
[4] Scaup objectives exclude offshore populations.
[5] January ground counts indicate historical (1986-89) and recent (1996-98) averages of 5,273 and 10,267, respectively.

Midwinter Duck Population Objectives

To obtain objectives for midwinter duck populations in the GCJV Initiative areas, we started with the NAWMP continental breeding population goals which total 62 million and are based on averages of 1970's breeding population surveys with adjustments for birds in nonsurveyed areas.

We then estimated, from nationwide midwinter survey data proportions, the numbers of those 62 million breeding ducks that should return on spring flights from the Mississippi and Central Flyway wintering areas; we adjusted those numbers for 10% January-to-May mortality to obtain midwinter goals for the Mississippi and Central Flyways. Finally, using 1970's midwinter survey data proportions from the Mississippi and Central Flyways, we calculated how much of each of the two flyway goals should be derived from each GCJV Initiative area. Figure 3 provides an example of how this general process was applied at the species level in the Laguna Madre Initiative area. Exceptions to this methodology include derivation of blue-winged teal and redhead objectives and the expected number of mottled ducks (see Derivation of GCJV Waterfowl Objectives and Migration Patterns section, p. 23).

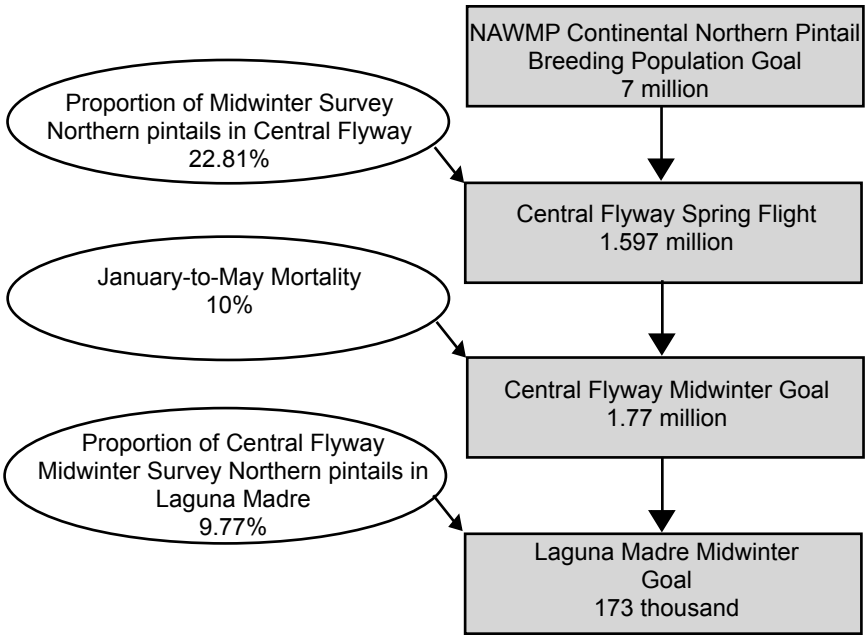


Figure 3. An example of how midwinter population objectives were obtained for a specific species, in this case Northern pintails, in the Laguna Madre Initiative area.

Midwinter Goose Population Objectives

Midcontinent lesser snow and Ross' geese, many of which spend winters in the GCJV, are exceeding their Canadian breeding habitat capacity to the detriment of their long-term health and the health of a myriad of other birds that share this arctic/subarctic breeding habitat. Greater white-fronted geese, as well as Canada geese in some GCJV regions, are also experiencing winter population increases. Therefore, regional goose objectives are expressed two ways. Recent population data are used to estimate a quantity of geese "expected" to occur and compete to some extent for finite resources, whereas actual objectives indicate the desired regional goose population. Both are based on indices from midwinter (December) surveys. "Expected" numbers are derived by averaging recent December surveys (1995-97), and actual objectives are derived from the 1982-88 average (Table 1).

Migration Chronology

Midwinter populations do not adequately represent the peak, or even the typical numbers of some waterfowl

species common to the GCJV region. Because of the variety of GCJV waterfowl and the interspecific variability in their migration patterns, incorporating species-specific migration patterns into population objectives is appropriate. Migrations differ regionally, even for the same species, so migration patterns were determined separately for each initiative area (see Migration Chronology for Waterfowl Species of GCJV Initiative Areas section, p. 26). Combining migration patterns and midwinter duck objectives (see Derivation of GCJV Waterfowl Objectives and Migration Patterns section, p. 23) yields semimonthly population objectives by species (Fig. 4). Similarly, combining goose migration patterns with expected numbers of midwinter geese yields semimonthly expected numbers of geese (Fig. 5).

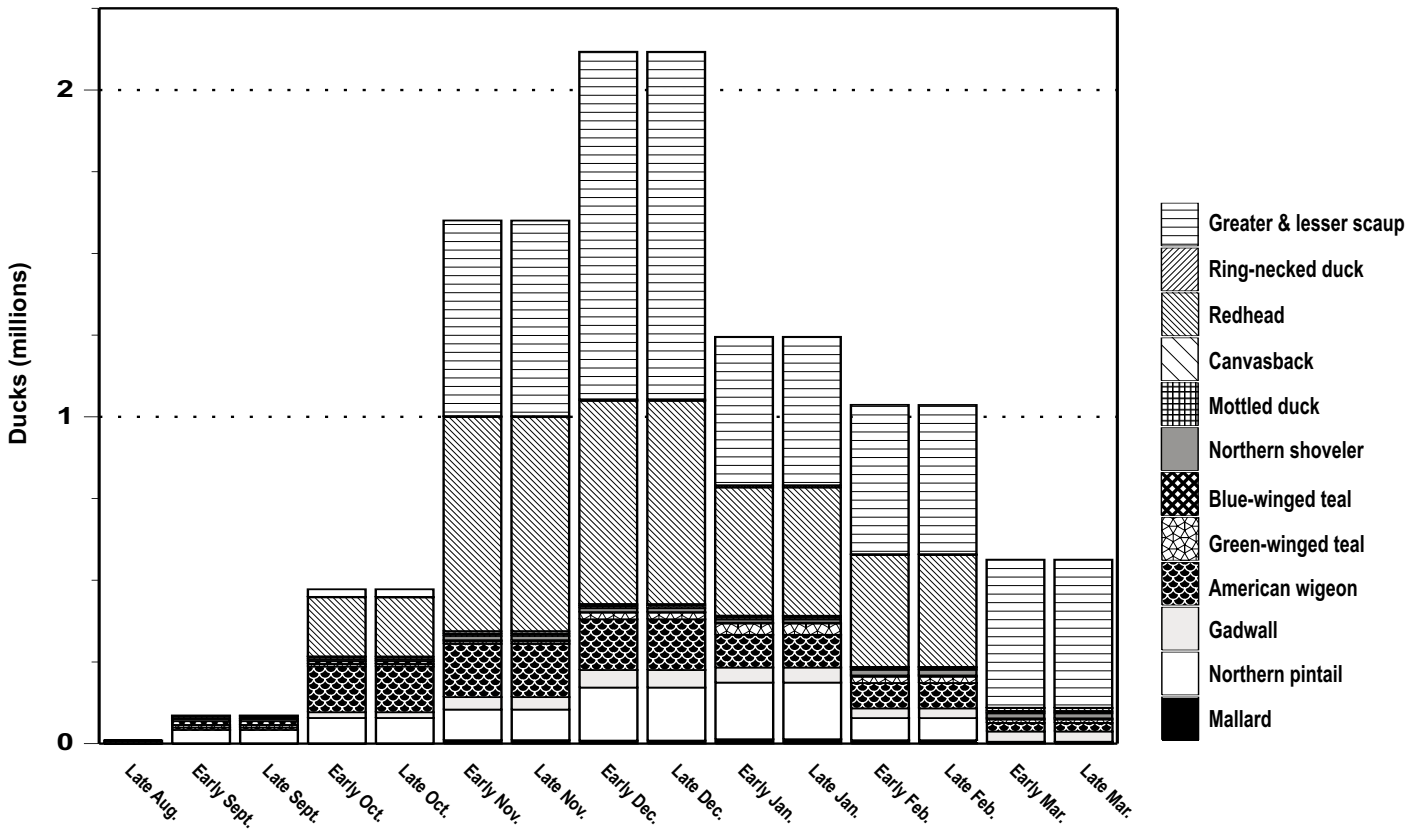


Figure 4. Semimonthly duck population objectives for the Texas Laguna Madre Initiative area.

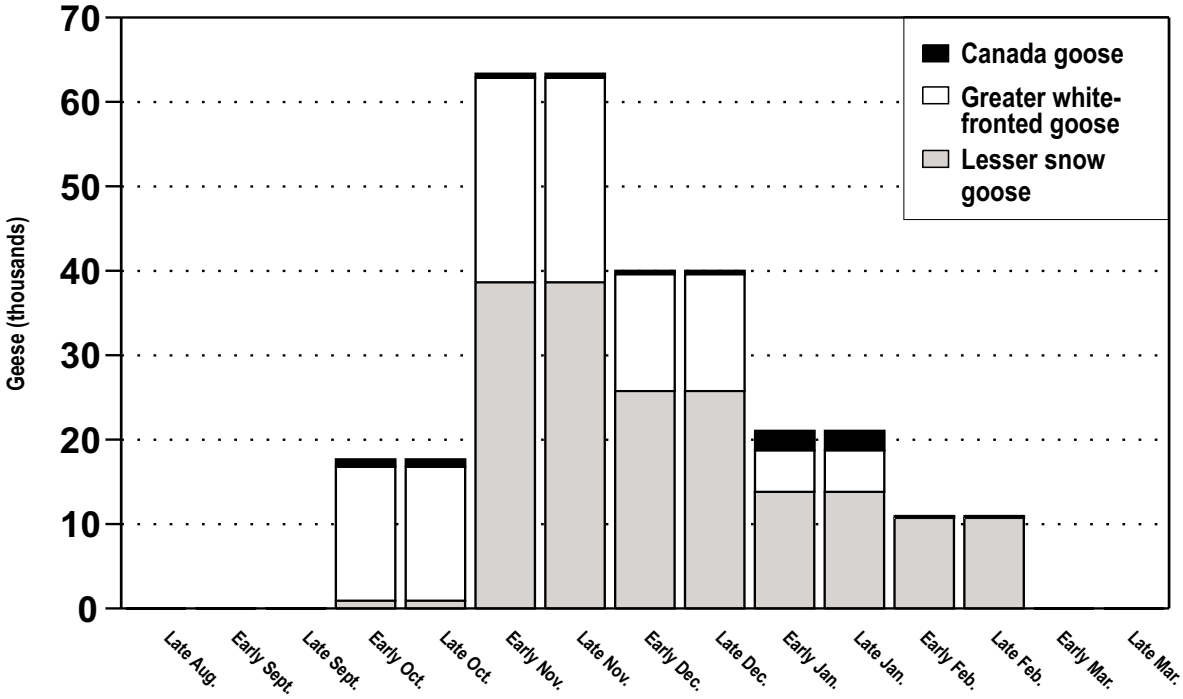
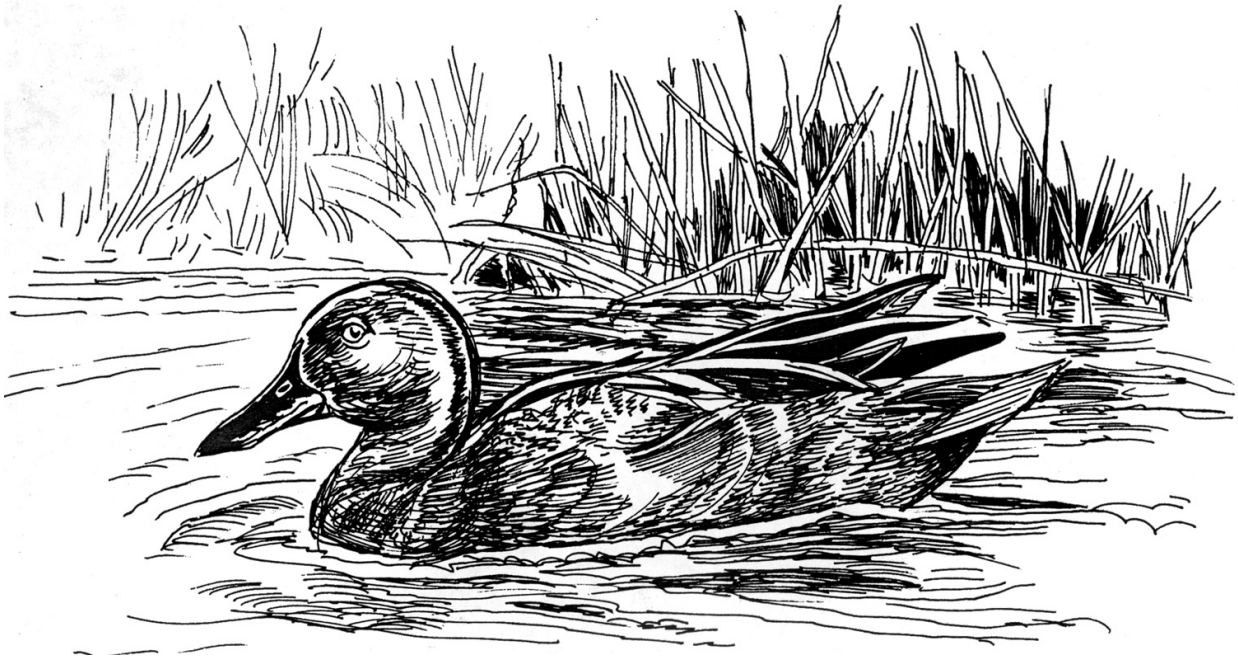


Figure 5. Semimonthly expected numbers of geese for the Texas Laguna Madre Initiative area.



The Laguna Madre Initiative Area

The Laguna Madre Initiative area is composed of five counties along the extreme lower coastal plain of Texas from the western shores of Nueces and Corpus Christi Bays to the mouth of the Rio Grande River and three adjacent inland counties. The initiative area's estuarine environment is a hypersaline lagoon system consisting of the Laguna Madre of Texas, Baffin Bay, Alazan Bay, and South Bay. Coastal prairie and sand plains dominate the inland areas. The entire Laguna Madre Initiative area covers approximately 11.7 million acres and has approximately 125 miles of coastline which are largely undeveloped. The west boundary of the initiative area extends approximately 275 river miles from the Gulf of Mexico to the northwest corner of Starr County on the Rio Grande. See the June 1990 Laguna Madre Initiative Plan for descriptions of the area's geology, climate, and land use.

The Laguna Madre of Texas is a long (124 miles), narrow (maximum width of 7 miles), shallow (less than 3 feet deep) lagoon that extends the entire length of the south Texas coast from Corpus Christi Bay to the Mexico border. It is separated from the Gulf of Mexico by barrier islands and is composed of distinct upper and lower geographic sections that are divided by extensive sand flats or "the land bridge" between the mainland and Padre Island. The land bridge begins just south of Baffin Bay and extends approximately 12 miles to the south.

The Upper Laguna Madre extends from the west side of Corpus Christi Bay south to the land bridge and includes the Baffin Bay complex. The Gulf Intracoastal Waterway cuts through the land bridge and provides a continuous water connection between the upper and lower parts of the laguna and increases water exchange with the Gulf of Mexico. The Lower Laguna Madre extends south from the land bridge to the Brazos Santiago Pass opening to the Gulf of Mexico near Port Isabel, Texas, and includes the South Bay ecosystem. It is fed by major drainage ways including the Arroyo Colorado, the Raymondville Drain, and the North Floodway. The arid nature of the watershed limits the frequency of freshwater inflow events to this system. The Port Mansfield Channel, near Port Mansfield, Texas, cuts through Padre Island providing a narrow opening to the Gulf of Mexico.

The Laguna Madre of Texas is part of the Laguna Madre of North America, a system of long, narrow, hypersaline lagoons along the U.S. and Mexico Gulf Coasts that includes the Laguna Madre of Tamaulipas (Mexico). The GCJV will seek to coordinate and cooperate with those involved with wetland conservation activities along the east coast of Mexico in order

American wigeon.

to foster an integrated continental perspective for migratory bird conservation as well as strengthen wetland conservation efforts in both countries (see Other Programs section, p. 20).

Although the Laguna Madre Initiative area consists of a variety of land types and wildlife habitats, this plan focuses on the two habitats that are of primary importance to waterfowl along the south Texas coast: historically hypersaline lagoons with associated seagrass beds and shallow freshwater wetlands on the adjoining mainland and barrier islands. In contrast to the upper and middle coasts of Texas, coastal marshes are not extensive on the lower coast. Emergent marsh can be found in a narrow band along tidally inundated shores of the mainland and barrier islands. There are considerable expanses of tidal flats of sand and mud in the Laguna Madre Initiative area. These flats generally lack macrophytic vegetation but support algal mats. They are often referred to as "wind-tidal flats" because they are periodically inundated by wind and storm tides.

Seagrass Beds

Seagrasses, primarily shoalgrass, provide food for wintering waterfowl and important nursery sites for several species of commercially important finfish and shellfish. It is estimated that currently 95% of the seagrass acreage in the Gulf of Mexico is localized in estuarine areas of Florida and Texas (USEPA 1999). Salinity, water depth, water clarity, and substrate are the dominant mechanisms affecting seagrass distribution.

In Texas, seagrass distribution, to a large extent, parallels the precipitation and inflow gradients to the bays along the Texas coast. Seagrass beds or meadows are located along the middle to lower coast where rainfall and inflows are low and evaporation is high. Nearly 80% of the state's seagrass acreage occurs in the Laguna Madre of Texas (Texas Parks and Wildlife 1999). Five species of seagrasses occur within the area: shoalgrass, turtlegrass, manateegrass, star grass, and widgeongrass. Large numbers of wintering redheads and Northern pintails, and fewer numbers of gadwalls and American wigeons forage in seagrass beds along the Texas Gulf Coast. The rhizomes of shoalgrass are the primary food source of redheads wintering along the Gulf Coast. The seeds, leaves, and stems of widgeongrass also serve as forage for a variety of duck species. Although the leafy portions and rootstock of manateegrass are not considered important dietary items of waterfowl, diving ducks routinely feed on animal matter found in association with this seagrass (Stutzenbaker 1999).

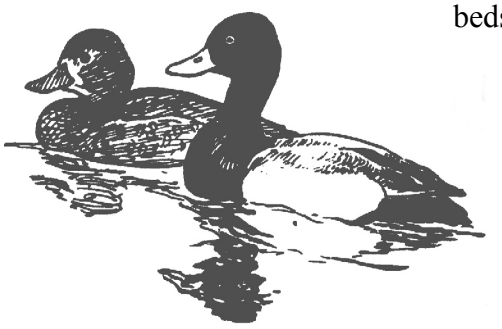
Seagrass Status and Threats

The National Oceanic and Atmospheric Administration Estuarine Eutrophication Survey estimated that the spatial coverage of seagrasses in the Gulf of Mexico was equivalent to 12-24% of the estuarine area (NOAA 1997). Losses of seagrasses in the northern Gulf of Mexico over the last 50 years have been large, from 20% to 100% for most estuaries with only a few areas experiencing increases in seagrasses (Handley 1995).

Seagrass meadows of the Laguna Madre of Texas are undergoing considerable change. Quammen and Onuf (1993) estimated that seagrass cover (i.e., percent of bottom vegetated) in

the Upper and Lower Lagunas was 75.2% and 70.5%, respectively. The area of vegetated bottom in the Upper Laguna increased 50 square miles between 1967 and 1988. Most of this increase was shoalgrass. At the same time, seagrass cover in the Lower Laguna decreased by 54 square miles. This decrease was confined to deeper areas, which was the result of reduced light reaching the bottom (Quammen and Onuf 1993).

Even larger areas of the Lower Laguna Madre have experienced changes in the species composition of seagrass beds. The work by Quammen and Onuf (1993) indicated that in 1988 shoalgrass covered 33% of the bay bottom compared to 82% in 1965. Concurrently, bay bottom coverage by manateegrass increased from 9% to 27%, and coverage by turtlegrass increased from 1% to 7%. Almost 40% of the loss of shoalgrass in the Lower Laguna between 1965 and 1988 was offset by an increase over the same period in the Upper Laguna. However, this increasing trend of shoalgrass cover in the Upper Laguna started to reverse in the early 1990's (Onuf 1995).



Greater scaup pair.

Natural disturbances to seagrass, including such things as hurricanes, cold-front storms, floods, and droughts, are cause for seagrass loss and cannot be controlled. However, human-induced disturbances are responsible for most of the changes in seagrass abundance and composition of surviving meadows in the Laguna Madre of Texas. Dredging of new canals can cause seagrass loss from both direct removal and burial of the vegetation. Of greater importance is the increased turbidity associated with dredging activities. The loss of seagrasses from deep areas, especially in the Lower Laguna, has resulted from reduced light reaching the bay bottom near navigation channels because of turbidity caused by maintenance dredging. Increased turbidity results from the resuspension of dredged sediments from spoil banks by wind generated waves.

Changes to the hydrology of the Laguna Madre of Texas are considered to be the primary cause of the expansion of seagrass cover in the Upper Laguna as well as the shift in the species composition of seagrass beds in the Lower Laguna. The permanent water connection (i.e., the Gulf Intracoastal Waterway) between these two lagoons and increased base flows from agricultural drains have resulted in modification of the salinity regime, especially in Lower Laguna Madre, and the subsequent shift in species distribution.

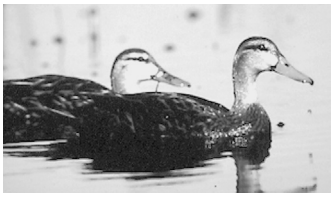
Human-induced disturbances associated with residential and industrial development pressures also impact seagrass meadows. Excess nutrients from sewage treatment discharges, septic systems, and drainage from agricultural fields (i.e., water quality) can stimulate growth of phytoplankton in the waters over seagrass beds. This phytoplankton growth decreases the amount of light reaching the plants. The long-term persistence of a phytoplankton bloom known as the "brown tide," believed to be related to human caused changes in nutrient levels in the Laguna Madre of Texas, has resulted in seagrass loss in the Upper Laguna. Seagrass beds are also often damaged

by recreational boating activity. Boat propellers and anchors can destroy the leaves, roots, and rhizomes of seagrass thereby disrupting the continuity of the beds. The propeller damaged areas (i.e., prop scars) may contribute to additional degradation of seagrass beds by accelerating erosion near the broken root mats. This erosion can also result in increased sediment resuspension (i.e., increased turbidity) which inhibits seagrass growth.

Seasonal Freshwater Wetlands

Shallow isolated depressions of the mainland and barrier islands, and resacas (i.e., oxbow wetlands which have formed in historic floodplain channels of the Rio Grande River) provide foraging and drinking sites for numerous species of ducks. High evaporation rates and temperatures combined with low rainfall cause many of these wetlands to lack surface water for variable periods from a few months to a few years. Flood control and land development in the Lower Rio Grande Valley (includes Cameron, Hidalgo, Starr, and Willacy Counties) have virtually eliminated flood flows to resacas. Although some of the oxbow wetlands are filled by pumping or input from irrigation return flows, most are filled only by rainfall. Seasonal wetlands of the Laguna Madre Initiative often contain a variety of seed producing plants that are dependent on the duration and timing of surface flooding. Dominant species of vegetation associated with the temporarily and seasonally flooded basins (water regime modifiers according to Cowardin et al. 1979) include spikerushes, flatsedges, cattail, Olney bulrush, annual sumpweed, seashore or inland saltgrass, seashore dropseed, and smartweeds; other characteristic plants include Drummond's rattlebush, brownseed paspalum, knotroot bristlegrass, and other grasses (Moulton and Dall 1998). The work of Spiller and French (1986) indicated that the pothole wetlands of the Lower Rio Grande Valley (Cameron, Hidalgo, Starr, and Willacy Counties) were generally from 0.1 to 15 acres in size and ranged in depth from 0.5 to 2.5 feet. The shape and ratio of open water to vegetation varied with location and season, but typically each pothole consisted of a circular body of water surrounded by emergent wetland vegetation.

The shallow basins provide the main source of freshwater for wildlife throughout the inland and barrier island areas of the Laguna Madre Initiative area. Dietary freshwater is an essential component of duck wintering habitat along the lower coast of Texas (Woodin 1994). Ducks feeding in the Laguna Madre are exposed to high levels of salt ingestion. Fresh drinking water provided by coastal ponds is critically important for ducks to use in diluting ingested salt loads (Woodin 1994, Adair et al. 1996).



Mottled duck pair.

Status and Trends

Temporary and seasonal freshwater "pothole" wetlands are located along the length of the Laguna Madre on the adjacent mainland and barrier islands. Although ground water input may contribute to the water supply of some of these wetlands, most of these shallow ponds are seasonal because of the area's low rainfall and high evaporation rates. These shallow basins are often called "hurricane ponds" because they are filled following rains associated with late summer and early fall tropical depressions. McAdams (1987)

documented the existence of 4.8 freshwater ponds per square kilometer following a hurricane in the coastal areas of southern Nueces County, all of Kleberg and Kenedy Counties, and northern Willacy County adjacent to the Laguna Madre. Spiller and French (1986) reviewed the status of inland pothole wetlands for the Lower Rio Grande Valley. They reported an average loss of 30% acreage and 41% for number of potholes from 1955 to 1979 for an area of the three southernmost counties (i.e., Cameron, Hidalgo, and Willacy) covered by six USGS quadrangle maps. Many of these shallow basins have been eliminated by land leveling practices and major drainage projects associated with crop production and by road development.

Precipitation has the greatest impact on abundance and distribution of hurricane ponds. The basins are numerous; however, many become filled with water only after a large rain. There has been little human-induced disturbance to the ponds within the rangeland of the sand plains. Although livestock often use these ponds there is not an apparent conflict with wintering waterfowl. Some ponds have been modified with a predictable water source (i.e., well or pipeline) for livestock. On the barrier islands, some freshwater wetlands have been lost to residential development, which continues to be a threat to remaining basins. Freshwater ponds are protected within the boundaries of Padre Island National Seashore and barrier island properties owned by The Nature Conservancy.

Resacas are found in urban and rural areas of the Lower Rio Grande Valley. Many of those in urban areas have been landscaped as community or residential showplaces, or they have been made a part of stormwater drainage systems. Most of the rural resacas are left as natural wetlands, but some are owned or leased by irrigation districts or municipal water corporations, and the hydrology of these wetlands is artificially controlled.

Lesser snow geese.

Habitat conservation is imperative for meeting the waterfowl population objectives of both the NAWMP and the GCJV. The critical habitat conservation needs on public and private lands of the GCJV are to stop and reverse the deterioration and loss of wetlands, especially coastal marshes, and to improve the waterfowl value of agricultural lands. The Laguna Madre is unique within the GCJV Initiative areas in that seagrass meadows are dominant among the wetland habitats important to waterfowl. Actions addressing the conservation of seagrass must be based largely on maintaining existing meadows and restoring those that have been lost or fragmented. Additionally, actions addressing the value of seagrass meadows to waterfowl will involve protecting, restoring, or creating adjacent freshwater wetland drinking sites in an appropriate spatial distribution. Enhancement of agricultural rangelands and pasture via restoration or creation of seasonal wetlands will also be a priority.

The availability of food resources is the most likely effect of winter habitat on survival and recruitment of waterfowl populations. Availability of food can be affected by production of foods (submerged aquatics, annual seeds, or invertebrates), flooding at appropriate times and depths for foraging, access to food influenced by human disturbance, access to dietary freshwater, or other factors. In addition to fall and winter food resources, mottled duck populations are also influenced by breeding and postbreeding habitat in the Laguna Madre. Availability of fresh or intermediate shallow water in brood-rearing and molting areas is critical during the spring and summer. Therefore, the habitat conservation actions outlined in this plan intend to influence one or more of these habitat parameters.

Conservation Strategies

Four broad strategies of wetland conservation are important for achieving the goals and objectives of the GCJV. These strategies are maintenance (i.e., loss prevention), restoration, enhancement, and creation of wetland habitat. Though not a strategy, routine management activities are important and inherent components of the restoration and maintenance strategies. Conservation actions under each of these strategies take several forms. The types of wetland conservation actions identified in each initiative area reflect the previously discussed differences that characterize each area. Descriptions of the strategies applicable to the Laguna Madre Initiative area are presented below.

Maintenance of Habitat

Maintenance involves preserving existing functions and values of the habitat. The intent is to prevent additional loss and degradation of seagrass beds, existing coastal marshes that are most vulnerable to degradation, and existing freshwater ponds adjacent to the Laguna Madre. Examples of conservation actions under this strategy include the following:

(1) promoting public policy, education, and placement of sign and channel markers around and within seagrass beds to avoid mechanical damage from recreational boat activity;
(2) promoting public policy, education, and technical assistance

that encourages maintenance of existing, critically located freshwater ponds; and

(3) securing vulnerable tracts through fee title acquisition, conservation easement, or management agreement for the purpose of implementing the above maintenance measures.

Flooded agriculture field.

Restoration of Habitat

Restoration involves conservation actions necessary to re-establish a naturally occurring but degraded wetland ecosystem. The goal is to restore or mimic the original wetland functions and values of the site. Examples of conservation actions under this strategy include the following:

(1) restoring water quality, and subsequent seagrass productivity (primarily shoalgrass) by reducing nutrient loading, fetch, and turbidity;

(2) planting seagrass, especially shoalgrass, where it once existed naturally (various techniques will be tried/developed);

(3) providing technical guidance to achieve the above restorative measures; and

(4) securing degraded tracts through fee title acquisition, conservation easement, or management agreement for the purpose of implementing the above restorative measures.

Enhancement of Agricultural Habitat

Enhancement of cropland, pasture, rangeland, and fallow fields improved for agriculture, and resacas are focused on the alteration of existing habitat to increase its carrying capacity for waterfowl. Actions under this strategy may actually be restoration of a former depressional or oxbow wetland. Enhancement actions under this strategy provide capabilities, management options, structures, or other actions to influence one or several functions or values of the site. Examples of conservation actions under this strategy include the following:

(1) providing structures and/or water delivery sufficient to flood agricultural and natural wetlands for early migrating ducks, wintering waterfowl, or summer brood habitat;

(2) providing reliable water, which may also be used for livestock watering, to freshwater basins adjacent to seagrass beds that are underutilized by waterfowl;

(3) providing technical guidance to achieve the above enhancements; and

(4) securing tracts through fee title acquisition, conservation easement, or management agreement for the purpose of implementing the above enhancements.

Creation of Habitat

Creation of habitat is the construction of wetlands where none previously existed in recent geological terms. Conservation actions develop the hydrological, geochemical, and biological components necessary to support and maintain a wetland. Examples of conservation actions under this strategy include the following:

(1) developing seasonal wetlands to provide foraging habitat for early migrating ducks and wintering waterfowl, or for summer brood habitat;

(2) developing freshwater wetlands adjacent to underutilized seagrass beds; and
(3) beneficially using dredge spoil from navigation projects to create emergent wetlands and associated mudflats.

Habitat Objectives

The two major waterfowl habitats available in the Laguna Madre Initiative area are hypersaline lagoons with associated seagrass beds and freshwater wetlands. Habitat objectives are based on the assumption that food availability is the most likely limiting factor for wintering ducks in the GCJV. Food availability is potentially influenced by factors that affect food production (e.g., marsh health, farming practices, etc.) and access (e.g., disturbance, water at appropriate depths, proximity to dietary fresh water, etc.).

Seagrass Beds

Some food density data are available for seagrass beds, and researchers have used existing information to model the carrying capacity of shoalgrass beds for redheads in Texas (Michot 2000) and Louisiana (Michot 1997). Laguna Madre seagrass beds have been estimated to encompass 1,808,210 acres of which 101,161 acres are shoalgrass (Onuf 1995). Using these estimates in a published model for redhead carrying capacity, Michot (1997) suggests that Laguna Madre seagrass beds can annually support 700,414 redheads through a given winter. Though this compares favorably with the region's redhead population objective of 392,650 based on 1970's averages, the model assumes that all portions of seagrass meadows are equally and totally accessible for redhead foraging, ignoring potential (but untested) effects of disturbance or lack of adjacent dietary fresh water in limiting redhead accessibility. For instance, if only 22% of the habitat is rendered unavailable by excessive recreational boating disturbance, and an additional 22% is not close enough to a dietary freshwater source to make feeding energetically advantageous, then the predicted carrying capacity would dip below the population objective. Combined, these factors suggest the potential for current habitat conditions to limit redhead populations during some years and suggest the need to protect the existing habitat base.

Beneficial use of dredge material.

Seasonal Wetlands

Estimates are available for the density of desirable plant seeds for waterfowl in seasonal wetlands, so we can model the waterfowl habitat requirements for that particular habitat. Based on the food habits research and general knowledge of habitat use by various species, we estimated the proportion of each species' energetic needs that we should provide for in these inland habitats (i.e., mainland and barrier island wetlands) to be 80% for mallards, blue-winged and green-winged teal, Northern shovelers, and mottled ducks, and 10% for gadwalls, American wigeons, and Northern pintails. While inland ponds are important drinking sites for diving ducks, we assume these species meet all their energetic needs elsewhere. We estimate 90% of Laguna Madre geese occur in these inland areas, and that one-fourth of inland geese feed in seasonal wetlands. These estimates result in population objectives for seasonal/temporary wetland habitats within the agricultural/rangeland portion of the Laguna

Madre (Figs. 6 and 7). We modeled the habitat requirements for this portion of our population objectives based on the dietary energy supply necessary to sustain them. Researchers estimate energetic requirements of mallards to be 290 kcal/day (Petrie 1994), with other species having energetic needs in proportion to their body weight (Kendeigh 1970). We therefore used average body weights of each species in conjunction with semimonthly population objectives and expected numbers of geese in these habitats to arrive at an energy demand curve, in terms of mallard-use-days, through the wintering waterfowl period (Fig. 8). Seed densities in Gulf Coast idle agricultural fields in rice rotations have been estimated at 149 kg/acre (Davis et al. 1960), which is slightly less than values that have been reported for moist-soil habitats in the Mississippi Alluvial Valley (Reinecke et al. 1989). We assume that moist-soil seeds in shallow freshwater wetlands of the Laguna Madre Initiative area occur at densities similar to idle rice fields. A minimum seed density threshold has been estimated at 20 kg/acre, below which we assume waterfowl foraging becomes too energetically costly to benefit them (Reinecke et al. 1989). Flooded, moist-soil seeds decompose at a rate of approximately 5% per month (Neely 1956).

True metabolizable energy for seeds of moist-soil plants have been estimated at 3.0 kcal/g (Petrie 1994). These estimates result in a prespoilage foraging value of 1,332 mallard-use-days for seasonal wetlands of the Laguna Madre Initiative area. Under these assumptions of energetic demand, prespoilage foraging value,

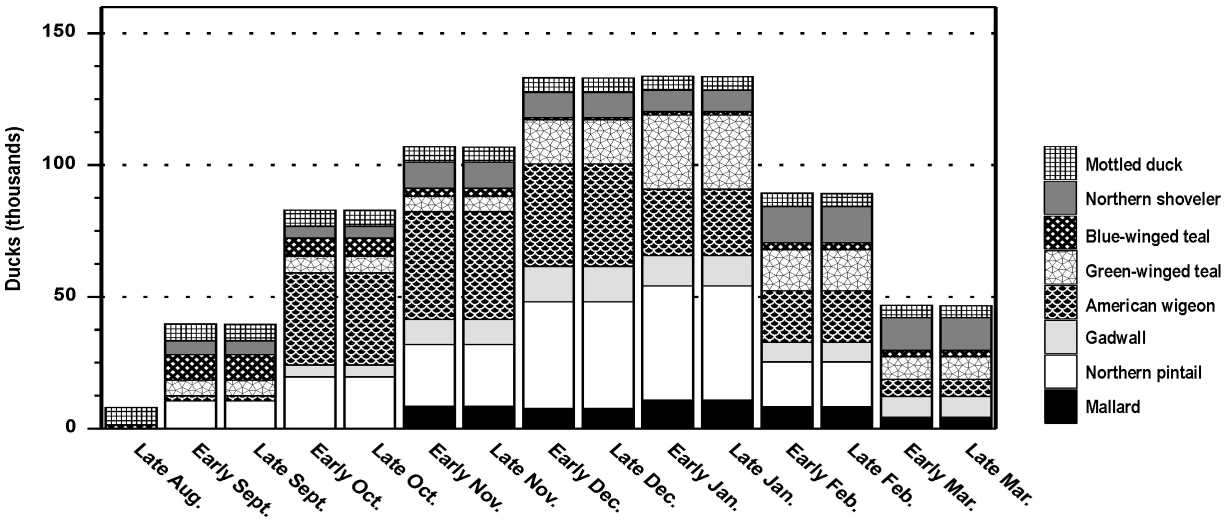


Figure 6. Semimonthly duck population objectives for the agricultural/rangeland portion of the Texas Laguna Madre Initiative area.

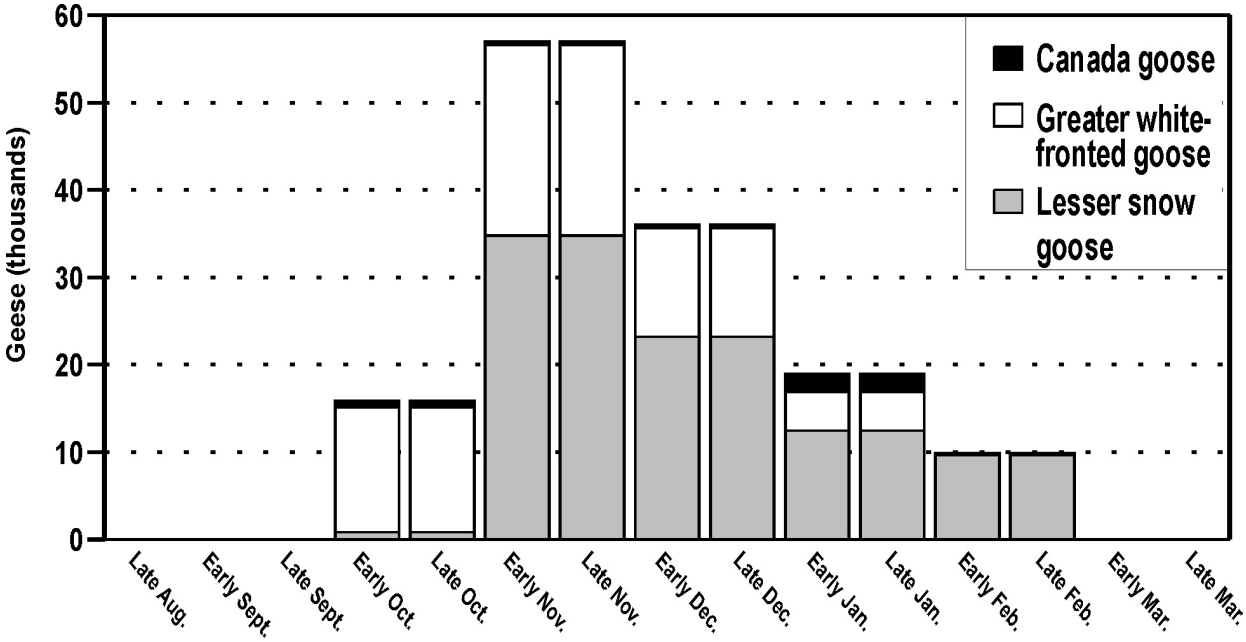


Figure 7. Semimonthly expected numbers of geese for the agricultural/rangeland portion of the Texas Laguna Madre Initiative area.

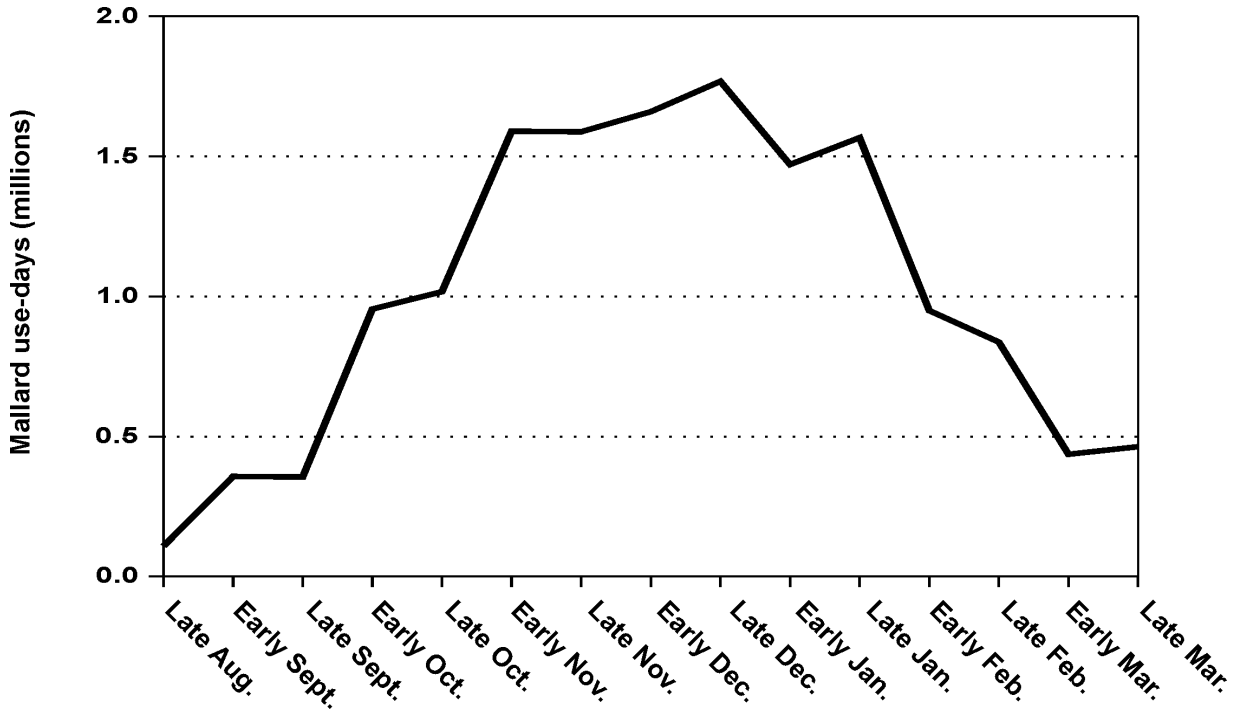
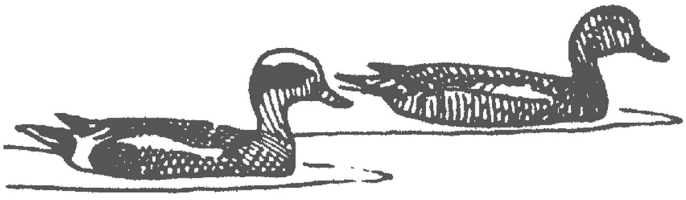


Figure 8. Energetic demands of all waterfowl objectives (mallard-use-days) in inland seasonal wetlands of the agricultural/rangeland portion of the Texas Laguna Madre Initiative area. Figure includes ducks and a percentage of geese expected to occur in seasonal wetlands (25%).

and monthly spoilage rate, we modeled habitat needs in the inland portion of the Laguna Madre Initiative area based on two target flooding periods. The early flooding period (late August through October) would serve the habitat needs of early migrants (Figs. 6 and 7) and several shorebird species. The late flooding period (November through March) coincides with the period of greatest habitat need (Fig. 8). We estimate a total need of 2,225 acres of seasonal wetlands during the early period, and an additional 10,133 acres during the late period to sustain our objective waterfowl populations. We emphasize that this habitat need includes existing acres of habitat. Because our goal is to consistently provide waterfowl foraging habitat, these should be viewed as minimum amounts of managed and unmanaged habitat (combined) that should be available in the driest of years. Until we are able to estimate the amount of flooded habitat that has occurred in the recent past during dry years, we suggest that 50% of this need represents flooding objectives for new agricultural/rangeland enhancement (Table 2).

These objectives are independent of the earlier noted need for a nearby source of fresh drinking water for waterfowl that feed in hypersaline habitats. The use of adjacent fresh drinking water by redhead ducks feeding in the Laguna Madre of Texas has been reported by Mitchell et al. (1994), Woodin (1994), and Adair et al. (1996). The work by Adair et al. (1996) also indicated that the coastal ponds that were classified as high use by diving ducks were closer to feeding sites than the ponds classified as low use. Mitchell et al. (1994) reported that redhead herbivory on shoalgrass beds can occur at such a level that the plants do not recover to their previous



American wigeon pair.

Table 2. Flooding objectives (in acres) for new agricultural/rangeland enhancement within the Laguna Madre Initiative area.

	Early	Late
Seasonal wetlands/ moist-soil	1,128	5,067

level the following growing season. Therefore, the presence and location of freshwater coastal ponds are believed to be factors limiting waterfowl use of seagrass beds in the Laguna Madre of Texas.

A group of biologists recently came together to review the literature, document freshwater needs of waterfowl in the Laguna Madre, and develop guidance for the conservation of freshwater wetlands adjacent to the Laguna Madre (i.e., Laguna Madre Freshwater Wetlands Study Group). In its report, the study group concluded that efforts are needed to protect freshwater wetlands that are near current concentrations of waterfowl feeding in the Laguna Madre. At the same time, efforts to manage freshwater wetlands near existing shoalgrass beds that are presumably suitable but are not presently being used by ducks needs to be initiated (*Conservation of Freshwater Wetlands Adjacent to the Laguna Madre of Texas and Mexico*, unpublished report from Laguna Madre Freshwater Wetlands Study Group, 2000). The GCJV will seek to incorporate the study group's recommendations (Table 3) into on-the-ground efforts that are designed to meet the modeled habitat objectives for new agricultural/rangeland enhancement.

Table 3. Recommended characteristics of restored or created freshwater wetlands adjacent to the Laguna Madre of Texas for optimum wildlife benefits (from Conservation of Freshwater Wetlands Adjacent to the Laguna Madre of Texas and Mexico*, unpublished report from Laguna Madre Freshwater Wetlands Study Group, 2000).*

Factor	Recommended Value
Size	1-5 ha (2-12 acres)
Open water	75% of surface area
Salinity	Less than or equal to 15 ppt; ideal is 6 ppt
Depth	About 0.5 m; ideal is 43 cm, maximum is 1 m
Distance to shoalgrass	Within 6 km, 10 km maximum
Number of wetlands	At least two wetlands per shoalgrass meadow

Specific Activities

The wetland habitat objectives of the GCJV will be addressed through various projects that focus on coastal marsh and agricultural lands. A package of actions designed to meet some of the Laguna Madre Initiative/GCJV objectives and contribute to the fulfillment of the NAWMP goals will be developed. Projects in the estuarine environment of the Laguna Madre Initiative area will concentrate on protecting existing seagrass beds from mechanical damage, dredging, and dredge disposal, and on restoring lost meadows. Projects on lands adjacent to the Laguna Madre will be designed to provide landowners with financial and technical assistance to develop freshwater wetlands for foraging habitat and to ensure the availability of necessary dietary freshwater. Additionally, partners will initiate activities described in this initiative as other opportunities become available. An evolving package of actions designed to meet some of the Laguna Madre Initiative/GCJV objectives, as well as contribute to the fulfillment of the NAWMP goals, has been developed and will be continually updated.

Other Programs

We recognize and support other conservation efforts that contribute to goals and objectives of this plan. Coastal marsh projects implemented under the Coastal Wetlands Planning, Protection and Restoration Act could possibly contribute to the maintenance and restoration objectives of this plan through the National Coastal Wetlands

American wigeon pair.

Conservation Grant Program in Texas. Similarly, shallow flooding provisions of some Natural Resources Conservation Service programs contribute to agricultural enhancement objectives.

The Laguna Madre of Tamaulipas, with similar physical and climatic features as the Laguna Madre of Texas, provides important habitat for a great number of waterfowl including redheads, Northern pintails, American wigeons, and greater and lesser scaup. The north end of this lagoon lies about 75 km south of the Laguna Madre of Texas. Any discussion of the Laguna Madre Initiative area's transient and wintering waterfowl populations would be incomplete without considering the valuable wintering areas of Mexico's east coast. The GCJV will pursue coordination and cooperation with those involved with wetlands conservation along the Laguna Madre of Tamaulipas.

Communication and Education

Public awareness of the importance of the Gulf Coast to waterfowl and other renewable resources is key to the success of the GCJV. Communications efforts will be developed to educate decision makers, resource managers, landowners, conservation organizations, and the general public about wetlands conservation in the Laguna Madre Initiative area. The GCJV will also work with existing communication and education efforts (e.g., Texas Sea Grant, Coastal Bend Bays and Estuaries Program, and The Nature Conservancy's Coastal Conservation Education Program) that address wetland conservation.

Relationship to Evaluation Plan

Objectives and strategies outlined in this document represent a compilation of the best available information regarding the habitat needs of waterfowl in this region. However, information gaps require numerous assumptions about both the basic framework for planning habitat conservation (i.e., food limitation) and specific variables used in energetic modeling of habitat needs (e.g., relative importance of habitat types by species). Testing of the most critical of these assumptions will be addressed in the GCJV Evaluation Plan, which is being developed simultaneously with this plan. The GCJV Evaluation Plan will provide a mechanism for feedback to, and refinement of, Initiative Area Implementation Plans. The initiative plans will therefore be updated periodically, as evaluation feeds the planning and implementation processes.

Northern shovelers and blue-winged teal.

Midwinter Duck Population Objectives

Although the coordinated midwinter survey is an inaccurate count of total wintering birds, and not corrected for visibility bias, it provides a reasonable approximation of the relative distribution of birds across broad regional and temporal scales. Therefore, we used averages from the 1970-79 midwinter surveys for each species to determine the proportion of surveyed ducks that occurs in each of the initiative areas. (For greater and lesser scaup, offshore counts were excluded due to inconsistent survey coverage, resulting in "inland-only" scaup objectives.) We then applied those species-specific proportions to the NAWMP continental breeding population objectives for each species to arrive at the number of birds each initiative area should supply to the breeding population. We assume 10% mortality between midwinter (January) and breeding (May) periods to arrive at midwinter objectives (Table 1).

Using mallards as an example, during 1970-79, 42.9% average of all continental mallards counted during the midwinter survey were in the Mississippi Flyway (see Fig. 3 for a similar example). The NAWMP continental breeding population objective for mallards is 11 million, so we estimate the proportion of the continental breeding population objective from the Mississippi Flyway to be 42.9% of that, or 4.72 million. Expanding this number to account for 10% mortality between January and May yields a midwinter objective of 5.24 million in the Mississippi Flyway. Because 9.8% of all Mississippi Flyway mallards were counted in the Louisiana Chenier Plain, we apply that percentage to the flyway goal and obtain a midwinter population objective of about 516,000 for mallards in the Louisiana Chenier Plain. This method yields midwinter

Lesser scaup pair.

objectives for most species of ducks that commonly occur in the GCJV area (Table 1).

Exceptions to this method include derivations for blue-winged teal and redhead objectives, and estimation of the expected number of mottled ducks. For blue-winged teal, the continental breeding population was first reduced by 79% to account for the proportion estimated to winter outside the range of the U.S. midwinter survey, mainly in Mexico and both Central and South America.

Population objectives for redheads were determined directly from average winter population estimates from the Special Redhead Cruise Survey for the same time period (1970-79). Using direct estimates from aerial winter surveys is appropriate for determining objectives for redheads, but not other ducks, because (1) wintering redheads occur almost exclusively in known locations of offshore seagrass habitat with good visibility, (2) visibility bias has been estimated and found negligible for portions of this special survey, and (3) redhead habitats are not consistently surveyed during the midwinter survey, precluding the methodology applied for most species.

To estimate the number of mottled ducks expected to occur during winter, we used mark-recapture analyses of direct recoveries from bandings in Louisiana and Texas during 1994-97. Preseason population estimates were derived from the assumption that the ratio of the total population to the total harvest (U.S. Fish and Wildlife Service estimate) equals the ratio of the banded population to the banded harvest (direct recoveries/band reporting rate estimate; band reporting rates are assumed to be 33% for 1994-95 and 59% for 1996-97). Preseason population estimates were then averaged, and an estimated fall/winter mortality rate of 30% was assumed to be evenly distributed September through March. The resulting midwinter estimate was then apportioned to initiative areas by the midwinter survey (Table 1).

Migration Patterns

Louisiana migration patterns for ducks were determined by using periodic coastwide aerial surveys along established transects that generally were flown one to two times per month September through March, 1970-1998 (Louisiana Department of Wildlife and Fisheries coastal transect survey, unpublished data). Chandeleur Sound, the primary redhead area in Louisiana, is not covered by these coastal transects, so for Louisiana redheads we instead used 1987-92 periodic redhead surveys from that region (Thomas C. Michot, U.S. Geological Survey, unpublished data). Each survey was assigned to a half-month period. For each species, each survey of a given year was expressed as a proportion of that year's peak. These proportions were averaged across all years to yield

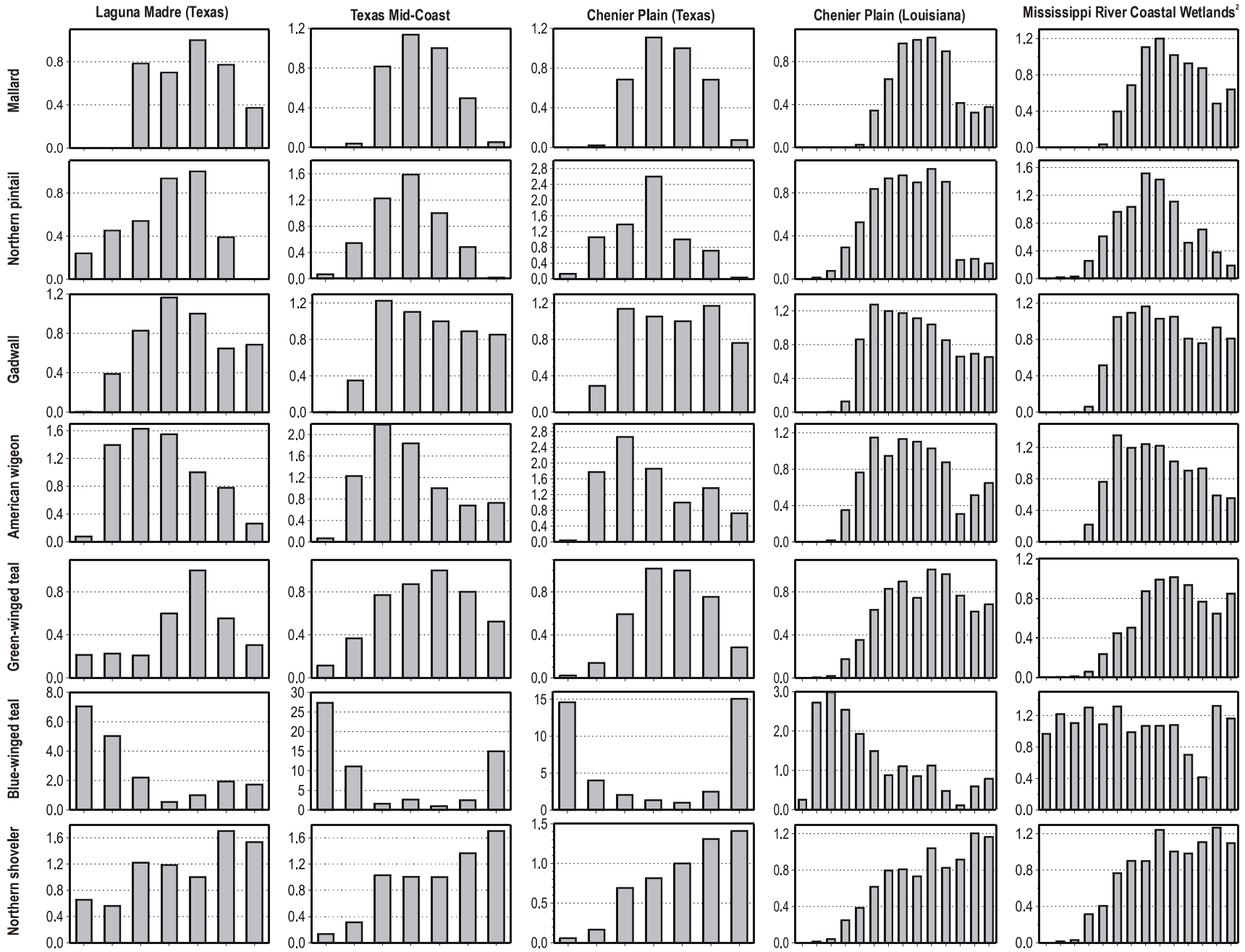
the average of the annual peak for each half-month period. All proportions were then expressed relative to the midwinter (January) proportion (see Migration Chronology for Waterfowl Species of GCJV Initiative Areas section, p. 26).

For Texas, aerial surveys of federal refuges and select other properties provide the basis for determining migration patterns (U.S. Fish and Wildlife Service's Coastal Waterfowl Survey Data, unpublished data). These monthly Texas surveys were conducted September through March of 1984-97, and data from all sites that were consistently surveyed within a given year were used. Analyses were conducted as above, except each survey represented an entire month (see Migration Chronology for Waterfowl Species of GCJV Initiative Areas section, p. 26).

Multiplying these semimonthly proportions by the midwinter population objectives yields semimonthly population objectives by species and initiative area (Figs. 4 and 5). Because Louisiana surveys were never conducted in late March, we assumed late March values for all species were 50% of early March values. Because Texas surveys were never conducted in late August, we assumed late August blue-winged teal values were 15% of early September values. Because geese are not periodically surveyed in Louisiana, we applied migrational information from the Texas Chenier Plain to all eastward initiative areas. For the Coastal Mississippi Wetlands and Mobile Bay Initiative areas, we applied duck migrational information from the Mississippi River Coastal Wetlands Initiative area (southeast Louisiana).

Blue-winged teal males.

Migration Chronology for Waterfowl Species of GCJV Initiative Areas[1].



Data sources: 1970-1998 Louisiana Department of Wildlife and Fisheries coastal waterfowl transect survey.
1984-1997 U. S. Fish and Wildlife Service coastal waterfowl surveys of refuges and selected properties.
Redhead Surveys of Chandeleur Sound, LA (Tommy Michot, USGS-NWRC, unpublished data).

[1]Average proportion of the annual peak, relative to January (midwinter) survey. Data are not available for Coastal Mississippi Wetlands and Mobile Bay Initiative areas.
[2]Southeast Louisiana.

Literature Cited

Adair, S.E., J.L. Moore, and W.H. Kiel. 1996. Wintering diving duck use of coastal ponds: an analysis of alternative hypotheses. Journal of Wildlife Management 60:83-93.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, FWS/OBS - 79/31, Washington, D.C.

Davis, J.P., C.H. Thomas, and L.L. Glasgow. 1960. Foods available to waterfowl in fallow rice fields of southwest Louisiana, 1960-1961. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commission 15:60-66.

Handley, L.R. 1995. Seagrass distribution in the northern Gulf of Mexico. Pages 273-275 *in* E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, editors. Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S. Department of the Interior, National Biological Service, Washington, D.C.

Kendeigh, S.C. 1970. Energy requirements for existence in relation to size of bird. Condor 72:60-65.

McAdams, M.S. 1987. Classification and waterfowl use of ponds in south Texas. M.S. thesis, Texas A&M University, College Station. 112 pp.

Michot, T.C. 1997. Carrying capacity of seagrass beds predicted for redheads wintering in Chandeleur Sound, Louisiana, USA. Pages 93-102 *in* J.D. Goss-Custard, R. Rufino, and A. Luis, editors. Effect of habitat loss and change on waterbirds. Proceedings of the 10th International Waterfowl Ecology Symposium, University of Aveiro, Portugal, 18-21 September 1995. Institute of Terrestrial Ecology Symposium No. 30, Wetlands International Pub. No. 42.

Michot, T.C. 2000. Comparison of wintering redhead populations in four Gulf of Mexico seagrass beds. Pages 243-260 *in* F.A. Comin, J.A. Herrera, and J. Ramirez, editors. Limnology and aquatic birds: monitoring, modelling, and management. Universidad Autónoma de Yucatán, Mérida (Mexico).

Mitchell, C.A., T.W. Custer, and P.J. Zwank. 1994. Herbivory on shoalgrass by wintering redheads in Texas. Journal of Wildlife Management 58:131-141.

Moulton, D.W., and D.M. Dall. 1998. Atlas of National Wetlands Inventory Maps for Nueces County, Texas. 58 pp.

National Oceanic and Atmospheric Administration (NOAA). 1997. NOAA's estuarine eutrophication survey, volume 4: Gulf of Mexico region. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Ocean Resources Conservation and Assessment (ORCA). 77 pp.

Neely, W.W. 1956. How long do duck foods last underwater? Transactions of the North American Wildlife and Natural Resources Conference 21:191-198.

Onuf, C.P. 1995. Seagrass meadows of the Laguna Madre of Texas. Pages 275-277 *in* E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, editors. Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S. Department of the Interior, National Biological Service, Washington, D.C.

Petrie, M.J. 1994. True metabolizable energy of waterfowl foods. M.S. thesis, University of Missouri, Columbia. 138 pp.

Quammen, M.L., and C.P. Onuf. 1993. Laguna Madre: seagrass changes continue decades after salinity reduction. Estuaries 16:302-310.

Reinecke, K.J., R.M. Kaminski, D.J. Moorhead, J.D. Hodges, and J.R. Nassar. 1989. Mississippi Alluvial Valley. Pages 203-247 *in* L.M. Smith, R.L. Pederson, and R.M. Kaminski, editors. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock.

Spiller, S.F., and J.D. French. 1986. The value and status of inland pothole wetlands in the Lower Rio Grande Valley, Texas. U.S. Department of the Interior, U.S. Fish and Wildlife Service, Special Report, Corpus Christi, Texas.

Stutzenbaker, C.D. 1999. Aquatic and wetland plants of the western Gulf Coast. Texas Parks and Wildlife Press, Austin. 465 pp.

Texas Parks and Wildlife. 1999. Seagrass conservation plan for Texas. 79 pp.

U.S. Environmental Protection Agency (USEPA). 1999. Ecological condition of estuaries in the Gulf of Mexico. EPA 620-R-98-004. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, Florida. 71 pp.

Woodin, M.C. 1994. Use of saltwater and freshwater habitats by wintering redheads in southern Texas. Hydrobiologia 279/280: 279-287.

Appendix

Scientific Names of Plants and Animals Mentioned in This Plan

I. Plants alphabetical by common name.

Common Name	Scientific Name
Annual sumpweed	*Iva annua*
Brownseed paspalum	*Paspalum plicatulum*
Cattail	*Typha* sp.
Drummond's rattle-bush	*Sesbania drummondii*
Flatsedge	*Cyperus* sp.
Knotroot bristlegrass	*Setaria geniculata*
Manateegrass	*Syringodium filiforme*
Olney bulrush	*Schoenoplectus americanus*
Seashore dropseed	*Sporobolus virginicus*
Seashore saltgrass or inland saltgrass	*Distichlis spicata*
Shoalgrass	*Halodule wrightii*
Smartweed	*Polygonum* sp.
Spikerush	*Eleocharis* sp.
Star grass	*Cynodon plectostachyus*
Turtlegrass	*Thalassia testudinum*
Widgeongrass	*Ruppia maritima*

II. Waterfowl alphabetical by common name.

Common Bird Name	Scientific Name
American black duck	*Anas rubripes*
American wigeon	*Anas americana*
Black-bellied whistling duck	*Dendrocygna autumnalis*
Blue-winged teal	*Anas discors*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Cinnamon teal	*Anas cyanoptera*
Fulvous whistling duck	*Dendrocygna bicolor*
Gadwall	*Anas strepera*
Greater scaup	*Aythya marila*
Greater white-fronted goose	*Anser albifrons*
Green-winged teal	*Anas crecca*
Lesser scaup	*Aythya affinis*
Mallard	*Anas platyrhynchos*
Mottled duck	*Anas fulvigula*
Northern shoveler	*Anas clypeata*
Northern pintail	*Anas acuta*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Ross' goose	*Chen rossii*
Lesser snow goose	*Chen caerulescens*
Wood duck	*Aix sponsa*

III. Other animals alphabetical by common name.

Common Name	Scientific Name
American alligator	*Alligator mississippiensis*
Muskrat	*Ondatra zibethicus*
Nutria	*Myocastor coypus*

For More Information

North American Waterfowl Management Plan. 1986. U.S. Department of the Interior and Environment Canada. 19 pp.

Laguna Madre Initiative Gulf Coast Joint Venture North American Waterfowl Management Plan. 1990. Laguna Madre Initiative Team. 50 pp.

1994 Update to the North American Waterfowl Management Plan: Expanding the Commitment. 1994. U.S. Department of the Interior, Environment Canada, and Secretaria de Desarrollo Social Mexico. 30 pp. + appendixes.

Expanding the Vision 1998 Update North American Waterfowl Management Plan. 1998. U.S. Department of the Interior, Environment Canada, and Secretaria de Medio Ambiente, Recursos Naturales y Pesca. 32 pp.

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