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Strategic Bird Monitoring Guidelines for the Northern Gulf of Mexico

GoMAMN STRATEGIC BIRD MONITORING GUIDELINES: WADING BIRDS

Authors:
Peter Frederick (1*)
Clay Green (2)

1. Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, FL
2. Department of Biology, Texas State University, San Marcos, TX
(*) Corresponding Author: pfred@ufl.edu

Roseate Spoonbill (*Platalea ajaja*). Photo credit: Keenan Adams

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GOMAMN STRATEGIC BIRD MONITORING GUIDELINES: WADING BIRDS

DESCRIPTION OF SPECIES GROUPS AND IMPORTANT HABITATS IN THE GULF OF MEXICO REGION

THE GULF OF MEXICO IS HOME TO 16 SPECIES WITHIN this group including egrets, herons, ibises, spoonbills, cranes, and storks. These species are most easily divided as cranes (Gruiformes) and the more traditionally classified long legged wading birds that includes herons, egrets, ibises and spoonbills (Pelecaniformes) and storks (Ciconiiformes). Across this group, these species use a variety of tidal, non-tidal, and freshwater wetlands, as well as some upland habitat (storks, ibises, cranes) along the Gulf of Mexico. In comparison to other species groups (e.g., marshbirds), the long-legged wading birds have been well studied as a group for a variety of reasons including conservation status (e.g., Whooping Crane, Mississippi Sandhill Crane, Reddish Egret, Roseate Spoonbill) and their role as indicators of ecosystem health and restoration (White Ibis, Wood Stork; Frederick et al. 2009). While the group as a whole has been well studied, certain species within the group have been less studied and a better understanding of their ecology and population status and trends is critical to the conservation of this group.

Long-legged wading bird ecology varies greatly across this group from common species that range across the Gulf of Mexico (e.g., Great Egret, Tricolored Heron) to more restricted, disjunct populations (e.g., Reddish Egret) to species with very limited distribution (e.g., Whooping Crane, Florida and Mississippi Sandhill Cranes). Most species within this group are permanent residents along the Gulf of Mexico with some having migratory and resident populations (e.g., Reddish Egret, Little Blue Heron, Great Egret, Tricolored Heron, Wood Stork, White Ibis) (refer to Appendix 1). The northern Gulf states (Louisiana, Mississippi, Alabama, and portions of Florida and Texas) often have migratory populations that winter south of the U.S., whereas Texas and Florida have more permanent (non-migratory) populations. However, what proportion of the population is resident versus migratory is not well understood for most species. Whooping Cranes *(Grus americana)* winter along the Gulf of Mexico and breed well north of the Gulf coast with the exception of the recently established experimental, non-essential population in Louisiana (Urbanek and Lewis 2015), whereas Mississippi and Florida Sandhill Cranes *(Antigone canadensis pratensis)* are strictly residents of the Gulf of Mexico (Gerber et al. 2014). Wood Storks *(Mycteria americana)* are both year-round and migratory in Florida, while Wood Storks in Texas only occur during post-breeding season (e.g., July–September) and are likely from the Mexican breeding population (Coulter et al. 1999).

Two of the three cranes (Whooping Crane, Mississippi Sandhill Crane), as well as Wood Storks are classified as threatened/endangered under the U.S. Endangered Species Act. While none of the other long-legged wading birds are federally-listed species, Reddish Egret *(Egretta rufescens)* is listed as a Bird of Conservation Concern at the federal level (USFWS 2008). Reddish Egret, Little Blue Heron *(Egretta caerulea)*, and Roseate Spoonbill *(Platalea ajaja)* are all listed as threatened in Florida (Kushlan et al. 2002, Wilson et al. 2014).

Breeding Season

All of the species in this group breed within the GoMAMN boundaries (Figure 1.2) including the recently established breeding population of Whooping Cranes in Louisiana. Tricolored Heron *(Egretta tricolor)*, Little Blue Heron, and Great Egret nest across the entire region from south Florida to south Texas, whereas the Reddish Egret, and Roseate Spoonbill are more disjunct, primarily breeding in coastal Texas, Louisiana, and coastal Florida (Dumas 2000, Koczur et al. 2019, McCrimmon et al. 2011, Rodgers et al. 2012, Frederick 2013). White Ibis *(Eudocimus albus)* breeding colonies are usually concentrated within a specific region of the GoMAMN boundaries, but have a wide range and shift their centroid of breeding in response to concentrations of food (Frederick et al. 1996). The Little Blue Heron breeds along much of the Gulf coastline, but a large portion of the population breeds at inland freshwater locations (Rodgers et al. 2012). Wood Stork occurrence in Texas is during the post-breeding season and the Wood Stork breeding population within the Gulf of Mexico is restricted to Florida (Coulter et al. 1999).

The long-legged wading birds are all colonial nesting birds, generally nesting in mixed-species colonies on islands

Table 8.1. *Wading bird species to be considered for monitoring programs at multiple geographic scales across the northern Gulf of Mexico. Table includes species residency status, landcover association, and the North American continental trend and conservation concern scores (Partners in Flight 2017).*

Common Name	Latin Name	Breeding	Wintering	Migratory	Landcover Association(s)[a]	Trend Score	Continental Concern Score
Florida Sandhill Crane	*Antigone canadensis pratensis*	x	x		Palustrine Emergent Wetland, Lacustrine/Riverine, Grassland, Upland Evergreen Forest (Wet Longleaf and Slash Pine Flatwoods & Savannas)	3	17
Mississippi Sandhill Crane	*Antigone canadensis pulla*	x	x		Palustrine Emergent Wetland, Lacustrine/Riverine, Grassland, Upland Evergreen Forest (Wet Longleaf and Slash Pine Flatwoods & Savannas)	1	15
Whooping Crane	*Grus americana*		x	x	Palustrine Emergent Wetland, Estuarine Emergent Wetland, Estuarine-Coastal (saltmarshes, shallow bays, and exposed tidal flats; also harvested cropfields & pasturelands)	1	16
Wood Stork	*Mycteria americana*	x	x		Palustrine Forested Wetland (bottomland hardwods), Palustrine Emergent Wetland, Estuarine Forested Wetland, Estuarine Emergent Wetland; utilizes aquaculture ponds (catfish, crawfish)	3	12
Great Egret	*Ardea alba*	x	x		Palustrine Forested Wetland (bottomland hardwods), Palustrine Emergent Wetland, Estuarine Forested Wetland, Estuarine Emergent Wetland; utilizes aquaculture ponds (catfish, crawfish) Estuarine Scrub/Shrub Wetland, Estuarine-Tidal Riverine Coastal	1	7
Little Blue Heron	*Egretta caerulea*	x	x		Palustrine Forested Wetland, Estuarine Forested Wetland, Estuarine Emergent Wetland, Estuarine Coastal, Estuarine Scrub Shrub	4	11
Tricolored Heron	*Egretta tricolor*	x	x		Estuarine Emergent Wetland, Estuarine Forested Wetland, Estuarine Scrub/Shrub Wetland, Estuarine-Tidal Riverine Coastal, Estuarine Coastal	2	11
Reddish Egret	*Egretta rufescens*	x	x		Palustrine Emergent Wetland, Estuarine Emergent Wetland (brackish to saltwater marshes), Estuarine Scrub/ Shrub, Estuarine-Coastal	3	15
White Ibis	*Eudocimus albus*	x	x		Palustrine Forested Wetland (bottomland hardwods), Palustrine Emergent Wetland, Estuarine Forested Wetland, Estuarine Emergent Wetland; utilizes aquaculture ponds (catfish, crawfish) Estuarine Scrub/Shrub Wetland, Estuarine-Tidal Riverine Coastal	3	12

Table 8.1 (continued).

Common Name	Latin Name	Breeding	Wintering	Migratory	Landcover Association(s)[a]	Trend Score	Continental Concern Score
Roseate Spoonbill	*Platalea ajaja*	x	x		Palustrine Emergent Wetland, Estuarine Emergent Wetland (brackish to saltwater marshes), Estuarine Scrub/ Shrub, Estuarine-Coastal	2	10

[a] See Chapter 1 and Appendix 2 for full description of landcover associations.

(e.g., barrier, spoil, or natural inland islands) or forested wetlands using a variety of tree, shrub, and other woody vegetation as nesting substrate. Colonies are typically over water (e.g., cypress-tupelo swamp, willow head, mangrove) or islands surrounded by water in a variety of marine, estuarine, and freshwater systems. Within these systems, Great Egrets, Wood Storks, and Roseate Spoonbill typically nest higher in trees (e.g., cypress, mangrove), whereas Little Blue Herons, White Ibises, and Tricolored Herons usually nest lower in trees or shrubs or other woody vegetation (Coulter et al. 1999, Dumas 2000, Heath et al. 2009, McCrimmon et al. 2011, Rodgers et al. 2012, Frederick 2013). Within barrier and spoil islands along Texas and Louisiana coasts, these species may nest in low woody vegetation, cacti or even on the ground. Reddish Egrets nest in mangroves (Florida) and low vegetation and cacti in Texas and Louisiana (Hill and Green 2011, Holderby et al. 2012). Wood Storks typically breed in freshwater and estuarine forests (e.g., bald cypress, black gum, willow), inundated by freshwater (e.g., tree islands) or tidally influenced waters (mangroves; Coulter et al. 1999, Tsai et al. 2016).

The Florida Sandhill Crane breeding range is restricted to peninsular Florida and the Mississippi Sandhill Crane *(Antigone canadensis pulla)* restricted to Harrison and Jackson County, Mississippi (Gerber et al. 2014). The Florida Sandhill Crane uses freshwater emergent palustrine marshes, often with higher herbaceous cover for nesting (Bennett 1989), whereas the Mississippi Sandhill Crane uses pine savannas, freshwater marsh, and pine plantations for nesting (Wilson 1987). During the breeding season, both cranes forage in a variety of freshwater, palustrine, and brackish marshes, as well as in some upland and agricultural habitats.

Spring And Autumn Migration Seasons

While the wading birds vary somewhat in migratory behavior across the Gulf of Mexico, all of the species are documented throughout the year across the Gulf states. Spring migration for migratory wading bird populations usually occurs in March/April with fall migration movements ranging between September and November. However, movements can occur at any time of year, and appear to be in response to local food and hydrological conditions (e.g., Bates et al. 2016, Frederick et al. 1996). Most of the wading bird species exhibit some post-breeding dispersal that typically occurs June into October. Coastal Texas and south Florida likely contain resident populations of Tricolored Heron, Little Blue Heron, Great Egret (*Ardea alba*), Roseate Spoonbill, White Ibis, and Reddish Egret, as individuals from each of these species are documented during both migration and wintering months. A decline in numbers of the Little Blue Heron, Tricolored Heron, and Reddish Egret in northern Gulf states (e.g., Louisiana) likely indicates at least some of the population is migrating southward during fall. Telemetry studies on Reddish Egrets reveal that ~40% of Texas/Louisiana birds migrate to Mexico and/or Central America, whereas the remainder are considered resident (Koczur 2017). Great Egrets are migratory throughout much of their range in North America, but along the Gulf of Mexico can be either residential or a mixture of resident and migratory birds from further north. Great Egrets are known to perform long-distance, trans-Gulf migrations in fall and spring (Fidorra et al. 2016). Roseate Spoonbills often exhibit inland movement during the post-breeding season and then may migrate to the Caribbean and/or Central and South America with resident populations remaining in south Texas and Florida. The White Ibis, perhaps the most nomadic of all of the wading birds, exhibit strong post-breeding dispersal, but can also be documented year-round in many Gulf states (Frederick et al. 1996). The Wood Stork occurs year-round in Florida and movements (e.g., post-breeding, winter) seem to be influenced by both season and regional environmental conditions.

Mississippi Sandhill and Florida Sandhill Cranes are considered strictly non-migratory populations and remain in Harrison and Jackson County, MS, and Florida/Georgia, respectively, year-round (Gerber et al. 2014). The Whooping Crane winter population at Aransas National Wildlife Refuge (Texas) usually begins spring migration in late March with the last bird migrating northward by the beginning of May (Urbanek and Lewis 2015). Autumn migration generally occurs in mid- to late-September and stretches to the end of October with the birds on their wintering territories by November.

Winter Season

The Gulf of Mexico provides important wintering habitat for all of the long-legged wading birds and cranes with some species (e.g., Great Egret) occurring throughout the Gulf states. While the Tricolored Heron, Reddish Egret, and Little Blue Heron can occur throughout the Gulf of Mexico during the winter season, there is some reduction in numbers of wintering individuals along the northern Gulf (e.g., north Florida, Mississippi, Alabama), but consistent occurrence of these species in coastal Texas and peninsular Florida. Roseate Spoonbills winter primarily in Texas and Florida with individuals in Louisiana being mostly restricted to southwest Louisiana (i.e., Cameron and Vermillion parishes, Dumas 2000). White Ibises occupy most of their breeding range during the winter season, but this can vary due to winter temperatures, and the regional nomadism and post-breeding dispersal exhibited by this species (Frederick et al. 1996). Wood Storks are also found primarily within their Florida breeding range during the winter, and during the winter the population in Florida is augmented with migrants from the Carolinas and Georgia.

Within the crane populations, the Mississippi and Florida Sandhill Cranes are non-migratory and occupy the same range for wintering and breeding. The Whooping Crane population in Texas winters primarily at Aransas National Wildlife Refuge and surrounding Texas coastal bend area, whereas the Florida and Louisiana populations are non-migratory and hence occupy the same general area year-round.

CONSERVATION CHALLENGES AND INFORMATION NEEDS

CRANES: All of the North American crane species (and subspecies) have been well studied. They share similar demographic profiles, having long adult life, low annual reproductive output, and low survival of offspring. Because of these characteristics, crane populations are sensitive to any influences on adult survival rates, such as traumatic mortality (hunting, powerline collisions), predation, and disease. Predation is the number one cause of mortality in adult and young Mississippi Sandhill Cranes (Seal and Hereford 1994, Gee and Hereford 1995, Olsen 2004) while collision with vehicles, powerlines, and fences are important secondary causes of mortality (S. Hereford, personal communication).

Since Whooping cranes are migratory, the risks of mortality during migration across large areas of unprotected habitat are of concern. Of particular concern is the suitability of wetland and riparian habitat along the migratory route.

Whooping Crane (*Grus americana*) family group. Photo credit: Michael Gray

Whooping Cranes and both subspecies of Sandhill Crane exist at low population sizes, and may be constrained by genetic problems though potential implications are currently not well understood. The Mississippi Sandhill cranes are highly inbred, contributing to low survival and nest success (Henkel 2010).

While Whooping Cranes breed well outside the GoM area, both Mississippi and Florida Sandhill Cranes are sedentary and breed well within the GoM area. Sandhill Crane nest success is strongly driven by predation on eggs and developing young (Seal and Hereford 1994, Dwyer and Tanner 1992). Predator protection relies largely on placing nests within ponds or extensive areas of inundated marsh, wet prairie, or savanna and heavy emergent wetland vegetative cover, and nest success may be augmented by trapping and removal of potential predators (Hereford, personal communication, Dwyer and Tanner 1992, Bennett and Bennett 1990). Similarly, predator avoidance of adults and young at night outside the nesting season is dependent on roosting areas that are inundated, allowing birds to detect the approach of nocturnal predators. Reduced areas of freshwater inundation and increased woody vegetation can increase predation rates and make otherwise suitable habitat functionally unsuitable, sometimes resulting in reduced survival probabilities and abandonment (Dellinger personal communication). In both Mississippi and Florida, crane populations are therefore increasingly vulnerable due to increased frequency and intensity of droughts, exacerbated by increased human use of freshwater resources in Florida. Vulnerability may come as a result of forced movement as habitat conditions degrade within a season (e.g., drought or disturbance). Sandhill Cranes will travel widely, often making them more vulnerable to mortality from collisions and predation (FWC 2013). Conversely, too large a rain event may flood nests and such flood events may be increasing in both frequency and intensity (S. Hereford personal communication). As Florida Sandhill Crane populations become surrounded by suburban and urban land uses, mortality may increase due to exposure to domestic pets and vehicular traffic, especially during periods of forced movements.

Cranes generally need open habitat to forage and to avoid predation, and habitat loss has been identified as an important threat to the Florida Sandhill Crane population (Nesbitt and Hatchitt 2008). Lack of fire in wetlands and in the wetland-upland interface has also been identified as a critical threat to habitat suitability for this species (FWC 2013). Open habitat can be achieved by a number of means including frequent inundation, fire, grazing, tree felling, mulching, and mowing. Decreased use of fire and shrinking pasturelands on the landscape are seen as important threats both generally, and for specific populations of Sandhill Cranes (FWC 2013). The Mississippi Sandhill Crane is especially dependent on frequent, low intensity fire to maintain the openness of the wet pine savanna habitat (Hereford 1995, Frost et al. 1996, Hereford and Billodeaux 2010)

The migratory population of Whooping Cranes is highly dependent during the winter on a small number of food types produced in estuarine habitats in and around the Aransas National Wildlife Refuge in Texas, though foraging is opportunistic. Juvenile and subadult Blue Crabs (*Callinectes sapidus*) are a primary food item (Westwood and Chavez-Ramirez 2005), and the production of crabs is strongly influenced by salinity regimes, which are driven by freshwater flows to the estuary (Pugesek et al. 2013). The fruits of Carolina wolfberry (*Lycium carolinium*) are another key food resource that is available for crane consumption through a portion of the winter season, and productivity of the wolfberry is dependent on moderate salinity conditions (Butzler and Davis 2006). The management of instream freshwater flows to coastal bays within the Guadalupe-San Antonio basin is therefore, of critical concern for this species, specifically in its wintering habitat within and around the Aransas National Wildlife Refuge (Wozniak et al. 2012). The net influence of drought or reduced freshwater flows during winter may not, however be the most important factor affecting this population (Butler et al. 2014). Habitat loss from development continues to be a serious concern on the wintering grounds. The recent establishment of black mangroves (*Avicennia germinans*) and continuing habitat conversion due to sea-level rise are natural phenomena from climate change that must be factored into habitat conservation for this species (Chavez-Ramirez and Wehtje 2012).

LONG-LEGGED WADING BIRDS: Of the priority long-legged wading birds, two are either coastal specialists (Reddish Egret) or are frequently associated with coastal habitats (Roseate Spoonbill). These species are dependent upon particular coastal habitats for foraging, like shallow seagrass beds and mudflats (Reddish Egret; Koczur et al. 2019), shallow coastal wetlands (Roseate Spoonbill; Koczur et al 2019), or Cypress-Tupelo swamps in Louisiana. Both species are also largely restricted to coastal island habitat for nesting. Because of this, critical habitats for these species are particularly vulnerable to effects of both sea-level rise (SLR) and coastal storm effects.

Generally, the long-legged waders show a strong connection between foraging and breeding, with poor nest success often associated with temporary declines in food supply (Frederick and Spalding 1994, Herring et al. 2010, Beerens et al. 2015), and breeding population size may fluctuate and be predicted from annual and antecedent hydrological conditions (Beerens et al. 2015). For this reason, any threats to the production or availability of food are of great importance to population responses.

All of the long-legged waders forage in shallow water (5–30 cm) and foraging success and choice of foraging site are sensitive to both depth and density of aquatic prey (Gawlik 2002). Prey populations and densities in shallowly inundated wetlands of many types are often strongly affected by hydroperiod (Reutz et al. 2005, Dorn and Trexler 2007), and there appears to be an important tradeoff between length of hydroperiod and community structure (Trexler et al. 2005, Dorn and Cook 2015). At very long hydroperiods, prey populations may be driven by piscine predators that are essentially in competition with birds. At the lower end of the hydroperiod scale, aquatic community structure and size of standing stocks of wading bird prey are more likely to be limited by time since drying.

In coastal zones, prey communities and standing stocks are also structured by salinity (Green et al. 2006, Lorenz and Serafy 2006), which is largely dependent upon upstream freshwater flow. In Florida Bay, for example, annual availability of prey of Roseate Spoonbills is dependent upon upstream flow from the Everglades, and success of nesting is predictable from hydrologic parameters (Lorenz et al. 2009). This follows the general finding that intermediate salinities typical of estuaries are at least partly responsible for greater productivity of fishes and invertebrates found there (Livingston et al. 1997), as well as structuring habitat in other ways (Flemer and Champ 2006). Reduced freshwater flows to estuaries are becoming more common in coastal areas generally (Alber 2002) and constitute a major threat to populations of long-legged waders. Similarly, flows are also becoming more highly managed, resulting in greater extremes of discharge, altered timing of releases, and increased variability in flooding regimes. These changes alter typical patterns of drying, directly affecting both production of prey (hydroperiod too short or long) and access to prey (drying patterns subdued or lost altogether).

Sea-level rise and altered freshwater flows may together also "squeeze" coastal foraging and nesting habitat for this group of birds. This results from a narrowing of the extent of appropriate salinities and hydroperiods as sea-level rises, and freshwater flows either decrease or become more highly variable.

Foraging success of long-legged waders is also sensitive to vegetative structure (Lantz et al. 2010, Adams et al. 2008), with some species strongly linked to particular habitats (seagrass beds, open flats), and a general avoidance of woody vegetation. As temperatures and sea-level both increase, there will be a tendency in the southern part of the monitoring area for increased coverage of woody coastal vegetation such as mangroves, with a concomitant reduction in coastal graminoid-dominated marshes. This may constitute a large reduction in foraging area. In other areas, it is not as clear that vegetation will shift towards woody species, and greater number and intensity of coastal storms in some cases may result in more open habitats such as mudflats and open water.

Reddish Egret (*Egretta rufescens*). Photo credit: Michael Gray

For these reasons, all of the long-legged waders appear to be strongly dependent on local hydrology and freshwater flow for suitability of foraging habitat. As such, all are vulnerable to changing rainfall patterns, upstream water management, sea-level rise and its effect on local hydrology, and the effects of hydrology on foraging habitat structure.

Long-legged waders are with rare exceptions colonial nesters, and while nest success is thought to be proximally driven by foraging success, nesting habitat preferences appear to be driven by predation, mostly by aquatic, arboreal mammals. Long-legged wading birds have no defensive behaviors that are effective against arboreal mammals like raccoons (*Procyon lotor*), and rely instead on inaccessibility of colony sites to exclude predators (Post and Seals 1993, Burtner and Frederick 2017). Breeding colonies are typically located on islands surrounded by water, or in large expanses of flooded forest. While presence of water may exclude some mammals by forcing them to swim, the presence of American Alligators (*Alligator mississippiensis*) below nests appears to exert a strong effect on exclusion of raccoons and other mammals (Burtner and Frederick 2017). There is also a clear benefit to alligators that reside under nests, because they have access to a large potential food resource through falling chicks (Nell and Frederick 2015). This process may have important demographic and habitat choice effects—the degree to which colonies of Wood Storks are surrounded by water is predictive of colony longevity (Tsai et al. 2016).

Islands and forested wetlands that are suitable for nesting are therefore, crucial to the breeding distribution, nest-site selection, and nest success of long-legged wading birds. This is especially the case where raccoon populations are increasing in coastal areas (Erwin et al. 1995, 2001). Although the availability of islands has been shown to limit colonial waterbird nesting (Erwin et al. 2001, Tsai et al. 2016), it is unclear whether islands of this kind are limited in number or type in various parts of the Gulf coastal states, and whether this ultimately limits populations. Certainly, coastal islands are being eroded and lost as sea-level rises, but islands may also be created through very similar processes.

Many historically important colonies of long-legged wading birds were coastal, and rising sea levels already appear to be degrading vegetation and substrate on those islands. It is unclear if the processes by which islands are created will keep up with this loss as coastal areas are inundated, and perhaps experience greater severity and frequency of storms. In the absence of other information it seems prudent to typify island availability as a potential threat.

Lastly, the GoM system is an area that produces oil spills of various frequencies and volumes annually (primarily in Texas and Louisiana; NOSC 2011). Long-legged wading birds are quite vulnerable to oiling in the coastal zone because they forage directly in shallow waters that are likely to either accumulate fresh oil from a spill or accumulate oil in sediments. Further, the prey that wading birds eat are small crustaceans and fishes that are likely to either be exposed to oil because

Florida Sandhill Cranes (*Antigone canadensis pratensis*). Photo credit: Randy Wilson

of their shallow habitats, and/or serve as biomagnifiers of oil because of their position in the trophic web. Oiling may also strongly affect the survival of young birds. Breeding colonies are often located in intertidal zones in the GoM area [cf 40% (Florida) to 77% (Texas)], and young birds may be oiled through a variety of processes including direct contact with parents, ingestion of prey boluses brought by parents, and direct oiling as they learn to feed. Typically, long-legged wader young learn to forage in the immediate vicinity of the colony (Rodgers 1987) and may remain in that area for a period of weeks before dispersing post-fledging. This period is one in which naive juveniles with no experience of oil or ability to avoid it could become heavily exposed. Finally, oiling can strongly affect survival of vegetation in coastal colonies, and the loss of this structure could lead to immigration to other locations for breeding in future years. Oiling, therefore, must be seen as a major threat to populations of this group of birds.

Methylated mercury is known to be particularly available and widely distributed in southeastern wetlands and is known to have strong effects on birds generally (Wolfe et al. 1998, Evers et al. 2008). Mercury bioaccumulates rapidly in wetland fauna because of complex food webs, and long-legged wading birds are good candidates for exposure because of their trophic position. Effects include teratogenesis, decreased hatching success, reproductive impairment, and endocrine disruption. Some of these effects are influential enough to affect population trajectories (Frederick and Jayasena 2010). The degree to which other contaminants may pose a threat is largely unknown for this group of birds. Wood Storks, Roseate Spoonbills, and White Ibis are among the species commonly observed foraging in roadside ditches and other habitats that may serve as conduits for contaminant exposure.

IDENTIFICATION OF PRIORITIES

Priority Management Actions

Information and learning about the effects of management actions on bird populations and life history parameters is of primary interest to individuals attempting to manage bird populations directly, or estimate the non-target effects of other management activities on birds in the coastal zone. The GoMAMN value model (Figure 2.2) prioritizes reducing uncertainty about effects of management actions on bird populations as one of the three main categories of values that relate directly to birds. In the case of cranes, many of the species are of critical conservation concern because of small population size, and direct management is needed to boost life history parameters and affect population size. Although the long-legged wading bird section has fewer endangered species than the cranes, many long-legged wading bird species are declining, in some cases rapidly, and many of these species are seen as indicators of wetland health. One of the challenges for this group is that individuals may be nomadic, and coordinated management actions are therefore needed throughout the range of these species. Priority management actions and monitoring goals are outlined in Table 8.2.

As above, we have split the priority management actions for wading birds into cranes, and long-legged wading birds.

CRANES. For cranes, land use, land management, and land conversion are thought to be management actions (Figure 8.1 and Appendix 8) that most strongly affect nesting, foraging, and roosting habitat for the representative species (Table 8.1). Burning practices in particular, have been repeatedly identified as having a strong influence on suitability of habitat for Mississippi and Florida Sandhill Cranes (USFWS 1991, Hereford 1995, FWC 2013), and on the use of upland habitats by Whooping Cranes in winter (Chavez-Ramirez et al. 1996). When burning is not possible due to smoke management concerns or other constraints, forestry mulching or other mechanical treatment to reduce woody vegetation can restore or maintain openness. Ecological restoration activities may also strongly influence different types of habitat, particularly where they affect open habitats and areas of degraded stopover, roosting, or feeding habitat. Freshwater management is also of critical concern for this group because of the linkage between hydroperiod and food production, water depth and predation, and freshwater flows and estuarine habitat suitability.

For Whooping and Sandhill cranes, water levels are of prime concern for management for a number of reasons. Roosting sites are of particular importance since cranes are exposed to greatly increased predation pressure when roosting in dry or partially dry sites. However, it remains unclear how much predation at these sites affects population size and demographic processes relative to other stressors. Measuring this effect is therefore a priority management need. For Whooping Cranes, flooded areas are known to be a critical resource on the breeding sites in Canada, but thresholds and net effect of breeding ground hydrology on demography is poorly understood. Data on this relationship are therefore a priority need for breeding area management. The majority of the wild Whooping Crane population winters in coastal estuarine habitat in Texas, and estuarine crabs are an important food source. Freshwater mixing in the estuary is probably important for maintaining crab populations, and management of upstream freshwater flow has been contentious and a focus for this species. However, the specific relationship between freshwater flow and crab abundance in the Aransas area is not well understood, and a focus on that question is a priority need to direct water management strategies. For Mississippi Sandhill Cranes, fire is known to be a critical force for maintaining open, coastal savannas that are preferred habitat. Before burning can be fully developed as a tool, we need an understanding of how much habitat is ultimately created or needed under different burning regimes. For all cranes, mortality from powerline and vehicle collisions is known to be a frequent problem, and for species with small population sizes, can have a significant effect on populations (Stehn and Wassenich 2008, Martin and Shaw 2010). Before management can be enacted on this subject, we need to know more about the degree to which powerline collisions affect demography, and the conditions under which powerline collisions occur.

Similarly, Whooping Cranes and Mississippi Sandhill Cranes have a critically low population size, and losses of long-lived adults have a particularly strong effect on demography. In recent years several individuals have been shot—the degree to which these illegal activities can be curtailed is not known

LONG-LEGGED WADING BIRDS. Reddish Egrets are listed as threatened or of concern at federal and state levels, and their close association with particular kinds of estuarine and marine habitat that are dynamic, and often at risk, put them on the front lines of management action. Along with many other species, Reddish Egrets often nest on dredge

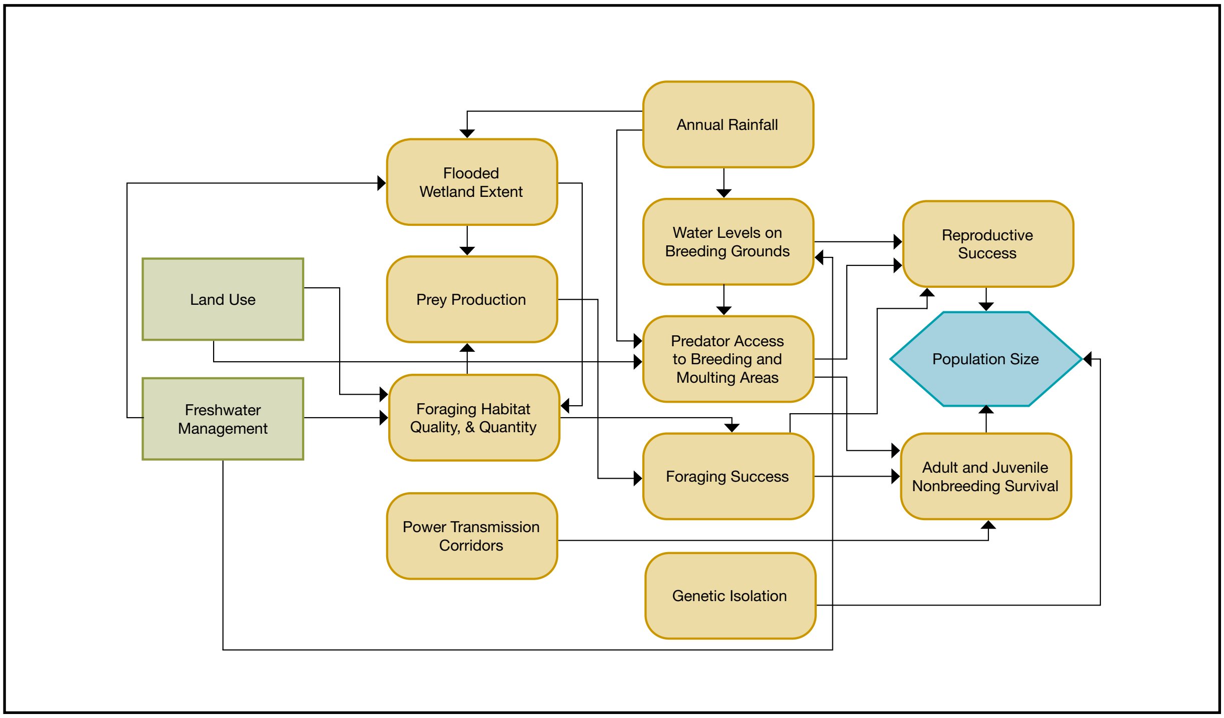

Figure 8.1. *Influence diagram of the relationship between management actions (green boxes), intermediate processes (gold boxes) and population size (blue hexagon) for the* ***Florida Sandhill Crane*** *(Antigone canadensis pratensis) within the Gulf of Mexico Region (see Appendix 8 for additional influence diagrams for other priority wading birds).*

spoil islands. Since dredging and deposition of material is a likely restoration response to various coastal issues, dredging activities could have a large impact on several wading bird species (Figure 8.1 and Appendix 8). It is unknown, however, whether nesting sites are limiting for these species, and if they are, under what conditions dredge spoil islands will be used if created (e.g., proximity to foraging habitat, disturbance or predators), resulting vegetative structure, island size, etc. This information could lead to a powerful management tool for several species and is thus, a high priority. Dredging activity is also of interest because in the case of Reddish Egret, it could be used to create the shallow, sparsely vegetated flats that are a preferred foraging habitat for this species. It is unclear, however, whether flats created from dredge material have or could have the same foraging value as natural flats. A comparison of foraging and nest success of birds foraging on natural and dredge material flats is therefore a priority for directing this potentially important management tool.

Similarly, nest success by most of the herons, ibises, and storks on the list are known to be strongly affected by quality of foraging habitat (Beerens et al. 2015; Figure 8.1 and Appendix 8). The role of hydroperiod is known to be critical to both abundance and composition of the fish community and nest success in the Everglades, and management of hydroperiod is therefore, effective as both a predictive and manipulative tool for managing these populations. While this information probably has some value for managing marshes outside of the Everglades, the relationships could be quite different, especially where riverine flow dominates, and where nutrient budgets are different than the oligotrophic Everglades. A robust understanding of those relationships (reproductive and foraging success in relation to hydroperiod) is therefore, needed to fully develop hydrological management in freshwater coastal marshes, and has risen to the level of being a priority need.

A second major driver of prey dynamics for coastal wading birds is salinity regime (Figure 8.1 and Appendix 8). Intermediate salinities of estuaries have been generally shown to be associated with enhanced secondary productivity, and the Everglades has served as a showcase of the effect of coastal salinization on avian foraging and reproductive success (Lorenz and Serafy 2006). As with freshwater hydroperiod (above) the transferability of this information to other coastal areas in the GoM is unknown. However this information could have considerable value both for managing foraging habitat through managing freshwater inflows from upstream, and for

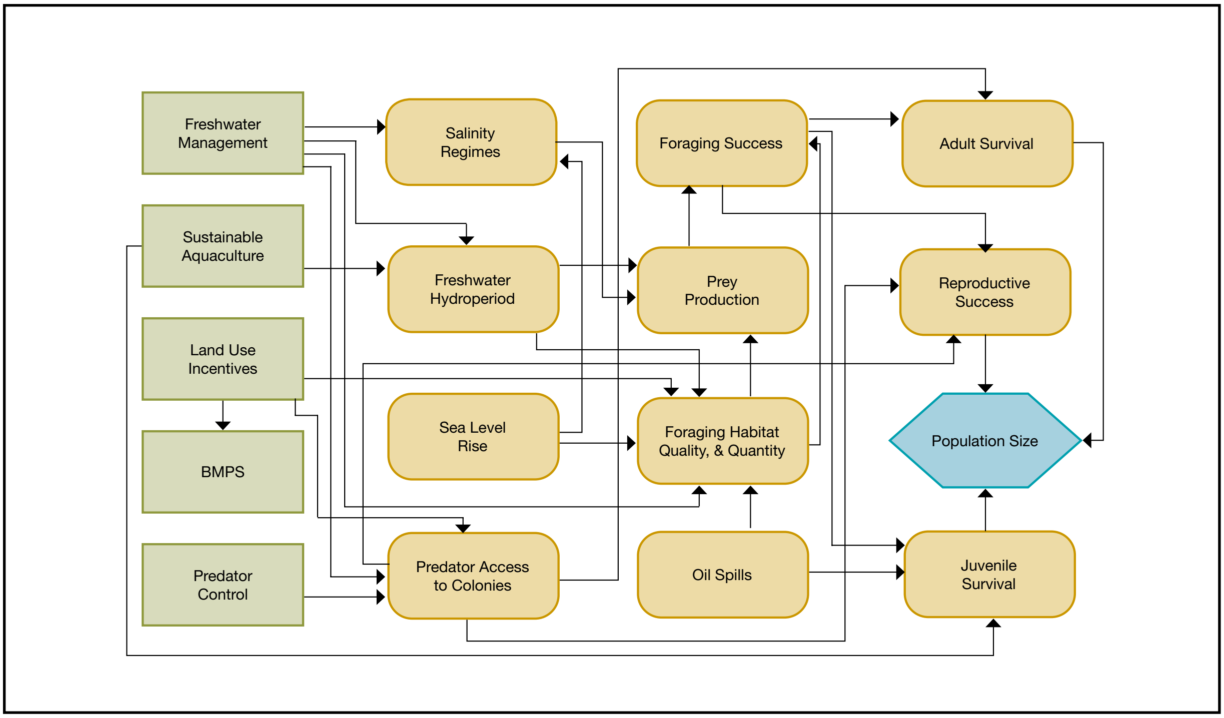

Figure 8.2. *Influence diagram of the relationship between management actions (green boxes), intermediate processes (gold boxes) and population size (blue hexagon) for the* ***Great Egret*** *(Ardea alba) within the Gulf of Mexico Region.*

Wading Birds

Table 8.2. *Uncertainties underpinning the relationship between management decisions and populations of wading birds in the northern Gulf of Mexico.*

Species Season(s)	Management Category[a]	Question(s)	End-point to measure mgmt. performance	Uncertainty Description	Uncertainty Category[b, D]	Effect Size[c, D]
Reddish Egret Breeding, Nonbreeding	Habitat and Natural Process Restoration (Dredging)	Dredging is one of the few ways new nesting habitat is created. Dredging may both create and destroy foraging habitat, and has strong potential to alter currents and flow in foraging habitat. What is the effect of dredging on REEG populations and how can it be used to increase REEG populations?	Comparison of foraging success in dredge spoil and natural habitats of varying ages. Occupancy analysis of colony locations on dredge spoil and natural islands	Both positive and negative effects are possible but neither have been measured. Interplay between open foraging and mangrove and/or SAV density may be key. This may be a powerful tool but the effects are unknown.	High	High
Whooping Crane Nonbreeding	Habitat and Natural Process Restoration (Freshwater Management)	Lack of surface water results in higher predation of adults and juveniles at molting sites. How important is this effect?	Predation rates in relation to water levels at molting sites	Degree to which this occurs is unknown but adults and juveniles are known to be very vulnerable to predation at this stage.	High	Unknown
Florida Sandhill Crane Breeding, Nonbreeding	Habitat and Natural Process Restoration (Freshwater Management)	Foraging habitat is critical to productivity of young. This is strongly affected by local hydropattern, but how strong is this effect on breeding initiation or success?	Nesting success and fledging success in relation to hydroperiod	Difficult to predict variability in rains and therefore difficult to predict population trajectory—this is extremely sensitive to future climate scenarios.	High	High
Roseate Spoonbill, Tricolored Heron, Wood Stork, White Ibis, Great Egret, Little Blue Heron Breeding, Nonbreeding	Habitat and Natural Process Restoration (Freshwater Management)	In freshwater areas, intermediate hydroperiods result in maximal production of small fishes and invertebrates, affecting foraging and nesting success. What is the magnitude of this effect in relation to other influences on reproduction and foraging?	Reproductive success and foraging success in relation to hydroperiod	This mechanism has been clearly demonstrated in the Everglades but has not been investigated in other parts of the range. Other parts of the range may have different relationships. Ability to manage surface water correctly depends on understanding this relationship.	High	High
Tricolored Heron, Roseate Spoonbill, Great Egret, White Ibis, Wood Stork, Whooping Crane Breeding, Nonbreeding	Habitat and Natural Process Restoration (Freshwater Management)	Production of prey may be positively affected by intermediate salinities in coastal areas, dependent upon freshwater flows. Prey productivity affects foraging and nesting success. How important is this effect on reproduction and foraging by wading birds in the coastal GOM?	Forage fish population fluctuation in relation to salinity regimes. Wading bird nest occupancy and success in relation to salinity regimes.	This mechanism has been clearly demonstrated in the Everglades but has not been investigated in other parts of the range. Uncertainty in a) relationship of salinity to forage fish populations, and b) how powerful this effect is in determining nest occupancy and success.	High	High

Table 8.2 (continued).

Species Season(s)	Management Category[a]	Question(s)	End-point to measure mgmt. performance	Uncertainty Description	Uncertainty Category[b]	Effect Size[c]
Whooping Crane Breeding	Habitat and Natural Process Restoration (Freshwater Management)	Flooded areas are a critical resource for initiation of breeding, breeding success and postbreeding survival of chicks. What are the thresholds for this effect on population size?	Need clarification from crane people	Thresholds for demographic effects through timing and level of water are poorly known. Ultimate effect on population trajectory unknown.	High	Unknown
Reddish Egret, Roseate Spoonbill, Tricolored Heron, Wood Stork, White Ibis, Great Egret, Little Blue Heron, Mississippi Sandhill Crane, Whooping Crane Breeding	Invasive/ Problematic Species Control (Predator Management)	Access of colonies or nests to nest predators results in large differences in nest success, driving recruitment and ultimately population size. What affects predator access to colonies or nests?	Predator access in relation to colony characteristics and colony management; inventory of suitable nesting colonies is needed.	Predator presence seems to be driven by distance from land, predator population density, and presence of alligators – but there may be other parameters affecting access, and the factors affecting mammalian predator populations are too poorly understood to be able to manage colonies directly.	High	High
Mississippi Sandhill Crane Breeding, Nonbreeding	Habitat and Natural Process Restoration (Habitat Management - Prescribed Fire)	Changes in fire frequency results in closing in of coastal savannahs and prairies resulting in suboptimal habitat – food and susceptibility to predation are both affected. How much habitat is needed under different burning scenarios?	Habitat quality in relation to burning regime.	How much habitat is needed and how does that affect demography?	High	High
Roseate Spoonbill, Little Blue Heron, Great Egret, White Ibis, Wood Stork, Mississippi Sandhill Crane, Whooping Crane Breeding, Nonbreeding	Habitat and Natural Processes Restoration (Habitat Management - Agriculture)	Productivity/availability of prey in some parts of the range is strongly affected by presence of shallow water aquaculture and rice culture. Prey productivity affects foraging and nesting success. What production practices are most compatible with long legged wading bird foraging/ reproduction in rice/ aquaculture fields, and how strongly can these practices affect reproduction?	Foraging success and nesting success in relation to specific rice aquacultural practices.	Prey productivity and availability are likely to be strongly driven by particular mixes of culture practices, and these effects are poorly understood for wading birds. Risk of mortality through depredation permits is unknown.	High	High
Whooping Crane Breeding, Nonbreeding, Migration	Species Management (Species Stewardship)	Direct mortality through shooting affects survival rates to the point that this may be limiting this very small population. The reasons for shooting are critical to understand.	Mortality due to shooting	Unclear why birds are being shot, and what can be done to reduce this part of mortality.	High	Low

Table 8.2 (continued).

Species Season(s)	Management Category[a]	Question(s)	End-point to measure mgmt. performance	Uncertainty Description	Uncertainty Category[b]	Effect Size[c]
Whooping Crane, Mississippi Sandhill Crane, Florida Sandhill Crane Breeding, Nonbreeding	Site/Area Management (Energy Development)	What features of powerlines are most likely to affect crane mortality rates?	Mortalities due to powerline collisions, in relation to powerline management actions.	Degree of effect is unknown and possibly changing; interventions are available but their effect is poorly understood.	High	Unknown

[a]Categories follow the classification scheme and nomenclature presented by Salafsky et al. (2008) and Conservation Measures Partnership (2016).
[b]Based on expert opinion using two levels of classification (high level of uncertainty or low level of uncertainty) based on anecdotal observations and published literature.
[c]Based on expert opinion using three levels of classification (high, low, and unknown) per the potential positive or negative impact on a population. Where high represents the likelihood of a major impact; low represents a minor impact; and unknown represents unknown consequences.
[d]To facilitate decision making, we utilized a scoring rubric that contrasted the degree of uncertainty against the presumed population effect size, where High-High=1 (highest priority); High-Unknown=2; Low-Unknown=2; Low-High=3; High-Low=4; and Low-Low=5 (lowest priority). Here, we only present questions that scored a 1, 2, or 3.

predicting net effects on long-legged wading bird populations in relation to sea-level rise. Sea-level rise may also be pushing oligohaline zones upriver and into coastal freshwater marsh systems, effectively reducing habitat availability and possibly reducing productivity of wading bird foraging habitats. Monitoring nest success and occupancy of long-legged wading birds in relation to local salinity regimes in foraging habitat is therefore a priority.

Because long-legged wading birds depend on high prey availability in shallow water for foraging (Gawlik 2003), shallow water aquaculture of various types is often an attractant, and in some parts of the range (Louisiana) may be a dominant part of the wetland landscape. Rice and crawfish aquaculture, in particular, produce large quantities of invertebrate and vertebrate prey in depths preferred by wading birds (Fidorra et al. 2015), but culture of aquarium, bait- and food fish may be equally important in some regions. The relationship may, in many cases, be beneficial to wading birds, but dependence of bird populations on aquaculture may make them susceptible to frequent and sometimes widespread interruptions in food supply due to conversion to other crops dictated by market forces, and changes in culture practices. Further, the majority of rice/crayfish aquaculture is centered in southwest Louisiana, which is vulnerable to salinization as sea-level rise continues and coastal marshes erode. This could have a large effect on wading bird populations, but little is known about the risks of this problem. It is also unclear to what extent the relationship of birds and aquaculture causes mortality due to animal damage control efforts. Both beneficial and detrimental aspects of the relationship with aquaculture are potentially strong, but there is not enough specific knowledge about nesting success or nesting propensity in relationship to specific aquaculture practices, certainly not enough to predict whether a population-level effect is likely. Enlightened management of this relationship requires more information about nesting and survival of birds in relation to rice and crawfish aquaculture. This priority should include annual information about the extent and type of aquaculture throughout the southeast.

Most of the long-legged wading birds nest colonially in locations isolated from high ground by water as part of a strategy to avoid nest predation (Post and Seals 1993). This mechanism depends in part on the action of alligators, that are attracted to colonies by dropping food, but also serve to deter nest predation by aquatic mammals (Burtner and Frederick 2017, Nell and Frederick 2015). Since wading birds have no other form of group or individual nest defense, these mechanisms have direct effects on nest success, nesting location, and ultimately population size (Tsai et al 2016, Nell and Frederick 2015). As medium-sized mammals like raccoons and opossums become more abundant in response to agriculture practices and urbanization patterns, this effect is likely to become magnified. Several management actions are possible (Table 8.2, Figure 8.1 and Appendix 8), including predator control, management of surface water, alligator management, management of encroaching floating mats around colonies, and creation of colony islands. However, use of these practices is hampered by specific knowledge about the effect size of specific management actions. It is also unknown whether safe colony sites are actually limiting the populations of birds. It is therefore, a high priority to understand: 1) the effect of specific actions on nest predation rates, 2) the conditions that limit access by predators to colonies, and 3) the inventory of suitable islands and forested wetlands throughout the range of the birds. A related problem is overwash and erosion of coastal islands as sea-level rises (Erwin et al. 1995), which can lead to outright loss of nesting habitat. A common reaction is to use dredge spoil to build up nesting islands—but this often increases elevation to the point that mammalian predators can live or at least temporarily shelter on the islands. A better understanding of inundation in relation to predation risk could strongly influence efficacy of constructed nesting islands, and is a high priority.

Priority Status and Trend Assessments

All of the priority species in this group are chosen either because they: 1) are listed species at federal or state levels, 2) had Partners in Flight (2017) Species Assessment scores >3, indicating high uncertainty as to population status, 3) are species that were particularly at risk during the Deepwater Horizon oiling event, or 4) are common species that are able to serve as surrogates for less widespread or less abundant species. For subspecies (i.e., Mississippi and Florida Sandhill Crane) that have not been ranked by the Partners in Flight (PIF 2017) Species Assessment, we have based our prioritization on USFWS and Florida Wildlife Commission (FWC) recent reports on status and trends of these subspecies. Priority monitoring actions for Status and Trends Assessments are provided in Table 8.2.

For long-legged wading bird and crane species, besides the population estimates from PIF, we have limited information for Little Blue Heron, Tricolored Heron, Great Egret, Roseate Spoonbill, and White Ibis (Appendix 1) status and trends at the population level within the Gulf of Mexico. Great Egret, Roseate Spoonbill, and Tricolored Heron populations are stable to increasing, whereas population estimates for White Ibis are uncertain and Little Blue Herons show a slight to moderate decrease (PIF 2017). For these species, we have no long-term monitoring programs across multiple states, but do have some information within regions (e.g., South Florida Wading Bird Report, Texas Colonial Waterbird database). For Reddish Egret, the Reddish Egret Working Group (REWG) maintains a colony database across the Gulf of Mexico (and throughout the species range) with most recent estimates at ~1,100 breeding pairs across the GoM (Wilson et al. 2014), although population trends per se have not been estimated. The breeding population of Wood Storks fluctuates annually, but recent estimates are ~10,000 nesting pairs and stable to slightly increasing trend (USFWS North Florida Ecological Services Field Office).

For the crane species, Whooping Cranes are increasing, both in the wintering population in Texas and the recently established non-migratory population in Louisiana. However, the global population is still critically low and trend estimates should be viewed cautiously. The Mississippi Sandhill Crane remains in critically low numbers (less than 130 individuals) with an estimated 25 breeding pairs (Hereford and Degrickson 2018). The Florida Sandhill Crane population is larger (~4,000–5,000 individuals), and has remained stable to slightly decreasing over the past decade (Nesbitt and Hatchitt 2008).

The species are ranked below as priorities by Partners in Flight (2017) and regional/working group reports.

- **Priority 1** – Mississippi Sandhill Crane, Whooping Crane, Reddish Egret
- **Priority 2** – Little Blue Heron, Wood Stork
- **Priority 3** – White Ibis, Tricolored Heron, Florida Sandhill Crane
- **Priority 4** – Roseate Spoonbill
- **Priority 5** – Great Egret

White Ibis and Great Egret are both numerous and common. In discussions about their value, the Long-Legged Wading Bird Working Group repeatedly cited these two species as widely distributed species that would be valuable for answering management (Table 8.2) and ecological process (Table 8.3) questions across the Gulf (Figure 1.2). These two species serve as bookends of the spectrum related to philopatry (White Ibis = nomadic, Great Egrest = high breeding philopatry), food habits (White Ibis = invertebrate, Great Egret = strictly piscivorous), foraging behavior (White Ibis = tactile forager, Great Egret = visual, stalking, spearing), and water depth requirements (White Ibis = 5–15 cm, Great Egret = 10–30 cm). Quite aside from the PIF scores, monitoring populations of ibises and Great Egrets has high value for understanding the effect of widespread management actions or ecological processes that occur at large geographic scales. They also may be indicative of the range of conditions associated with habitat suitability for many species (see Influence Diagrams). Tricolored Herons were chosen, in part, because of their tendency to breed and feed in coastal estuarine areas, and their foraging habit suggests they may be indicators of small fish populations in shallow waters of estuaries.

Response metrics for status and trends of Mississippi Sandhill Cranes, Whooping Cranes, Reddish Egrets, Little Blue Herons, Wood Storks, Tricolored Herons, Florida Sandhill Cranes, and Roseate Spoonbills are the global

Table 8.3. *Uncertainties related to how ecological processes impact populations of wading birds in the northern Gulf of Mexico.*

Species Season(s)	Ecological Process Category[a]	Question	End point to measure	Uncertainty Description	Uncertainty Category[b, d]	Effect Size[c, d]
Reddish Egret, Roseate Spoonbill Breeding, Non-breeding	Interactions Between Organisms	Is reproductive success driven primarily by foraging success, and is foraging success driven primarily by prey standing stock or density?	Reproductive rates in relation to food availability, habitat suitability, and predation.	Unclear whether other events like disease and predation may also affect demography. Factors affecting prey production are unknown and assumed to be 1) related to quality of mangrove/ submerged aquatic vegetation patches close to foraging areas and/or 2) water quality (e.g. salinity, freshwater flows, turbidity).	High	Unknown
Mississippi Sandhill Crane, Florida Sandhill Crane Breeding	Climatic Processes	By what mecanisms are nesting propensity and nesting success affected by local hydrology and local weather processes?	Nest success in relation to local hydrology.	Difficult to predict variability in rains and therefore difficult to predict population trajectory—this is extremely sensitive to future climate scenarios	High	High
Reddish Egret Breeding, Non-breeding	Climatic Processes	How do hurricanes affect foraging habitat and prey base, and can this mechanism affect demography?	Foraging habitat in response to local hurricane effects.	Mechanisms have not been demonstrated, and degree of effect of both habitat creation and prey production are unknown. Interplay between open foraging habitat and mangrove and/or submerged aquatic vegetation density may be key for this species.	High	Unknown
Reddish Egret, Roseate Spoonbill, Tricolored Heron, Great Egret, Little Blue Heron, White Ibis, Wood Stork Breeding, Non-breeding	Climatic Processes	Will sea level rise affect foraging habitat by altering hydrological and depth characterisstics of existing foraging habitat, and altering salinity characteristics?	Foraging habitat suitability through modeling and measurements in response to sea-level rise.	This process is well known in Florida Bay but not demonstrated elsewhere. Relative contributions of hydraulic effects and salinity effects are unknown. Possibility of creation of novel habitat through sea-level rise and storm action exists but has not been demonstrated.	High	High
Reddish Egret, Roseate Spoonbill, Tricolored Heron, Great Egret, Little Blue Heron, White Ibis, Wood Stork Breeding, Non-breeding	Climatic Processes	To what degree will sea-level rise physically create or destroy foraging habitat through erosion and salinization, leading to altered patterns of vegetative communities and depths of foraging areas.	Rates of foraging habitat flux in relation to sea-level rise.	Rates and mechanisms by which destruction and creation of foraging habitat are unknown but could both be widespread. Predictive abilities are very poor at the moment. Interactions with storms suggests these effects are going to be episodic.	High	High

Table 8.3 (continued).

Species Season(s)	Ecological Process Category[a]	Question	End point to measure	Uncertainty Description	Uncertainty Category[b, d]	Effect Size[c, d]
Whooping Crane Non-breeding	Climatic Processes	How will coastal development and sea-level rise affect wintering habitat for Whooping Cranes?	Wintering habitat acreage and suitability in relation to sea-level rise.	Uncertain how coastal development and mangrove invasion will affect inland movement of habitat; rates and whether habitat can keep up with it. Displacement or loss?	High	High
Mississippi Sandhill Crane Breeding, Non-breeding	Movements of Organisms	To what extent does inbreeding depression affect population trajectories?	Rates of genetic drift and inbreeding depression in relation to chick viability.	Degree to which this process affects survival and recruitment.	High	Unknown

[a]Categories follow the classification scheme and nomenclature presented by Bennet et al. (2009).
[b]Based on expert opinion using two levels of classification (high level of uncertainty or low level of uncertainty) based on anecdotal observations and published literature.
[c]Based on expert opinion using three levels of classification (high, low, and unknown) per the potential positive or negative impact on a population. Where high represents the likelihood of a major impact; low represents a minor impact; and unknown represents unknown consequences.
[d]To facilitate decision making, we utilized a scoring rubric that contrasted the degree of uncertainty against the presumed population effect size, where High-High=1 (highest priority); High-Unknown=2; Low-Unknown=2; Low-High=3; High-Low=4; and Low-Low=5 (lowest priority). Here, we only present questions that scored a 1, 2, or 3.

and local population sizes, and trends based on those sizes. For White Ibises and Great Egrets, total population size is of less interest, but specific responses to priority ecological drivers and management actions is of direct interest.

Priority Ecological Processes

The GoMAMN value model also prioritizes reduction of uncertainty about ecological processes that typically drive avian populations. These are valued because they help us to understand large swings in populations that arise from natural fluctuation in physical or meterological cycles that eventually will allow prediction of population fluctuations in the absence of management actions. All of the species in this group travel widely during their annual life-cycle within the GoMAMN area, and considerable evidence suggests movements are often because of attraction to or repulsion from particular ecological conditions. Understanding such relationships and how they affect demography is of high priority to the GoMAMN value model. Priority Ecological Processes for monitoring are shown in Table 8.3. The ecological processes driving wading bird populations are often related to management actions (e.g., hydrologic patterns and water management) and many are already treated within the Priority Management Actions section. The examples highlighted below are largely independent of specific management actions.

CRANES: Nesting by all three of the cranes is affected by surface water, either as a deterrent to predation, or as a predictor of future water and prey abundance. While this relationship is often quantitatively described, it is extremely difficult to predict future population trajectories because climatic patterns remain too variable to work with effectively. The ability to understand and predict the effects of this relationship depends on 1) more specific relationships between rainfall, local hydrology, and reproductive success, and 2) better downscaled models of future rainfall.

The majority of the Whooping Crane population winters in estuarine marshes of coastal Texas, where the low elevation gradients make coastal marshes susceptible to sea-level rise. Further, with increasing temperatures predicted from climate change, much of the area may transition from saltmarsh to mangrove forest. These are obvious concerns for the future of the primary winter foraging habitat for this critically endangered species. The uncertainties are primarily ones of degree—how fast the habitat will be lost, and ultimately, how much will be lost. A better understanding of this process is a priority because it will lead to a reduction in uncertainty about the future of the population.

The effects of inbreeding depression and genetic drift can become problematic in the current population sizes of all of the crane species or populations of concern to GoMAMN. These effects may be manifested through reduced survival, fecundity, and nest success. Genetic effects are currently unknown, in part, because they may be cryptically embedded or masked in a mix of other, non-genetic effects. It is a priority to understand rates of chick production in relation to genetic measures of drift and introgression.

LONG-LEGGED WADING BIRDS: Foraging success and reproductive rates of long-legged wading birds are strongly influenced by quality of foraging habitat. In the coastal zone, foraging habitat is very likely to be affected by global change processes including SLR, increasing temperatures, and increasing storm frequency and intensity. Some of the mechanisms may be complex—higher sea level may, for example, result in lower annual differences in water level, which birds may depend on seasonally for prey availability. It is unclear whether these processes will create new habitat as old habitat is destroyed, and predicting the net effect and location of the new habitat is of keen interest to imagining future demography and occupancy by wading birds. Monitoring habitat flux and suitability in relation to SLR and storm events in targeted areas and species around the Gulf is therefore of high priority.

Reddish Egrets and Roseate Spoonbills both rely heavily on marine flats and shallows for foraging. Unlike in freshwater wetlands, the factors controlling standing stocks of prey in these habitats are poorly understood, but may be important for predicting habitat quality, occupancy, and nest success. Understanding factors affecting food availability in these habitats is therefore of high priority for these two species. Reddish Egrets rely almost exclusively on very shallow, sparsely vegetated marine flats for foraging. The conditions that create or maintain an inventory of these somewhat ephemeral habitats are not well understood, but severe storms like hurricanes may be cyclically important. Measuring foraging habitat in relation to local storm activity is therefore a targeted priority for this species.

Roseate Spoonbill populations have grown quite slowly from lows in the last century, and there appears to be a considerable lag in occupancy of new, apparently favorable habitat. This lag may be a characteristic of a general tendency towards philopatry or it could be driven by density dependence (i.e., birds begin to move into unoccupied habitat as their population approaches carrying capacity). Understanding which these two processess is dominant could be important to predicting demographic responses, and forming expectations about the timing of responses to the creation or enhancement of habitat. Monitoring long-distance movements of individuals, and their responses to newly created habitat is therefore of high priority for this species.

Great Egret (*Ardea alba*). Photo credit: Robert H. Burton

Large oil spills are clearly anthropogenic in origin in modern epochs, but are not considered a management action in the context of the GoMAMN. Two main classes of effects could strongly affect wading bird populations—direct effects from oiling of eggs, adults, or juveniles would result in expected declines in survival, and/or indirect effects through long-term damage to nesting and foraging habitat and the associated prey base. While the effects are well known in a qualitative sense, the degree, amount, and time to recovery are poorly understood. There are two classes of priority information needed to reduce uncertainty about effects on populations. First, there is a need for information on the dose-response relationship of oil on various species of long-legged wading birds in relation to both survival and future reproduction. Second, there is a need for information on the long-term effect and response time of foraging habitat and prey populations to oiling events.

SUMMARY AND MONITORING RECOMMENDATIONS

★ Establish baseline monitoring of multi-species nesting colonies of all long-legged wading birds to facilitate status and trend assessments. This information can also be used to assess geographical movements, impacts of hurricanes, changes in foraging habitat, and the relationship between foraging habitat variables (salinity and hydropattern) and nesting success. Further, the focus on colonies can also be used to understand the importance of predation, and the effect size of management options that can be used to affect predators and their access to colonies.

★ Evaluate the effects of salinity dynamics on foraging and nesting success of wading birds nesting in estuaries. Salinization and unnaturally pulsed freshwater flows are becoming common in Gulf estuaries, and appear to have strong effects on both foraging habitat, and prey abundance and composition. This knowledge could have strong implications for watershed management throughout the Gulf coast.

★ Evaluate the impacts of sea-level rise and changing temperatures on foraging habitat and potential nesting locations for wading birds. Sea-level rise physically creates and destroys foraging habitat through erosion and salinization leading to altered patterns of vegetative communities (e.g. mangrove intrusion) and depths of foraging areas. Monitoring quality and extent of habitat are both important, and these parameters should be compared to evolving knowledge of habitat needs of each species.

★ Increase knowledge of the relationship between particular aquaculture/rice practices and rotations, and their value to foraging and nesting wading birds. The extent (acreage) of each practice needs to be tracked through time, and the relationship of different practices evaluated for each species.

★ Continue population monitoring of each of the crane species/subspecies. Where possible, relate population dynamics and vital rates (fecundity, survival, longevity) to hydrological variables like hydroperiod, wetted area, and rainfall to further the understanding of the role of hydropattern in propensity and success of nesting and survival of offspring.

★ Perform specific adaptive studies of the effects of prescribed fire and mechanical woody vegetation management on Mississippi Sandhill Crane habitat value in order to establish an effective burn program.

★ Establish a monitoring program that allows rapid assessment of the effect of episodic coastal oiling on long legged wading bird survival and health. This may extend to tracking of survival of individual birds oiled.❦

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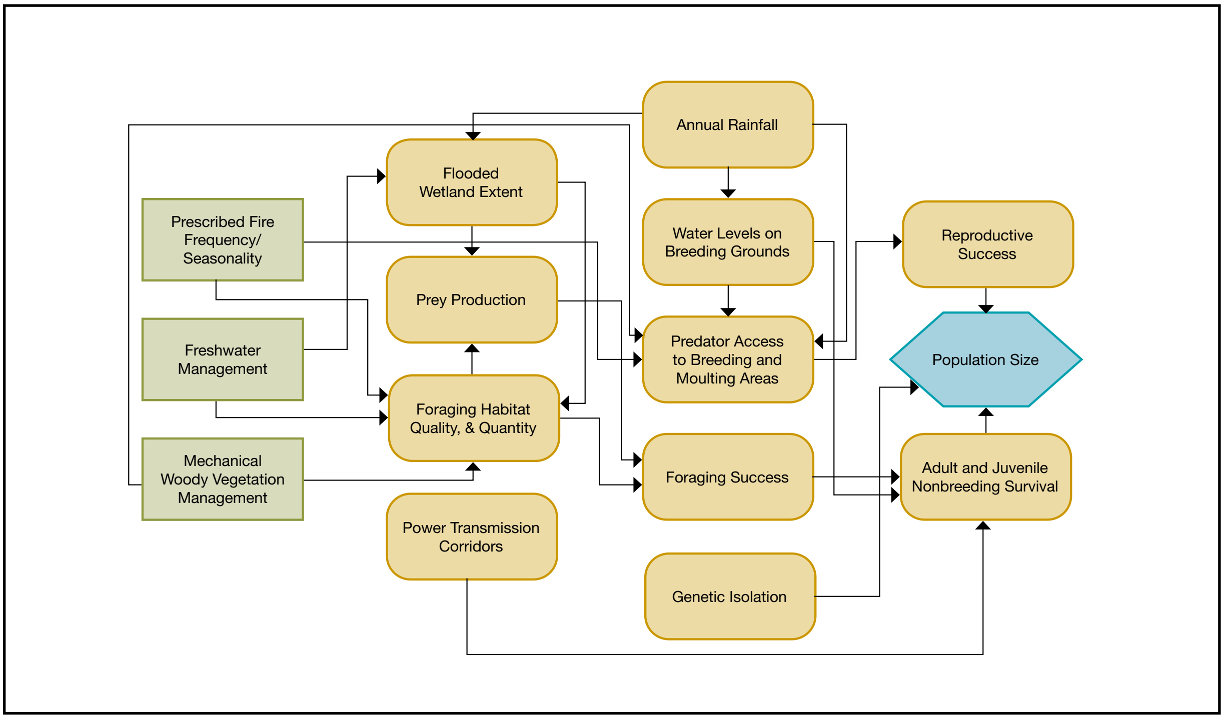
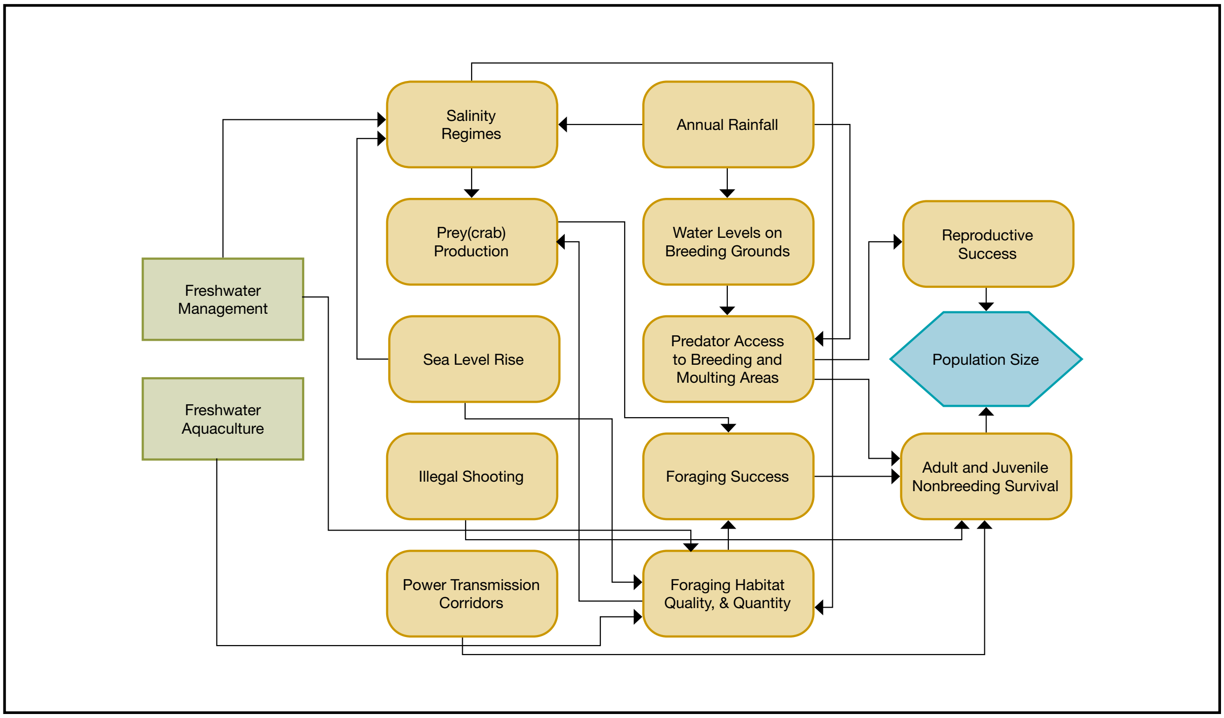
APPENDIX 8

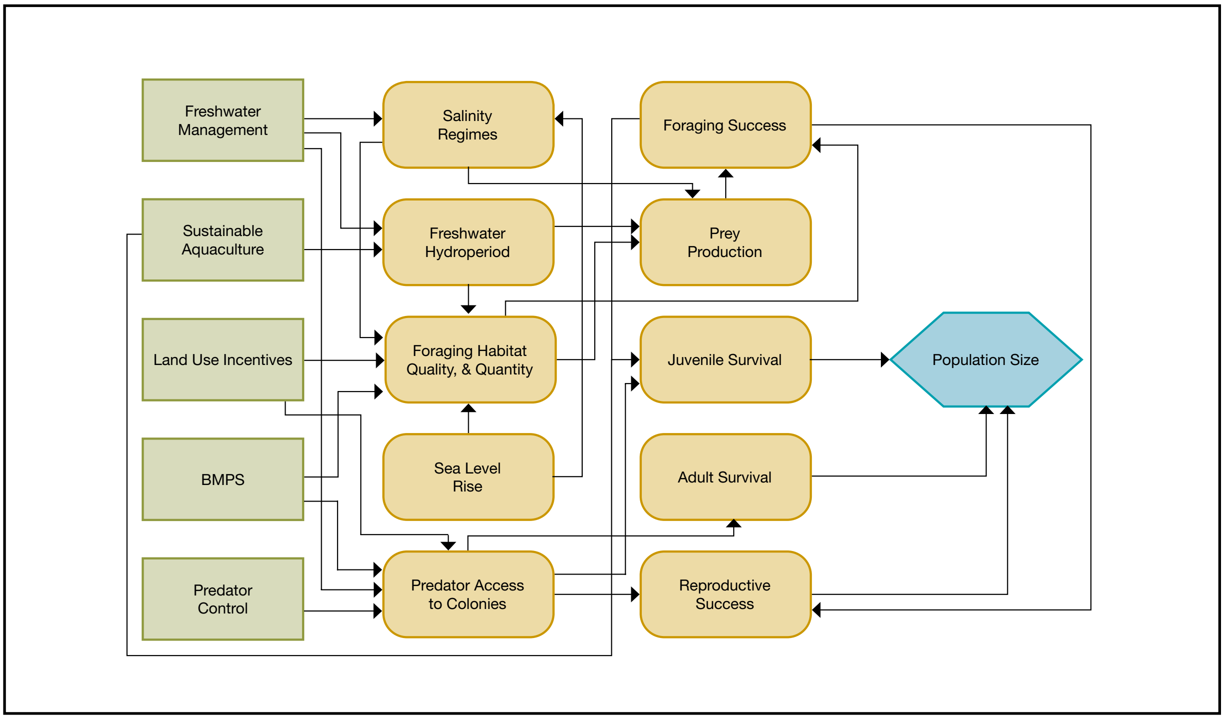
Supplementary influence diagrams depicting mechanistic relationships between management actions and population response of wading birds.



Influence diagram of the relationship between management actions (green boxes), intermediate processes (gold boxes) and population size (blue hexagon) for the ***Mississippi Sandhill Crane*** *(Antigone canadensis pulla) within the Gulf of Mexico Region.*

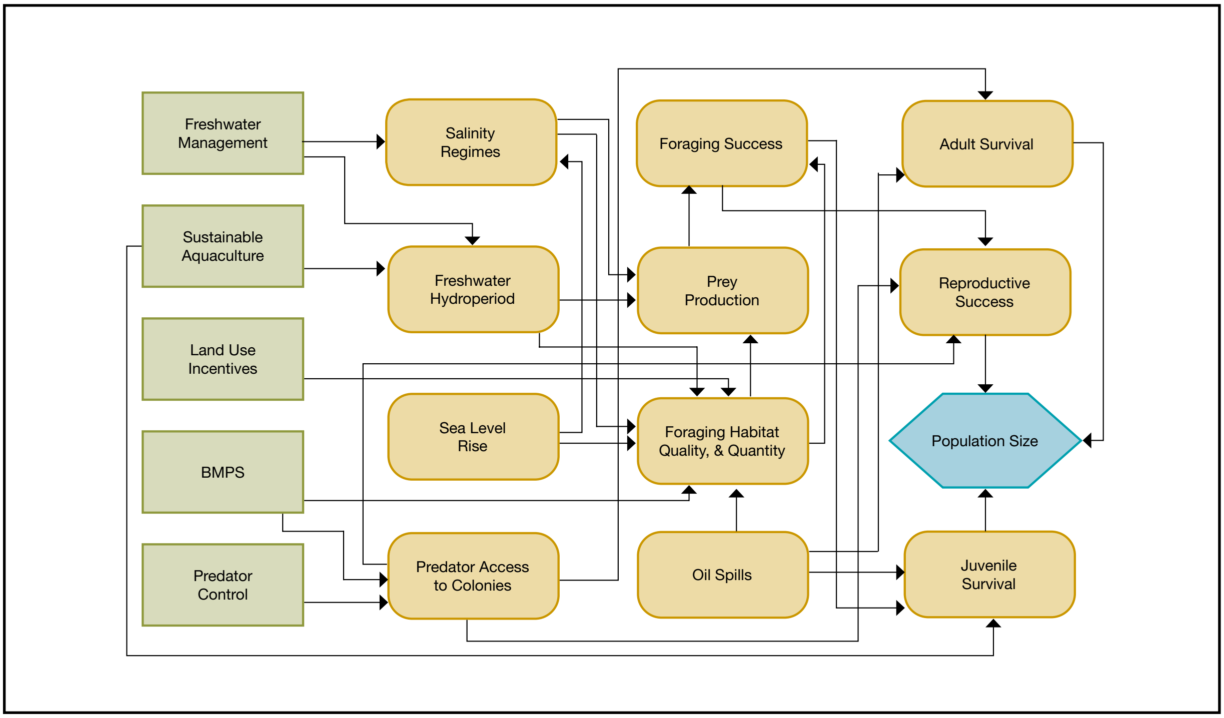


Influence diagram of the relationship between management actions (green boxes), intermediate processes (gold boxes) and population size (blue hexagon) for the ***Whooping Crane*** *(Grus americana) within the Gulf of Mexico Region.*

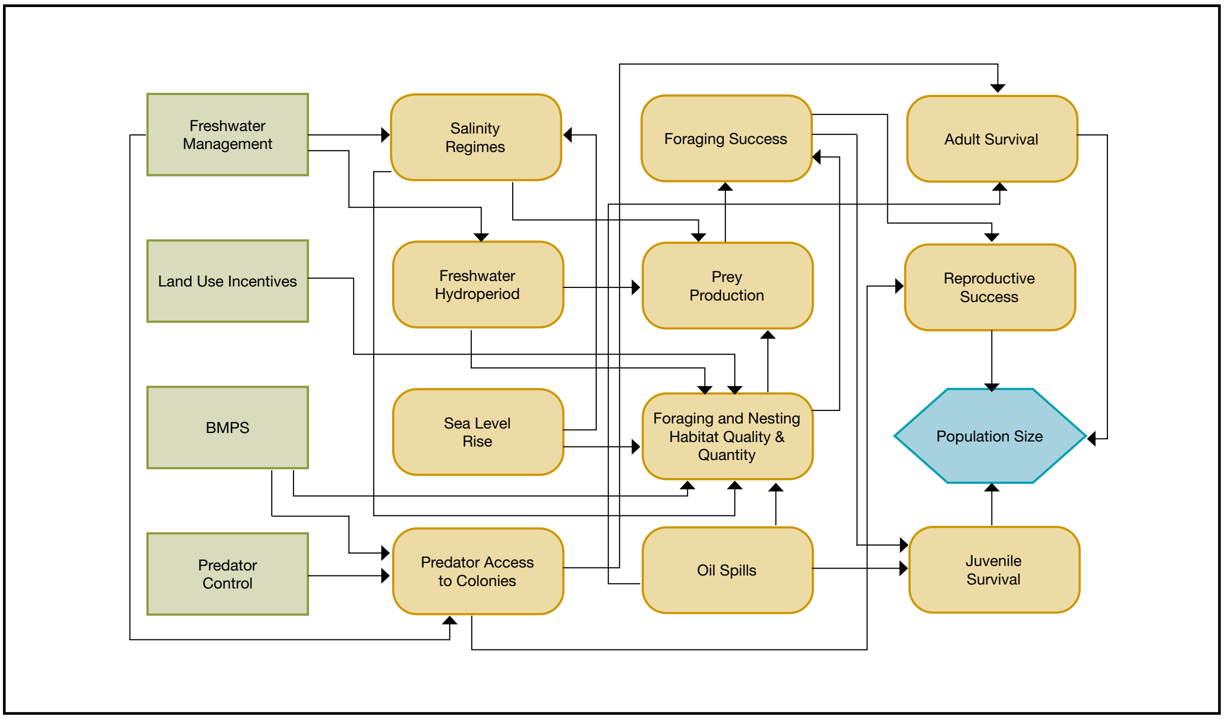


Influence diagram of the relationship between management actions (green boxes), intermediate processes (gold boxes) and population size (blue hexagon) for the ***Wood Stork*** *(Mycteria americana) within the Gulf of Mexico Region.*

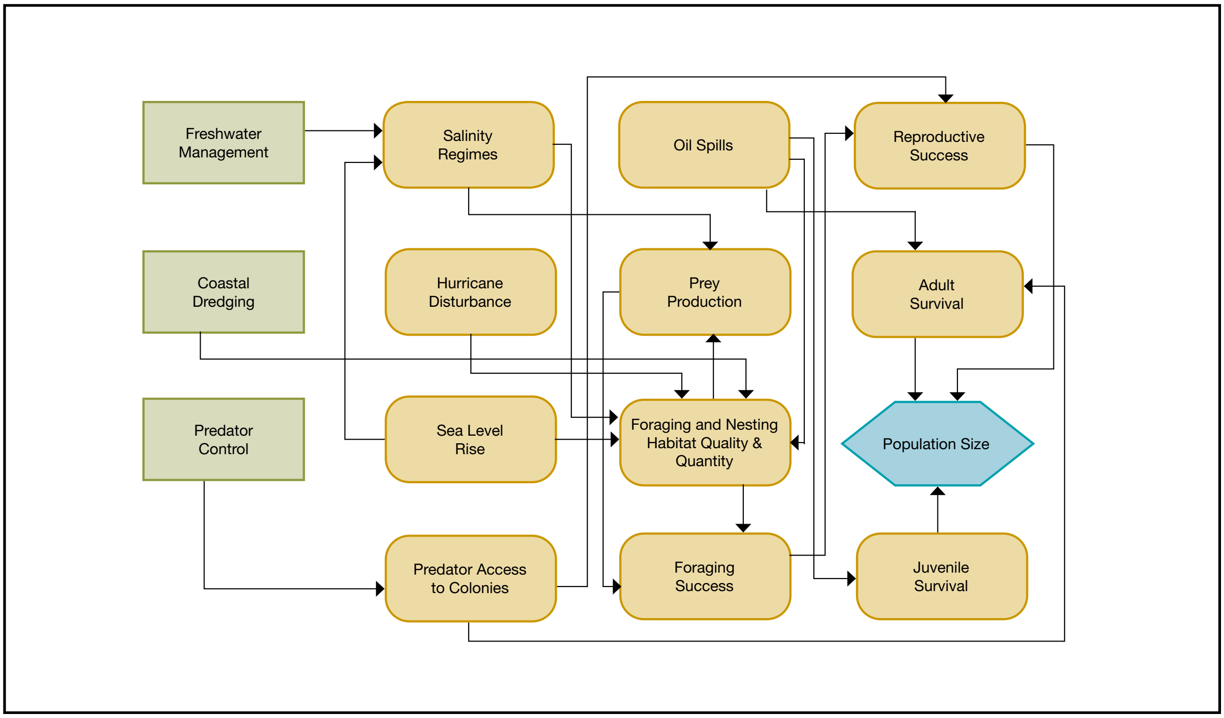
Wading Birds



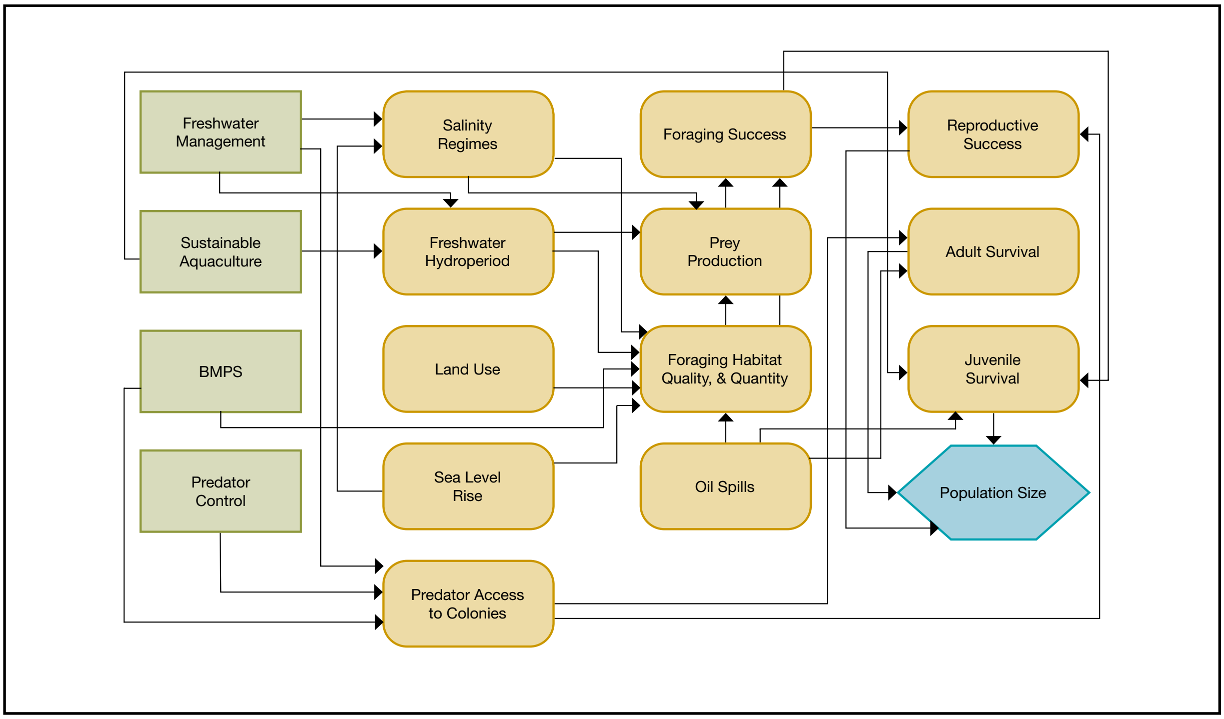
Influence diagram of the relationship between management actions (green boxes), intermediate processes (gold boxes) and population size (blue hexagon) for the ***Little Blue Heron*** *(Egretta caerulea) within the Gulf of Mexico Region.*



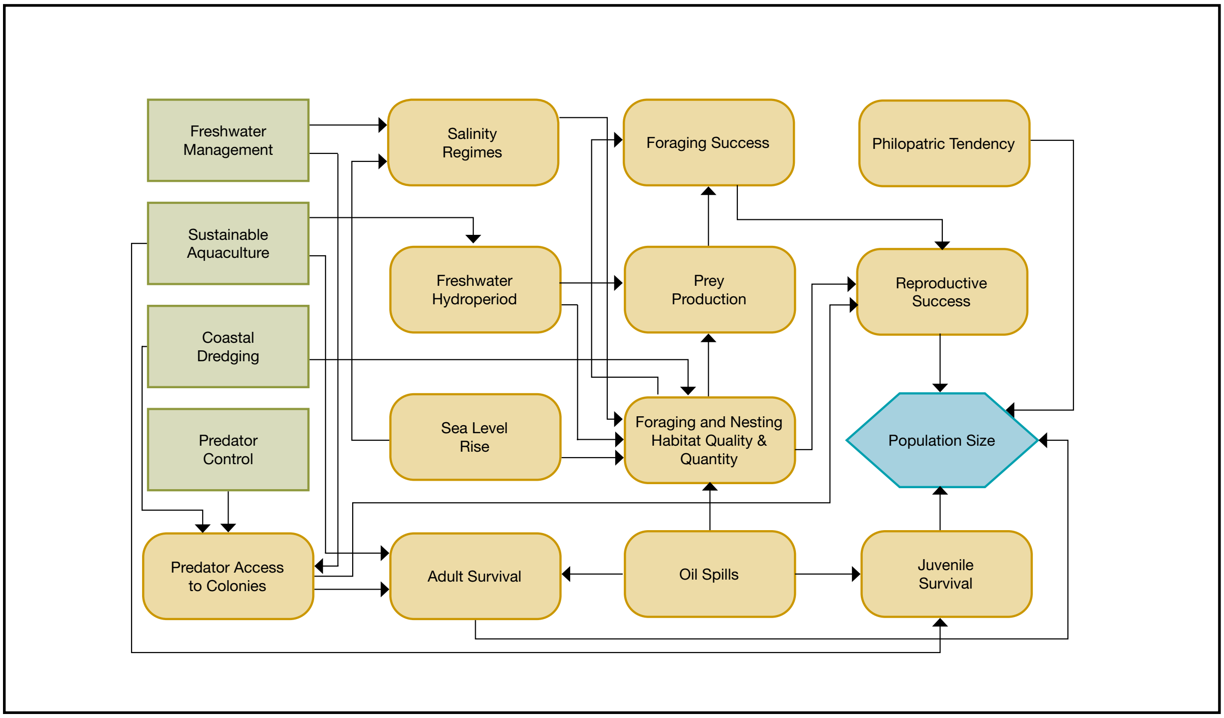
Influence diagram of the relationship between management actions (green boxes), intermediate processes (gold-boxes) and population size (blue hexagon) for the ***Tricolored Heron*** *(Egretta tricolor) within the Gulf of Mexico Region.*



Influence diagram of the relationship between management actions (green boxes), intermediate processes (gold boxes) and population size (blue hexagon) for the ***Reddish Egret*** *(Egretta rufescens) within the Gulf of Mexico Region.*



Influence diagram of the relationship between management actions (green boxes), intermediate processes (gold boxes) and population size (blue hexagon) for the ***White Ibis*** *(Eudocimus albus) within the Gulf of Mexico Region.*



Influence diagram of the relationship between management actions (green boxes), intermediate processes (gold boxes) and population size (blue hexagon) for the ***Roseate Spoonbill*** *(Platalea ajaja) within the Gulf of Mexico Region.*