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Strategic Bird Monitoring Guidelines for the Northern Gulf of Mexico

GoMAMN STRATEGIC BIRD MONITORING GUIDELINES: RAPTORS

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Osprey (*Pandion haliaetus*). Photo credit: George Gentry

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Chapter 5

GOMAMN STRATEGIC BIRD MONITORING GUIDELINES: RAPTORS

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

Few groups of North American birds garner as much veneration as raptors. Members of this diverse group, from the diminutive American Kestrel (*Falco sparverius*) to the formidable Bald Eagle (*Haliaeetus leucocephalus*), have at least one thing in common: they actively hunt other animals, seizing prey with their feet. While the diurnal and nocturnal raptors share a common lifestyle, the hawks and eagles, the owls, and the falcons are only distantly related (Hackett et al. 2008). This divergent ancestry should be considered when threats arise, as responses may differ physiologically and behaviorally.

As apex predators, few adult raptor species need to worry about natural predators—unless a larger species of raptor lurks nearby. Cooper's Hawks (*Accipiter cooperii*), for example, are implicated as predators upon American Kestrels (Farmer et al. 2006), and Great Horned Owls (*Bubo virginianus*) will hunt virtually any species smaller than themselves (Artuso et al. 2013). But their position atop the food web comes at tremendous costs; as predators, raptors are often maligned by humans and, frequently, needlessly and erroneously targeted for destruction (Millsap et al. 2007). Although state and federal law now prohibits such wanton slaughter of wildlife, shooting and poisoning of birds of prey are still unfortunate realities (Harness 2007, Millsap et al. 2007).

Because of their position at the top of the food chain and their conspicuous nature, raptors can often act as sentries of environmental health (Bildstein 2001). When populations of large, predatory, meat-eating birds decrease dramatically in a short period of time, citizen scientists and others tend to notice and seek answers. One frequently cited example is that of the population decline of apex, predatory birds caused by their exposure to the pesticide DDT and its derivatives (Ratcliffe 1970, Grier 1982, Peakall 1987, Henny and Elliott 2007, Blus 2011). The toxins, particularly DDE, the result of degraded DDT, were bioaccumulated and biomagnified through the food web. When concentrated in the tissues of Brown Pelicans (*Pelecanus occidentalis*), Ospreys (*Pandion haliaetus*), Bald Eagles (*Haliaeetus leucocephalus*), Peregrine Falcons (*Falco peregrinus*), and others, DDE caused decreased deposition of calcium in the eggshells, which resulted in accidental breakage by incubating adults (Blus et al. 1971, Blus 2011). In what must be among the greatest conservation success stories of all time, after DDT was banned in 1972, population of pelicans and raptors showed almost immediate signs of a path to recovery (Grier 1982; Holm et al. 2003). In Louisiana, where Bald Eagles decreased to around five active nests by the early 1970s, eagles have now increased to more than 350 active nests as of 2015 (M. A. Seymour, unpublished data). In August 2007, the Bald Eagle was removed from the federal list of threatened and endangered species. In August 1999, the U.S. Fish and Wildlife Service (USFWS) removed the American Peregrine Falcon from the list of endangered and threatened species. Despite their substantial recovery, because many raptors feed on pest species, wildlife biologists must remain vigilant in monitoring raptor populations in case novel pesticides create novel consequences.

An active hunting lifestyle also makes many raptors particularly susceptible to injury and death from collisions and electrocution. Their proclivity to ride thermals and use prevailing winds renders them vulnerable to collisions with structures such as wind turbines and power lines (Pagel et al. 2013, Hunt et al. 2017). Their inclination to hunt along roadsides makes them susceptible to collisions with motor vehicles. Their attraction to roadsides and power line right-of-ways coupled with their tendency to hunt from dominant perches renders them susceptible to electrocution (Avian Power Line Interaction Committee 2006, Bierregaard et al. 2016). Larger species are more at risk of electrocution, because their extremities are more likely to make contact across wires, transformers, fuses, and other energized structures. As the human population grows and expands, so too must the power infrastructure to support it; increased risks of collisions and electrocutions are, therefore, likely without proper "siting and routing, improving line marking devices... and increasing awareness" (Avian Power Line Interaction Committee 2012).

Raptor diversity in the northern Gulf of Mexico (GoM) is high. Including new world vultures, osprey, kites, eagles, hawks, owls, and falcons, the bird checklists from the five states that rim the northern GoM contain 55 species, though several are represented by a handful or fewer records. Especially notable is the Mexican influence of birdlife in Texas, which lists 54 of the 55 species on its official state checklist (Texas Bird Records Committee 2018); Hook-billed and Double-toothed Kites (*Chondrohierax uncinatus* and *Harpagus bidentatus*), Crane and Roadside Hawks (*Geranospiza caerulescens* and *Rupornis magnirostris*), and Collared Forest-Falcons (*Micrastur semitorquatus*), and others are not likely encountered elsewhere within the GoM region. Louisiana and Florida have both recorded 36 species of raptors, and Mississippi and Alabama have both recorded 33 species of raptors (Louisiana Bird Records Committee 2016, Florida Ornithological Society 2016, Mississippi Ornithological Society Bird Records Committee 2015, Alabama Ornithological Society and Alabama Wildlife and Freshwater Fisheries Division 2017). State wildlife action plans from the

Table 5.1. *Raptor species of greatest conservation need as assigned by GoM State Wildlife Action Plans (Texas Parks and Wildlife Department 2012, Florida Fish and Wildlife Conservation Commission 2012, Alabama Department of Conservation and Natural Resources 2015, Holcomb et al. 2015, Mississippi Museum of Natural Science 2015)*

Raptor Species of Greatest Conservation Need from State Wildlife Action Plans						
Common Name	**Latin Name**	**Texas**	**Louisiana**	**Mississippi**	**Alabama**	**Florida**
Osprey	*Pandion haliaetus*		x	x		x
White-tailed Kite	*Elanus leucurus*		x			x
Hook-billed Kite	*Chondrohierax uncinatus*	x				
Swallow-tailed Kite	*Elanoides forficatus*	x	x	x	x	x
Golden Eagle	*Aquila chrysaetos*	x		x	x	
Northern Harrier	*Circus hudsonius*	x				
Bald Eagle	*Haliaeetus leucocephalus*	x	x	x		x
Mississippi Kite	*Ictinia mississippiensis*	x				x
Snail Kite	*Rostrhamus sociabilis*					x
Common Black Hawk	*Buteogallus anthracinus*	x				
Harris's Hawk	*Parabuteo unicinctus*	x				
White-tailed Hawk	*Geranoaetus albicaudatus*	x				
Gray Hawk	*Buteo plagiatus*	x				
Red-shouldered Hawk	*Buteo lineatus*	x				
Broad-winged Hawk	*Buteo platypterus*					x
Short-tailed Hawk	*Buteo brachyurus*					x
Swainson's Hawk	*Buteo swainsoni*	x				
Zone-tailed Hawk	*Buteo albonotatus*	x				
Ferruginous Hawk	*Buteo regalis*	x				
Barn Owl	*Tyto alba*			x		
Eastern Screech-Owl	*Megascops asio*					x
Ferruginous Pygmy-Owl	*Glaucidium brasilianum*	x				
Burrowing Owl	*Athene cunicularia*	x				x
(Mexican) Spotted Owl	*Strix occidentalis lucida*	x				
Short-eared Owl	*Asio flammeus*	x	x	x	x	x
Crested Caracara	*Caracara cheriway*		x			x
(Southeastern) American Kestrel	*Falco sparverius paulus*	x	x	x	x	x
Merlin	*Falco columbarius*					x
Aplomado Falcon	*Falco femoralis*	x				
Peregrine Falcon	*Falco peregrinus*	x	x	x		x

GoM region include 30 species (Texas Parks and Wildlife Department 2012, Florida Fish and Wildlife Conservation Commission 2012, Alabama Department of Conservation and Natural Resources 2015, Holcomb et al. 2015, Mississippi Museum of Natural Science 2015; Table 5.1). From this list of species of greatest conservation need (SGCN), six species were chosen by the Raptor Working Group of the GoMAMN: an obligate fish-eater (Osprey); an acrobatic, aerial forager (Swallow-tailed Kite; *Elanoides forficatus*); a formidable predator and occasional scavenger (Bald Eagle); a crepuscular marsh and grassland dweller (Short-eared Owl; *Asio flammeus*); a strikingly dimorphic, cavity-nester (Southeastern American Kestrel; *F. s. paulus*); and a hard-hitting, aerial assailant (Peregrine Falcon). These six eclectic birds represent the Raptors of Conservation Concern on which to concentrate efforts to reduce uncertainty of the ecological processes and the management actions that affect our GoM raptors (Table 5.2).

Breeding season

Forty species of raptors have been known to nest in the five states of the GoM region. Of those forty species, approximately 26 species nest within the GoMAMN boundary. In general, 13 of the 26 species nest in forested landscapes, while the other 13 prefer grasslands for nesting. However, several species nest in trees, but require open forest or grassland for foraging (e.g., Swallow-tailed Kite and American Kestrel), which makes this generalized classification less clear. An increase in open habitats such as agriculture and pastureland has likely fueled the expansion of traditionally grassland species further east; Swainson's Hawk (*Buteo swainsoni*) and Crested Caracara (*Caracara cheriway*), for example, have rapidly expanded their breeding ranges from southwestern through the south-central regions of Louisiana within the last two decades (Morrison and Dwyer 2012; M. A. Seymour, unpublished data). Other species have benefited from anthropogenic habitat disturbances as well, often at the expense of other native birds. Great Horned Owls readily use sparsely wooded neighborhoods, which when adjacent to upland pine and bottomland hardwood forests, create conflict with nesting Swallow-tailed Kite, a Raptor of Conservation Concern. Like the presumed depredation of American Kestrels by Cooper's Hawks (Smallwood et al. 2009), a species that has also increased in abundance in the region, loss of kites to Great Horned Owls may be a factor in continued declines of these imperiled birds (Coulson et al. 2008).

A cosmopolitan species, found on every continent except Antarctica, the piscivorous Osprey nests throughout the GoMAMN focal area in estuarine and palustrine forested wetlands and emergent wetlands (Bierregaard et al. 2016). Nests are often constructed at the tops of standing snags, cypresses, mangroves, telephone poles, electrical transmission towers, telecommunication towers, and nesting platforms; ground-nesting may occur in areas without suitable vertical structure and without mammalian predators (Bierregaard et al. 2016). Because Ospreys are piscivorous, nests are almost always close to waterbodies and are often built atop structures in water such as standing boles of baldcypress (*Taxiodium distichum*). The breeding season in Texas through central Florida begins in February (early) or March (more likely), with the earliest nesting occurring in south Florida beginning in late November (Florida Fish and Wildlife Conservation Commission 2003, Tweit 2006b, Bierregaard et al. 2016). The Osprey is a rare nester in Texas, with possible, sporadic nesting at Port Isabel through Matagorda Bay up to approximately Port Arthur. Elsewhere within GoMAMN, the Osprey is a common nester, with concentrations in Louisiana in the lower Atchafalaya River, Mississippi River, and Pearl River drainages; in Mississippi, in the barrier islands, lower Pascagoula River and Escatawpa River drainages and Grand Bay National Estuarine Research Reserve; in Alabama, in the barrier islands and Mobile Bay; and in Florida, along the Gulf Coast through the Florida Keys. Recovery of Osprey populations following the DDT era was greatly enhanced by provisioning artificial nesting platforms (Houghton and Rymon 1997). Three thousand or more nesting pairs of Ospreys occur within the five GoM states (Bierregaard et al. 2016).

Like nests of the Osprey, those of the Bald Eagle, a North American endemic, are most often found near permanent waterbodies, particularly within palustrine forested wetlands (Buehler 2000). Nests are constructed upon similar substrates as those of Osprey. However, due to the large size and the substantial mass of nests, Bald Eagle nests are rarely constructed atop pole-like structures. Instead, eagles tend to use strong crotches of large trees such as baldcypress. However, where access to large trees is limited, mangroves, electrical transmission towers, telecommunication towers, and nesting platforms may be used (Buehler 2000). In fact, in many areas of the GoMAMN geography, particularly where baldcypress or other suitable trees are scarce or compromised by saltwater intrusion, Bald Eagles are increasingly found nesting on manmade structures. Where vertical structures are scarce, ground-nesting may occur (Buehler 2000). Bald Eagles typically build alternate nests within their territories; such nests may remain unoccupied for several years before becoming active again. This behavior of maintaining multiple, serviceable nests has led to the protection of all eagle nests, whether active or inactive, under the Federal Bald and Golden Eagle Protection Act. Because Bald Eagles have a more varied diet than Ospreys, eagles may frequently nest in large,

Table 5.2. *Raptor 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	Winter	Migration	Landcover Association(s)[a]	Trend Score	Continental Concern Score
Osprey	*Pandion haliaetus*	X	X		Palustrine Emergent Wetland, Palustrine/Riverine Forested Wetland, Lacustrine Forested Wetland, Estuarine Forested Wetland, Estuarine Emergent Wetland (brackish to saltwater marshes), Estuarine-Tidal Riverine Open Water	1	7
Swallow-tailed Kite	*Elanoides forficatus*	X		X	Palustrine Forested Wetland (bottomland hardwoods), Lacustrine/Riverine, Estuarine Forested Wetland, Upland Evergreen Forest (Wet Longleaf and Slash Pine Flatwoods & Savannas), Grassland (including pasture), Cultivated (row crops)	3	12
Bald Eagle	*Haliaeetus leucocephalus*	X	X		Palustrine Emergent Wetland, Palustrine/Riverine Forested Wetland, Lacustrine Forested Wetland, Estuarine Forested Wetland, Estuarine-Tidal Riverine Open Water	1	9
Short-eared Owl	*Asio flammeus*		X		Grassland, Upland Scrub/Shrub, Upland Evergreen Forest (Dry & Mesic Longleaf Flatwoods, Xeric Longleaf Pine Barrens), Beach/Dune, Cultivated (rice), Palustrine Emergent Wetland, Estuarine Emergent Wetland	5	12
(Southeastern) American Kestrel	*Falco sparverius paulus*	X	X		Grassland (including pasture), Upland Scrub/Shrub, Upland Evergreen Forest (Dry & Mesic Longleaf Flatwoods, Xeric Longleaf Pine Barrens), Upland Mixed Forest	4	11
Peregrine Falcon	*Falco peregrinus*		X	X	Grassland, Palustrine Emergent Wetland, Palustrine/Riverine Forested Wetland, Lacustrine Forested Wetland, Estuarine Forested Wetland, Estuarine Shrub/Scrub Wetland, Estuarine Emergent Wetland, Estuarine-Coastal, Beach/Dune, Urban, Cultivated (rice)	2	10

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

isolated trees within agricultural landscapes where they feed on waterbirds and carrion. In fact, the southern Bald Eagle is primarily a winter nester—likely taking advantage of the exceptional waterfowl abundance that occurs during winter. The nesting season extends from September through July (J. O. Coulson, unpublished data), with "occasional second clutching" in Florida (Florida Fish and Wildlife Conservation Commission 2003). Confirmed nesting of Bald Eagles extends discontinuously from the coastal bend of Texas through the Florida Keys; the species is an uncommon nester in coastal Mississippi, Alabama, and much of the Florida Panhandle until approximately Tallahassee, Florida (Turcotte and Watts 1999, Florida Fish and Wildlife Conservation Commission 2003, Tweit 2006a, Alabama Ornithological Society 2009; M. A. Seymour, unpublished data). Bald Eagle populations have continued to recover from the DDT era, when 417 breeding pairs were estimated in the contiguous U.S.A. in 1963 (Buehler 2000); by 2007, almost 10,000 pairs were estimated across the same area, 35 years after the ban of DDT (USFWS 2009). More than 1,900 pairs of eagles currently

Bald Eagle (*Haliaeetus leucocephalus*). Photo credit: Dave Menke

nest from Texas to Florida (Turcotte and Watts 1999, Tweit 2006a, Alabama Ornithological Society 2009, Zimmerman et al. 2017; M. A. Seymour, unpublished data). The spectacular recovery of the Bald Eagle was aided by state and federal wildlife agencies, who reintroduced eagles throughout their former range and mounted effective environmental education efforts.

Another species found in palustrine forested wetlands, the Swallow-tailed Kite once nested in as many as 21 states in the U.S.A. (Meyer 1995). The dramatic population decline and range reduction that occurred from 1880 to 1940 may have been due to large-scale logging of nesting habitat. Now regularly breeding in only seven southeastern states, this aerial forager is, nevertheless, conspicuous and unmistakable where found (Meyer 1995). Swallow-tailed Kites are early returnees from wintering grounds in South America to their breeding grounds in the Southeast, arriving as early as late February. Nesting begins almost immediately, with egg-laying in March through May and with nests typically placed high in the fork of an emergent tree, often a pine species (*Pinus*), baldcypress, Eastern cottonwood (*Populus deltoides*), or sweetgum (*Liquidambar styraciflua*)(Meyer 1995, J. O. Coulson, unpublished data). Vertebrate prey items like frogs, lizards, and nestling birds are gleaned from trees; but Swallow-tailed Kites also frequently forage over agricultural lands and other open grasslands where they hunt insects and other small organisms (Meyer 1995). Although the U.S.A. population of Swallow-tailed Kites appears stable or slightly increasing in the core of its range, active management needs to be maintained or increased to create suitable nesting habitat, particularly uneven or all-aged forests with live, emergent trees. Only 1,200 or so nesting pairs are extant in the U.S.A., and most of those occur within the GoMAMN geography—demonstrating the responsibility of our region to the persistence of this rare species. Moreover, the U.S.A. breeding population is disjunct; it is geographically separated from the next nearest breeding subpopulation by most of Mexico.

The American Kestrel, a small, brightly colored falcon, is one of the most abundant raptors in the USA with an estimated population of 2.5 million (Partners in Flight 2017). Despite its abundance, there is growing concern that the species is declining throughout its range (Smallwood et al. 2009). Although the species generally responds well to human encroachment, the southeastern subspecies of American Kestrel (*F. s. paulus*) has failed to rebound from the widespread harvest of pines in its native habitat, the longleaf pine (*Pinus palustris*) savanna. In the GoMAMN geography, the Southeastern American Kestrel occurs from east Texas (Seyffert 2006) to most of Florida (Florida Fish and Wildlife Conservation Commission 2003), but exact distribution, especially throughout its life cycle, is still unresolved. This cavity nester relies on woodpeckers to create natural cavities in trees and is a permanent resident in our region where it can be found in open pine habitats and adjacent grasslands (Smallwood and Bird 2002). American Kestrels also readily accept manmade nest boxes, and provisioning such artificial cavities in suitable habitat has been shown to be an effective conservation measure for the southeastern subspecies (Smallwood and Collopy 2009). The breeding season extends from March to July through most of the Southeast. Kestrels prey on a variety of small animals from invertebrates like grasshoppers to small vertebrates like lizards, mice, and birds, most of which are captured by sitting-and-waiting hunting. The species' hunting style and food preference necessitate open habitats for successful foraging (Smallwood and Bird 2002). Open pine habitats and other grassland types in the Southeast were historically maintained by natural fires; the exclusion of fire in these systems, coupled with incompatible natural resource usage, has greatly decreased available nesting and foraging habitats in our region, likely the main factor in the decline of the southeastern subspecies. Like the Swallow-tailed Kite, almost the entire breeding range of the southeastern subspecies of American Kestrel occurs within the GoMAMN boundary; monitoring of the species and reducing uncertainty of the interactions of various life history parameters and drivers are the responsibility of our region. Mcclure et al. (2017) provides commentary on elucidating the kestrel's decline.

Two of the six GoMAMN Raptors of Conservation Concern, Peregrine Falcon and Short-eared Owl, do not nest in the GoMAMN geography, instead utilizing the region during migration and nonbreeding (winter) months (White et al. 2002, Wiggins et al. 2006). A powerful and agile raptor, the Peregrine Falcon is a cosmopolitan species, occurring on all continents except Antarctica (White et al. 2002). Apparently, Peregrine Falcons never nested in the GoMAMN geography, and within the five GoM states, it currently only nests in the western Rio Grande Joint Venture region in Brewster Co., Texas (McKinney 2006). The Short-eared Owl breeds in open habitats on five continents (all except Antarctica and Australia) where it preys mostly on small mammals and the occasional bird. The species does not nest in the GoMAMN geography or within any of the states along the Gulf Coast (Wiggins et al. 2006).

Spring and autumn migration seasons

Raptor abundance and distribution in North America change with seasonal migration. These movements most often result from changes in the seasonal distribution and abundance of food resources. Peregrine Falcons, for example, fly south in autumn to hunt shorebirds and waterfowl, which are more abundant and concentrated during that season and during winter. Of 26 raptor species that breed within the GoMAMN geography, four species mostly or entirely leave the region during late summer and autumn, returning to breed the following spring: Swallow-tailed and Mississippi Kites and Broad-winged and Swainson's Hawks; small numbers of the latter two species remain in the region in south Texas; the Bird's Foot Delta, Louisiana; and peninsular Florida in winter. As primarily winter nesters, southern Bald Eagle exhibit an unusual migratory pattern, flying north in spring after nesting, and often covering substantial distances as evidenced by satellite telemetry studies (Mojica et al. 2008, Smith et al. 2017). However, a small proportion of the southern Bald Eagle population can be found in the GoM region at any time of the year (J. O. Coulson, unpublished data).

Birds of prey frequently use visual cues such as rivers and coastlines for navigation, refueling, and resting at stopover sites along the route (Goodrich and Smith 2008). The geography of most of the GoM region precludes a funneling effect of migrant raptors in spring, but circum-Gulf migrants are readily observed along the Gulf Coast as they travel through Texas and Florida. Unlike many migratory landbirds, which frequently migrate at night, raptors, excluding owls, are primarily diurnal, or daytime, migrants. Daytime flights are facilitated by deflection and thermal updrafts and allow diurnal raptors to more readily find prey species, which often feed or loaf during the day (Goodrich and Smith 2008). A species' habitat use during migration is similar to that of its breeding season, although as migrating individuals begin to encounter conspecific, resident birds, migrants may be forced into habitats of lesser quality or appropriateness. Of the six GoMAMN Raptors of Conservation Concern, only the Swallow-tailed Kite completely leaves its North American breeding grounds during nonbreeding. Conversely, the Southeastern

American Kestrel is "essentially resident" within its range in the southeastern U.S.A. (Smallwood and Bird 2002).

Several raptors, including the Swallow-tailed Kite, congregate before or during migration, which allows biologists to count a large proportion of the populations of some species. The formation of pre-migration, communal roosts in late summer by Swallow-tailed Kites has allowed researchers to collaborate on a region-wide, synchronous survey; this ability to survey an almost entire population at once provides an exceptionally rare opportunity for biologists (Meyer 1994). Ospreys congregate in the thousands in Cuba each spring before migrating north across the Gulf of Mexico (Goodrich and Smith 2008). Large numbers of migrating hawks can be readily observed in the GoM in both spring and autumn. In spring, the GoM geography and the direction of migration make for a weaker funneling effect of migrants, but autumn flights can be spectacular, particularly for species that migrate over land (i.e., circum-Gulf) to regions south of the GoM. Hawkwatch sites, where observers count migrating raptors, in the GoMAMN geography have tallied almost a quarter of a million individuals (Corpus Christi, TX), but the majority of sites along the GoM report thousands to tens of thousands of hawks each autumn. Hawkwatchers in Veracruz, Mexico, tally 4-6 million raptors of potentially 30 or more species, including some GoMAMN Raptors of Conservation Concern, each autumn (Goodrich and Smith 2008). Regardless of whether diurnal raptor surveys are site counts or "censuses," data should, at least, allow indices of abundance and trend (Bednarz et. al 1990, Bildstein 2001, McCarty and Bildstein 2005).

Due to their cryptic nature, migration of owls is very poorly understood. In fact, what is known about the migration of the Short-eared Owl, a GoMAMN Raptor of Conservation Concern, is currently restricted to recoveries of previously banded birds and anecdotes (Wiggins et al. 2006). Short-eared Owls are able to "migrate over vast expanses of oceans" (Wiggins et al. 2006) and have been recorded from offshore oil platforms in spring and autumn (Russell 2005).

Nonbreeding season

Although most breeding species of raptors occur year-round to some degree in the GoM, populations of several species show marked changes during the nonbreeding season (winter for most North American raptors). For example, the relative abundance of the easily observed Red-tailed Hawk increases >500% from breeding season to nonbreeding season in the five GoM states (eBird 2017). American Kestrel (subspecies pooled) relative abundance may increase >2500% over the same seasons in the same geography (eBird 2017). Two species of raptors are absent from the GoM entirely during nonbreeding—Swallow-tailed Kite, a Raptor of Conservation Concern, and Mississippi Kite. In the United States, small numbers of Broad-winged and Swainson's Hawks, both of which form spectacular migratory flocks, are restricted to south Texas, the Bird's Foot Delta region of Louisiana, and peninsular Florida during winter, most of their populations having migrated to Central and South America. With the exception of southern peninsular Florida, most of the GoM Ospreys are apparently migratory, with the relative abundance in the five Gulf states roughly doubling in winter (eBird 2017), augmented by northern breeders (Bierregaard et al. 2016). Two Raptors of Conservation Concern—Short-eared Owl and Peregrine Falcon—do not occur in the GoMAMN region in breeding season, instead utilizing the area during migration and nonbreeding; conservation actions, therefore, would need to be tailored to these species during nonbreeding in this geography.

Unlike the other GoMAMN Raptors of Conservation Concern that nest in spring and summer, the Bald Eagle nesting season occurs in fall and winter in the GoM region. Although the species may be found throughout the year in the five Gulf states, relative abundance generally decreases 50% outside of nesting season (eBird 2017). After winter nesting in the southern United States, most Bald Eagles migrate north in spring, traveling as far away as Canada (Mojica et al. 2008, Smith et al. 2017). Bald Eagles observed in the GoM during summer may be post-breeding, northern breeders or southern breeders that have remained behind. Immature eagles are more likely to restrict their movements to local areas rather than migrate (Buehler 2000). Within the GoM during nonbreeding season, Bald Eagles tend to occur in habitats similar to that of breeding birds (e.g., palustrine forested wetlands). Habitats or systems targeted for restoration for Bald Eagles, therefore, would benefit birds year-round.

Neither of the two remaining GoMAMN Raptors of Conservation Concern that occur in the GoM during both breeding and nonbreeding seasons—Osprey and Southeastern American Kestrel—exhibits a significant shift from those habitats used during breeding season, although they may widen the breadth of habitat utilization. Throughout the year, Ospreys are obligates of open water where ample surface-dwelling fishes exist (Bierregaard et al. 2016). The more generalist kestrel, however, readily diversifies. For example, resident kestrels nesting in open pine forest may continue to occupy that habitat in winter or may increase their use of more disturbed habitats such as agricultural fields. Wintering migrant kestrels likewise occupy similar habitats, but sexual segregation occurs such that females, which arrive earlier than males, tend to use more open, often higher quality, habitat than males (Smallwood 1987, Smallwood and Bird 2002).

Short-eared Owl (*Asio flammeus*). Photo credit: Krista Lundgren

Kestrel sexual segregation, particularly when associated with habitat quality, may have management implications.

The Short-eared Owl, a species that does not breed in the GoMAMN geography, winters in open areas, particularly grasslands including estuarine and palustrine emergent wetlands, coastal prairies and agricultural fields (Wiggins et al. 2006, Booms et al. 2014). On the western edge of the GoM region, the species is regularly observed in rice country, where they roost and feed upon small vertebrates in the crop or in the stubble after harvest. Although often difficult to detect due to their crepuscular habits (Clark 1975), fields heavily favored by Northern Harriers often coincide with the presence of Short-eared Owls, as the two species occupy similar dietary niches but forage at different times of the day. The distribution of Short-eared Owls across the GoMAMN region is discontinuous, with the species more commonly observed in coastal Texas, Louisiana, and peninsular Florida (eBird 2017).

Because Peregrine Falcons have such a varied diet, the species is able to make use of many different habitat types with varying levels of human disturbance, ranging from riverine forests to agricultural lands, and from remote beaches and barrier islands to urban environments (White et al. 2002). In winter, waterfowl and shorebirds are abundant in grasslands, particularly coastal prairie and working wetlands (e.g., rice fields and crawfish aquaculture) and on beaches, making these areas especially attractive as hunting grounds for Peregrine Falcons. In cities, these falcons make use of tall manmade structures like buildings and bridges as hunting perches. Despite the many dangers of urban life (e.g., collisions with windows or vehicles), the species can find copious food resources like Rock Pigeons (*Columba livia*), feral waterfowl, and bats (White et al. 2002).

CONSERVATION CHALLENGES AND INFORMATION NEEDS

Primary Threats and Conservation Challenges

Throughout much of U.S.A. history, raptors were maligned, often without merit, as killers of livestock, beloved pets, gamebirds and other wildlife. Such perceived assaults on these resources resulted in wanton slaughter of thousands of raptors, particularly at migration bottlenecks where large numbers of birds are constricted to a small geographic area (Bildstein et al. 2007, Harness 2007). This level of destruction was unsustainable and led to drastic losses in the populations of several species. Although perhaps not as vilified as they once were, raptors, nonetheless, experience direct and indirect negative, anthropogenic impacts. Mortality of raptors by shootings and poisonings, both intentional and unintentional, is still a concern, particularly among larger or more conspicuous species such as Bald Eagles, Ospreys, and Swallow-tailed Kites. Even American Kestrels may be targeted due to their preference for open habitats and use of prominent perches (Smallwood and Bird 2002).

In general, intentional take of these species has declined dramatically in the last several decades—likely the result of federal laws (Bald and Golden Eagle Protection Act, the Endangered Species Act, and the Migratory Bird Treaty Act) and their enforcement, as well as successful education of the public regarding the benefits of such birds. Persecution of raptors remains, however—frequently a result of poor observational skills and assumptions by the persecutor or careless and illegal use of pesticides. Poison-laced carcasses targeting coyotes and other predators and scavengers invariably kill nontarget species like eagles, vultures, hawks, and, even, owls (M. A. Seymour, personal communication). One of the most frequent concerns from members of the public is that of pet safety when any sort of predatory bird is observed on their property; with increasing popularity of backyard poultry and "toy" breeds of dogs, perceived or actual conflicts will, certainly, increase. In perhaps the most egregious example, a Swallow-tailed Kite, one of a mated pair, was shot in central Louisiana in the early 2000s, because the shooter believed the kite would kill doves in his yard; the doves were believed to be Eurasian Collared-doves (*Streptopelia decaocto*), an invasive, exotic species (M. A. Seymour, personal communication). Contemporary shooting of most raptor species, including the GoMAMN Raptors of Conservation Concern, likely does not cause population level impacts (Meyer 1995, Smallwood and Bird 2002, Wiggins et al. 2006, Bierregaard et al. 2016). Nevertheless, more critically imperiled or localized breeders like the Swallow-tailed Kite may be disproportionately affected, particularly if the individual killed is important to the social unit (J. O. Coulson, personal communication).

Shootings may be among the most readily identifiable sources of anthropogenic mortality of raptors, but, like most wildlife, alteration of habitat, which impacts the birds' access to food and clean water and roosting and nesting areas, is the primary threat to GoMAMN's Raptors of Conservation Concern. Although these species vary in habitat requirements, anthropogenic threats that potentially negatively impact raptor communities include (Figures 5.1 and Appendix 5):

1. climate change and sea-level rise,
2. altered hydrology,
3. contaminants,
4. agriculture,
5. land development,
6. disturbance,
7. biological resource use,
8. energy transmission,
9. transportation corridors,
10. wind energy, and
11. invasive species and biotoxins.

Climate change, coupled with sea-level rise, may have a significant impact to raptors and their habitats (Langham et al. 2015), especially in the GoM region where coastal habitats may receive greater impact. The influence diagrams for most of the Raptors of Conservation Concern include "climate change" and its associated impacts (Figures 5.1 and Appendix 5). In the southern U.S.A., modeled future climate scenarios suggest rising temperatures and decreasing available moisture, for no matter how much precipitation may increase or decrease in these scenarios, "rising temperatures and increasing evapotranspiration will more than offset any increase in precipitation" (Kunkel et al. 2013, Holcomb et al. 2015). Changes in temperature and available moisture will cause habitat migration as conditions become less favorable for

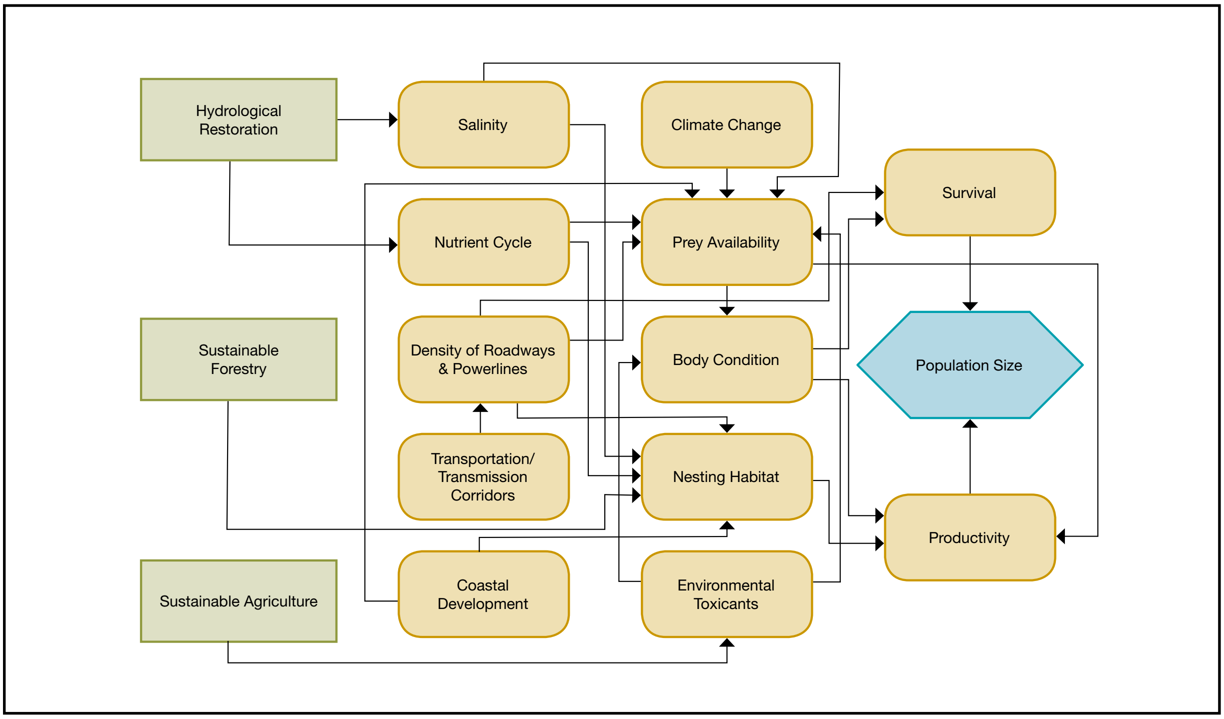

Figure 5.1. *Influence diagram of the relationship between management actions (green boxes), intermediate processes (gold boxes) and population size (blue hexagon) for the* ***Osprey*** *(Pandion haliaetus) within the Gulf of Mexico Region.*

some plants but more favorable for others. Coastal habitats will be doubly taxed as sea-level rise, accelerated by climate change, will exacerbate land loss, because habitat migration may not be able to keep pace with sea-level rise. In addition, particularly in coastal Louisiana, subsidence, or the sinking of the land, will further decrease available terrestrial habitat (Yuill et al. 2009); lack of natural sediment and fresh water influx from spring floods due to the leveeing of the Mississippi River further decreases likelihood of recovery. Increased frequency and intensity of tropical cyclones in the Gulf may lead to increased mortality of trans-Gulf migrants like Swallow-tailed Kites.

Sea-level rise and the decrease in available moisture, which results in less recharge of aquifers with fresh water, allow saltwater intrusion into coastal communities. Altered hydrology that prevents flushing of wetlands with fresh water also allows increased salinities and can alter food resources of piscivores. Plants intolerant of increased salinities and lacking nutrients transported by freshwater inflow may be killed, and loss of their anchoring roots intensifies land loss. In the southeast, hundreds of hectares of forested wetlands have been killed by increased salinities (Conner and Inabinette 2005, White and Kaplan 2017); Bald Eagles and Ospreys build nests atop the standing snags, but the decreased longevity of the dead trees likely results in more nest structure (and nest) failures than live trees. Prone to exploit manmade structures such as telecommunication towers and tall power line transmission towers, loss of natural nesting substrates may increase conflicts among Bald Eagles, Ospreys, and humans.

Raptors are susceptible to secondary poisoning through consumption of contaminated prey. The plight and subsequent highly successful recovery of Osprey, Bald Eagle, and Peregrine Falcon populations after years of exposure to DDT and its derivatives is well documented (Ratcliffe 1970, Grier 1982, Peakall 1987, Henny and Elliott 2007, Blus 2011). Briefly, by consuming prey items that had bioaccumulated and biomagnified DDE (the product of DDT decomposition), these predators produced unusually thin eggshells, which were easily crushed under the weight of incubating birds. Although DDT may no longer be a serious concern in the U.S.A., the pesticide was still available (and likely stockpiled) in many Latin American countries at least until the 2000s, making the potential of continued exposure possible for some migrant raptors (van den Berg 2009). Because birds of prey sit atop the food chain, introduction of new pesticides must be carefully scrutinized, and effects on the productivity and survivorship of these birds should be monitored (Buehler 2000).

Despite a ban on the use of lead shot for waterfowl hunting in 1991, use of lead ammunition is still common in other forms of hunting. Scavenging raptors like Bald Eagles may uptake lead fragments from gut piles or unrecovered carcasses of hunter-killed deer, hogs, and coyotes; lead sinkers used in fishing may also contribute to these poisonings (Buehler 2000). Lead poisoning causes severe neurological complications and depresses the functions of several organs resulting in reduced fitness and almost certain death (Henny and Elliott 2007). Population level impacts of lead and pesticide poisonings are not well resolved and clearly warrant surveillance (Henny and Elliott 2007).

Several anthropogenic threats result in direct loss of habitat or habitat quality; the decrease in availability of suitable habitat may be the most pervasive and persistent threat faced by the Raptors of Conservation Concern. Land development for residential communities is particularly prevalent in upland areas of the GoMAMN geography; loss of open pine woods such as longleaf pine savanna reduces available nest cavities for Southeastern American Kestrel (see Appendix 5). Encroaching civilization in these systems frequently precludes the use of prescribed fire to maintain the necessary early seral stage preferred by the kestrels. Similarly, inappropriate and incompatible forest management practices can create unsuitable habitat and possible population sinks throughout the Gulf states. For example, in parts of the Gulf Coast Joint Venture geography, when forests traditionally occupied by Swallow-tailed Kites are overly thinned, Great Horned Owls invade. These owls are important predators of the imperiled Swallow-tailed Kite, honing in on nests with young and also depredating adult kites (Coulson et al. 2008). Localized, but potentially substantial, losses may result; when adults or multiple nests are depredated, kites may abandon nesting neighborhoods altogether (J. O. Coulson, unpublished data). Swallow-tailed Kites and Bald Eagles tend to nest in emergent trees, those that penetrate the canopy of the forest, and, consequently, forestry practices that encourage growth of all-aged or uneven-aged forests are preferable for these nesters. Mature trees are also used by roosting flocks of migrating raptors like Swallow-tailed Kites; such roosts should be protected from human disturbance.

Fragmentation of habitat can cause otherwise high-quality habitat to become unsuitable, particularly during nesting periods. As forest patches are harvested or cleared, the landscape becomes more open and forest patches smaller, allowing two apex predators, Great Horned Owls and Red-tailed Hawks, to occupy previously unsuitable habitat (Bosakowski and Smith 1997, Smith et al. 1999). Fragmentation also increases edge effects increasing risks of exposure and predation. When fragmentation is caused by transmission and transportation corridors, direct mortality may be magnified. For larger birds of prey like Bald Eagles and, less commonly, Ospreys, electrocutions may result from interaction with power lines (Avian Power Line Interaction Committee 2006, Loss et al. 2014, Bierregaard et al. 2016). Collision with power lines is also a leading cause of anthropogenic mortality in birds, although the extent to which this impacts bird populations is not well established (Manville 2005, Avian Power Line Interaction Committee 2012, Loss et al. 2014). Species that hunt along roadways are prone to vehicle strikes, especially those that scavenge roadkill. Of the Raptors of Conservation Concern, Bald Eagle, a scavenger, is a common victim of vehicle strike (Buehler 2000). Traveling to and from foraging grounds, Ospreys, Short-eared Owls, and American Kestrels may be struck by vehicles while crossing roads or bridges (Smallwood and Bird 2002, Wiggins et al. 2006, Bierregaard et al. 2016). Although not known, the crepuscular nature and low level flights of Short-eared Owls could place them at a greater risk for vehicle strike. Establishment of wind energy turbines, necessarily constructed in large open spaces, fragments the landscape and creates physical obstructions to flight (Manville 2005, Loss et al. 2013, American Wind Wildlife Institute 2017). In the GoMAMN region wind turbines are already situated along beaches and in agricultural fields, coincidentally the same habitats used by shorebirds and waterfowl, prey species that may draw raptors into wind farms. Large birds like eagles may be disproportionately susceptible to collision with turbines, but carcasses of large birds are also more likely to be detected (Arnett et al. 2007, Smallwood 2007, Pagel et al. 2013).

Invasive, exotic species of organisms can lead to severe consequences to native species. Intuitively, invasive plants may alter habitat structure, which may impact animal communities. In the southern U.S.A., highly invasive, freshwater, aquatic weeds such as *Hydrilla verticillata* can quickly form dense mats of vegetation. This abundant substrate allows a cyanobacterium (*Aetokthonos hydrillicola*) to thrive (Wilde et al. 2014). Cyanotoxins produced by the cyanobacterium are inadvertently eaten by herbaceous waterbirds, especially American Coots (*Fulica americana*). Bioaccumulation of the toxin in the coots causes the birds to suffer neurological issues, which makes them easy prey for Bald Eagles, which then develop neurological symptoms as well and, ultimately, perish. Avian vacuolar myelinopathy (AVM), the disease caused by the neurotoxic cyanotoxin, was only just discovered in 1994 (Birrenkott et al. 2004). Increased temperatures associated with climate change may increase the geographic range of hydrilla (Maki and Galatowitsch 2008), possibly aiding the spread of *A. hydrillicola* and AVM.

Collectively, birds of prey are well-studied, largely due to their conspicuous and charismatic nature, but also because of their interactions with humans. The ancient sport of falconry has greatly advanced both the study of raptors and their conservation (Kenward 2009). Conversely, the persecution of raptors and their subsequent population declines produced one positive consequence: Osprey, Bald Eagle, and Peregrine Falcon are among the most studied birds in North America. In fact, monitoring of the latter two species was mandated due to federal requirements as formerly endangered species. Nonetheless, continued monitoring of raptor populations is essential, as some species act as sentinels for ecosystem health (Bildestein 2001). Monitoring of Short-eared Owls has been limited to breeding areas, and improvement of population monitoring has been identified as a "pressing conservation [priority]" for the species (Booms et al. 2014, Miller et al. 2016, Hawkwatch International 2017).

Monitoring is vital to conservation, as these data, when collected over many years, may be used to estimate status and trends in populations (McCarty and Bildstein 2005). Equally important, however, is the disentangling of the effects of ecological processes from those of management actions. Targeted, question-based monitoring will be required to decrease uncertainty in order to develop Best Management Practices (BMPs) to ensure continued population recovery or population stabilization. As climate change and habitat loss continue to threaten these species, the avian conservation community must remain nimble in its response.

IDENTIFICATION OF PRIORITIES

The avian conservation community must act immediately to address existing data gaps and uncertainties in the degree of impact of both anthropogenic and natural processes. Data gaps and uncertainty hinder our ability to make informed conservation decisions and can lead to delayed actions, a lag that permits further loss of diversity and unchecked habitat alteration and loss. Although the breadth of data gaps are not consistent across the GoM region, nor among the Raptors of Conservation Concern, GoMAMN identified three overarching objectives (discussed in Chapter 2; Figure 2.2):

1. Maximize our understanding of management actions (How do our actions intentionally and unintentionally affect raptors?)
2. Maximize our understanding of status and trends (How are raptor populations and their required habitats doing?), and
3. Maximize our understanding of ecological processes (How are large-scale ecosystem processes impacting raptors?).

These three objectives help define the priority foci necessary to better affect raptor conservation in the GoM.

As a generally well-studied taxon, raptors have been the topic of numerous study designs from monitoring of breeders to migrants. Less common is monitoring during the nonbreeding season (Andersen 2007); nonbreeding species-specific protocols will need refinement. The GoMAMN Raptor Working Group values projects that include investigation of impacts to juveniles, subadults, and adults and both sexes. Existing evidence suggests habitat usage, timing of migration, and geographic endpoints are linked to age- and/or sex-specific survival rates for several species (Smallwood 1987, Buehler 2000, Mueller et al. 2000, Martell et al. 2001). In addition to the sections below, avian biologists interested in raptor monitoring would be wise to review *Raptor Research and Management Techniques* (Raptor Research Foundation 2007), which includes comprehensive coverage of all aspects of raptor science.

Priority Management Actions

The bird conservation community through GoMAMN (see Figure 2.2) has demonstrated its values through the objectives hierarchy. Part of the objectives hierarchy refers specifically to management actions, showing that we value projects that (1) affect many priority species, (2) have a large spatial scope, (3) reduce uncertainty about the impact of management action(s) on raptors, (4) address management actions that are in common use as part of Gulf of Mexico restoration activities, and (5) use an adaptive management framework to answer questions about management actions.

Priorities for management actions can be found in Table 5.3. Actions that were scored as high priorities were ranked as such: (1) because the effect size of that action was unknown or, if known, suspected of impacting large portions of raptor populations and (2) because uncertainty in that effect size was higher than others. Although many priority management actions will likely benefit several species, others may be negatively impacted. For example, replanting a former agricultural field with hardwoods in the Mississippi Alluvial Valley may eventually provide nesting substrate for eagles, but planting trees will render the site unsuitable for wintering Short-eared Owls. In addition, documenting duration and seasonality of actions (e.g., harvesting timber in winter to avoid colonial waterbirds, but ignoring nesting Bald Eagles) may be critically important to addressing impacts.

The selection of management actions that benefit the GoMAMN Raptors of Conservation Concern necessitates evaluation of the impacts and applicability to all raptors within the GoMAMN geography. Management actions expected to impact raptors in the GoMAMN geography include hydrological restoration (to minimize saltwater intrusion and permit nutrient flow); promotion of sustainable forestry (e.g., retention of mature trees and snags); promotion of sustainable agriculture (to minimize pesticide loads and to maintain acreage of rice, crawfish, and other working agriculture); minimization of development and disturbance within key breeding and roosting areas; promotion of prescribed fire; restoration of marshes, beaches, and barrier islands; sustainable harvest management (to minimize lead in the environment); and removal of invasive species (to minimize negative trophic impacts and biotoxins). Figure 5.1 and Appendix 5 demonstrate the influence of these actions on raptor productivity and survivorship.

In general, management actions of greatest priority are those listed on the Raptors of Conservation Concern Influence Diagrams (Figure 5.1 and Appendix 5) as well as the actions listed in Table 5.3. Priority management actions include promotion of sustainable agriculture and forestry management. Sustainable agriculture was included on all of the diagrams. Historic efforts to minimize or eliminate nontarget impacts and other unintended effects of dangerous pesticides (e.g., DDT), coupled with the commonality of pesticide impacts on the diagrams, demonstrates the persistent uncertainty of their impacts, especially those of novel pesticides. Bald Eagles, Short-eared Owls, and Peregrine Falcons use rice fields for foraging and/or roosting (Short-eared Owl only). A reduction in the market value of rice could cause farmers to shift to crops of less wildlife value. Given the loss of natural grassland habitats, retention of rice acreage may be an essential management technique. In forested landscapes, promotion of raptor-friendly management to retain snags and tall canopy trees and to prevent an even-aged forest could be highly beneficial to all forest nesting species. The magnitude of impact on productivity and survivorship from reduced habitat suitability caused by unsustainable forestry warrants more study.

Other actions were found to be more specific to one or two species of Raptors of Conservation Concern; however, omission of these actions from other species' influence diagrams does not imply that the actions are not expected to affect those species—only that the action is not believed to be as impactful to those species as the other listed actions. For example, restoration of hydrology clearly impacts food resources and nest sites of Ospreys, Bald Eagles, and Swallow-tailed Kites, but other actions simply ranked higher for Swallow-tailed Kite such as maximizing sustainable forestry, which increases nest tree availability and potentially decreases nest predator abundance. Additional management actions specific to Bald Eagles include regulation of lead (i.e., to prevent lead ammo fragment uptake by scavenging birds) and removal of invasive species (i.e., to prevent a trophic cascade that poisons eagles). Uncertainty persists in the

Raptors

Table 5.3. *Uncertainties underpinning the relationship between management decisions and populations of raptors in the northern Gulf of Mexico.*

Species Season(s)	Management Category[a]	Question	End-point to measure mgmt. performance	Uncertainty Description	Uncertainty Category[b, d]	Effect Size[c, d]
Osprey and Bald Eagle Breeding, Non-breeding, Migration	Habitat and Natural Process Restoration (Habitat Management-Freshwater Management)	Do altered/reduced fish populations due to reduced freshwater inflow significantly impact piscivorous raptor species?	Productivity; Adult/Juvenile Survivorship	Unknown magnitude and spatial extent	High	Low
Osprey and Bald Eagle Breeding, Non-breeding, Migration	Habitat and Natural Process Restoration (Habitat Management-Forestry)	Do timber harvests reduce habitat quality and quantity and productivity of Ospreys and eagles?	Productivity; Adult/Juvenile Survivorship	Unknown magnitude and duration of impact	High	Low
Osprey, Swallow-tailed Kite, Bald Eagle, Short-eared Owl, American Kestrel, Peregrine Falcon Breeding, Non-breeding, Migration	Species Management (Contaminants)	To what magnitude do stockpiled DDT inventories or novel pesticides impact productivity and survivorship of apex raptors?	Productivity; Adult/Juvenile Survivorship	Unknown unknowns	High	Unknown
Swallow-tailed Kite Breeding, Migration	Site Area/ Management (Disturbance)	To what magnitude does human disturbance of communal roosts impact kite fitness? Does it impact juveniles differently from adults?	Adult/Juvenile Survivorship	Unknown magnitude and whether age classes affected equally	High	Low
Swallow-tailed Kite Breeding, Migration	Habitat and Natural Process Restoration (Habitat Management-Forestry)	Do timber harvests reduce habitat quality and quantity for nesting and roosting kites?	Productivity; Adult/Juvenile Survivorship	Unknown magnitude and duration	High	Low
Swallow-tailed Kite Breeding	Habitat and Natural Process Restoration (Habitat Management-Forestry)	Will the increase in Great-horned Owls and Red-tailed Hawks in traditional kite neighborhoods impact kites long term?	Productivity; Adult/Juvenile Survivorship	Unknown magnitude and duration	High	High
Bald Eagle Breeding, Non-breeding, Migration	Species Management (Contaminants)	How widespread and to what degree is continued use of lead ammunition for big game and lead sinkers for fishing affecting eagle survivorship and productivity?	Productivity; Adult/Juvenile Survivorship	Unknown magnitude and spatial extent	High	Unknown

Table 5.3 (continued).

Species Season(s)	Management Category[a]	Question	End-point to measure mgmt. performance	Uncertainty Description	Uncertainty Category[b, d]	Effect Size[c, d]
Bald Eagle Breeding, Non-breeding, Migration	Invasive/ Problematic Species Control (Habitat Management-Invasive Plants)	How widespread is the cyanobacterium that causes Avian Vacuolar Myelinopathy and is removal of invasive aquatic plants a viable option to disrupt the pathway to eagles?	Adult/Juvenile Survivorship	Unknown magnitude and spatial extent	High	Unknown
Short-eared Owl Non-breeding, Migration	Habitat and Natural Process Restoration (Habitat Management-Agriculture)	To what extent will conversion of rice agriculture have on nonbreeding Short-eared Owls?	Population Density	Unknown unknowns, unknown magnitude and extent of impacts	High	Unknown
Short-eared Owl Non-breeding, Migration	Habitat and Natural Process Restoration (Habitat Restoration)	Does restored marsh provide similar amounts of prey and roost sites for Short-eared Owls to natural marsh?	Small Mammal Density; Population Density	Unknown magnitude of impacts	High	Unknown
Short-eared Owl Non-breeding, Migration	Habitat and Natural Process Restoration (Habitat Management-Prescribed Fire)	What fire interval produces the highest quality of habitat for roosting and feeding Short-eared Owls?	Small Mammal Density; Population Density	Unknown magnitude of impacts	High	Unknown
(SE) American Kestrel Breeding, Non-breeding	Habitat and Natural Process Restoration (Habitat Management-Forestry)	Do timber harvests reduce habitat quality and quantity for nesting kestrels?	Small Mammal, Herp, and Invertebrate Density; Population Density; Productivity; Adult and Juvenile Survivorship	Unknown magnitude and duration	High	High
(SE) American Kestrel Breeding, Non-breeding	Site Area/ Management (Land Use)	To what extent will encroaching residential areas impact the ability to maintain kestrel habitat via fire?	Small Mammal, Herp, and Invertebrate Density; Population Density; Productivity; Adult and Juvenile Survivorship	Unknown extent	High	Low
Peregrine Falcon Non-breeding, Migration	Habitat and Natural Process Restoration (Habitat Management-Agriculture)	To what extent will conversion of rice and crawfish agriculture/ aquaculture have on nonbreeding Peregrine Falcons?	Population Density	Unknown unknowns, unknown magnitude and extent of impacts	High	Unknown

Raptors

Table 5.3 (continued).

Species Season(s)	Management Category[a]	Question	End-point to measure mgmt. performance	Uncertainty Description	Uncertainty Category[b, d]	Effect Size[c, d]
Peregrine Falcon Non-breeding, Migration	Habitat and Natural Process Restoration (Habitat Restoration)	Does coastal restoration maximize benefit to prey species of Peregrine Falcon and how does that translate to benefits to falcons?	Shorebird Density; Population Density	Unknown magnitude and duration	High	High
Peregrine Falcon Non-breeding, Migration	Habitat and Natural Process Restoration (Habitat Restoration)	Does restored marsh provide similar amounts of prey for Peregrine Falcons to natural marsh?	Waterfowl and Shorebird Density; Population Density	Unknown magnitude of impacts	High	High

[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.

extent to which populations are currently impacted especially within the geographic distribution of those threats.

Restoration and maintenance of beaches and barrier islands, as well as that of grasslands like marsh, coastal prairie, and pine savanna, would benefit Short-eared Owls, American Kestrels, and Peregrine Falcons. In particular, prescribed fire should be utilized where and when appropriate. Maintenance of anthropogenic habitats like rice fields and other moist soil units should also benefit these species, as these habitats act as foraging or roosting grounds. To what magnitude and extent in our inability to perform prescribed fire due to encroaching human settlements affect open pine species like American Kestrels warrants attention. Restoration of coastal habitats like beaches and barrier islands must include an evaluation on the restoration's impact to the local food web (e.g., deposit of dredge material on to a beach may impact forage for shorebirds, which impacts prey resources to falcons).

The GoMAMN's primary goal is to reduce uncertainty in how management actions and ecological processes drive the population dynamics of birds in order to better inform conservation. Monitoring programs should attempt to minimize the uncertainty of priority management actions listed above (see also Table 5.3). Because of the somewhat eclectic nature of the Raptors of Conservation Concern, multiple projects would need to be devised to successfully study these management actions. Ideally, monitoring programs that investigate the effects of management actions should do so under a framework of adaptive management; that is, the results of monitoring should allow practitioners to determine if a management action is providing a desired outcome (Franklin et al. 2007). If the action does not, then it should be corrected.

In order to maximize our understanding of management actions and how they impact bird populations, monitoring programs must be rigorously designed to capture relevant data. Avian response variables, those dependent upon the actions of management or ecological processes (see Priority Ecological Processes below), must be clearly defined and appropriate to the question. For management questions (e.g., Can we increase survivorship of Bald Eagles if we minimize *Hydrilla*, an invasive aquatic plant that provides substrate upon which a deadly biotoxin-producing cyanobacterium grows?), population size, survivorship, reproduction, and movement could be valid response variables.

Key to any monitoring program is the ability to quantify the population responses of the study organism using sound methods. For example, abundance, or the total number of individuals in a given area at one point in time, can be a metric to gauge success of a management action. Density of a population can also be used, and, intrinsically, this value is created when an abundance measure is made. For example, fixed transects to survey for active eagle nests would enumerate the number of nests and provide the area surveyed. Although most land managers will want to measure changes in abundance, density, etc., and link those changes to local conditions created through habitat management, carryover effects (e.g., productivity at breeding grounds) may not be evident on-site. Because Short-eared Owls and Peregrine Falcons nest outside the GoM, monitoring of productivity, obviously, would have to occur outside our region. Nonbreeding surveys of Short-eared Owls would likely be occupancy only (a boolean measure of presence) that, while useful, especially for cryptic species, is of less value than abundance and density. In addition, Efford and Dawson (2012) note that occupancy may be "confounded with home-range size or detection distance."

As undeniably important as a measure of population size is, the data can be of limited value when collected alone. Although population size may provide trend information, it does not explain that trend. It is, therefore, advisable to measure other response variables in combination with abundance and density. One such variable, survivorship, must take into account the age and sex of the bird, as age- and sex-biased mortality has been documented in birds, including raptors (Ferrer and Hiraldo 1992, Dwyer and Mannan 2007). Differential mortality can be due to a variety of factors such as sexual segregation within habitats, differences in parental roles and behaviors, and the reverse sexual dimorphism exhibited in most species of raptors. Existing and emerging technologies such as increasingly smaller radio transmitters may assist in measuring survival as long as those methods themselves do not significantly impact survivorship.

Reproductive success, like survivorship, helps explain trends and, historically (e.g., during the pesticide era of the mid-1900s), population level effects were found to occur during nesting. The age of first breeding can be delayed in many raptors, particularly the larger species; thus, the magnitude of impact of a management action (or an ecological process) may vary with age (Millsap et al. 2004). In many species of raptors, fecundity is relatively low, compensated for by a longer lifespan. Delayed breeding and longer lifespan, therefore, may necessitate the monitoring of multiple ages of cohorts. Several parameters are important to measure during bird reproduction including clutch size, brood size, nest success, and fledging success.

Some raptor nests can be relatively easily surveyed, especially if they occur in emergent trees and if aircraft are available or if the species are nest box users. Species that create prominent nests—large in size and in emergent or isolated trees—can be effectively monitored via aerial surveys (Carrier and Melquist 1976, Ewins and Miller 1994, Andersen 2007). The kestrel's inclination to use nest boxes assists in monitoring of productivity and can assist in capture for instrumenting (Katzner et al. 2005, Bloom et al. 2007). Others, like grassland nesters, may be more challenging (Larson and Holt 2016). Brown et al. (2013) discuss the advantages and limitations of using apparent nest success to gauge reproductive success in raptors. Monitoring parameters of reproductive success are necessarily time consuming and often costly. However, to properly understand impacts to raptors, one must accept the challenges. Steenhof and Newton (2007) provide standardization of various parameters used in determining nest success and productivity and discuss survey methodologies.

Movement can also provide valuable information on management success. For example, if birds instrumented with tracking devices unexpectedly move out of an area that has been managed, land managers could focus on where the birds went and why and, possibly, could then replicate those conditions at the managed site. Please see the Priority Status and Trends Assessments section below for a more in-depth treatment on "movement."

Clearly, the importance of measuring the proper avian response variables cannot be overstated, but to provide an answer for why they have responded, one must also consider non-avian covariates. Measuring the impacts of these covariates is absolutely essential to disentangling the effects of management actions and ecological processes on populations, particularly if there are confounding variables. Local conditions should be included in monitoring projects, especially basic habitat measures, weather, etc. For example, salinity, density of aquatic vegetation, water turbidity and temperature, prey fish distribution, etc., may impact piscivorous raptors. Prey abundance may impact behaviors, as well, and might be beneficial to monitor in conjunction with bird abundance, survivorship, etc. The number of hunters using lead ammunition, in part, describes the poisoning risk that eagles and other scavengers may face. Distance to human settlement(s) may dictate timing of prescribed fires, which may impact food and habitat resources. Depth of dredge materials placed during beach nourishment may prevent feeding by shorebirds, affecting the food resource of Peregrine Falcons. Selection and measurement of non-avian covariates can be complicated and time-consuming, but models may be improved (i.e., better explain results) with inclusion of proper covariates.

Additional and up-to-date information on current management practices and activities can be found through the Deepwater Horizon Project Tracker Database (http://www.dwhprojecttracker.org/).

Priority Status and Trends Assessments

The GoMAMN's objectives hierarchy (Figure 2.2) demonstrates what the avian community believes is most critical for maximizing the usefulness of monitoring data collected to address questions on status and trends. The community places the most value on projects that 1) evaluate species that are experiencing the greatest declines, 2) evaluate species for which trends are highly uncertain, 3) cover the greatest geographic extent, and 4) include mechanisms to ensure the monitoring is long-term. The GoMAMN recognizes that annual monitoring may be excessive for many species; continuity of data may include intervals of no surveys, but gaps in surveys ideally should be based on life history of the species and be consistent (e.g., surveys occur year 1, 3, 5, etc.).

The population status and trend estimates for each species of Raptor of Conservation Concern may be found in (Table 5.2). The Partners in Flight (2017) Avian Conservation Assessment Database (PIF ACAD) was used to populate Continental Population Trend (PT-c in PIF ACAD) and maximum Continental Concern (CCSmax in PIF ACAD) scores (see Panjabi et al. 2017 for context) for each species. Raptors for which PT-c is more or less stable or highly uncertain or highly variable received a score of 3. Species with a score < 3 are of less concern, whereas those with a score > 3 are of greater concern. CCSmax scores are the maximum value calculated between breeding and nonbreeding season: the higher the number, the greater concern.

The GoMAMN Raptor Working Group established the following status and trends priorities for the Raptors of Conservation Concern in the Gulf of Mexico. Whereas, all raptor species in Table 5.2 are priorities, these species were further ranked by a composite score calculated by the species' PT-c and CCSmax scores from the Partners in Flight Avian Conservation Assessment Database (2017).

- **Priority 1** – Short-eared Owl
- **Priority 2** – Southeastern American Kestrel and Swallow-tailed Kite
- **Priority 3** – Peregrine Falcon, Bald Eagle, and Osprey

The bird community's history of determining bird trends has relied heavily on the venerable USGS Breeding Bird Survey (BBS), which is a defensible and repeatable methodology of monitoring many bird species (Sauer and Droege 1990). However, due to timing of the BBS season (e.g., mostly outside southern Bald Eagle nesting season), the time of day (i.e., mostly diurnal species detected), species' detectability, species' rarity coupled with a clustered distribution (e.g., Swallow-tailed Kite) and others, this survey may not best represent actual trends of some species (Sauer and Droege 1990). Targeted monitoring, therefore, may be a necessity for several birds like Osprey, Bald Eagle, Short-eared Owl, and many others. Seasonality may impact survey design, and counts on breeding grounds may be preferable to those on nonbreeding grounds. Short-eared Owls, for example, are likely most detectable during breeding season display flights; the species' nomadism and more crepuscular behavior in winter make detection during that season difficult (Miller et al. 2016). Bird behavior during migratory periods such as kettling (i.e., flocking of soaring, migratory birds) may facilitate abundance estimates. At the most basic level, counts of migrating raptors at geographic bottlenecks is one way to measure abundance, and such data may inform population indices (Bednarz et al. 1990, Farmer and Smith 2010).

Population trends of several raptor species have been estimated. According to the BBS (Sauer et al. 2017), in the U.S.A. between 2005 and 2015, the Osprey population experienced an annual increase of approximately 4.9%. According to the BBS (Sauer et al. 2017) Swallow-tailed Kites increased 5.5% annually in that same time frame, but this species may be less suited to BBS analyses due to its rarity and patchy distribution. Bald Eagle populations increased approximately 12.4% annually (Sauer et al. 2017). Trends for Short-eared Owls and American Kestrels appear to show declines, but the data are inconclusive in the U.S.A. (Sauer et al. 2017). In Canada, Short-eared Owls declined approximately 16.5% annually between 2005 and 2015 (Sauer et al. 2017). These percentages are provided with the caveat that no species' population trend above was estimated without some level of uncertainties in the sample (e.g., credibility measure, sample size indicator, etc.). PIF (2017) suggests that Short-eared Owl and American Kestrel may be experiencing significant declines (Table 5.2). Despite the trend information for many raptors, it is important to note that the longevity of the applicability of data to inform status and trends is finite. In other words, despite most GoMAMN Raptors of Conservation Concern actually showing possible population increases according to BBS data (Sauer et al. 2017), without frequent monitoring to obtain up-to-date counts, trends may quickly lose relevance.

Although trends are extremely important in determining the trajectory of a population and conceptually simple, status is multifaceted—taking into account a mixture of habitat availability, total population size (i.e., relevant to persistence), scope and persistence of threats, fecundity, and other variables. Status of species necessitates evaluation of environmental conditions such as changes in habitat quantity or quality. Resolution or scale of habitat measurements will vary based on study design, but the GoMAMN suggests that programs collect habitat data over the long-term. Habitat associations of the Raptors of Conservation Concern are included in Tables 5.1 and 5.2. The GoMAMN uses the Coastal Change Analysis Program (C-CAP) habitat classes in this document. C-CAP information is available at NOAA's Office for Coastal Management Digital Coast's website (http://coast.noaa.gov/digitalcoast).

One positive result of the historic and precipitous population declines of the Bald Eagle and the Peregrine Falcon was that periodic surveys were required to monitor recovery (USFWS 2003, 2009, 2016; Green et al. 2006). Most monitoring occurs during the breeding season to capture productivity, which is important when assigning status. Surveys for nesting eagles occur periodically in the Gulf states with only Florida having a specific action plan for the species (Florida Fish and Wildlife Conservation Commission 2017). In addition, Audubon Florida (2016) also promotes project EagleWatch, a citizen science project that monitors eagles. Louisiana collected Bald Eagle nest data, including productivity, most recently in the 2017/2018 nesting season (M. A. Seymour, unpublished data). USFWS performed region-wide surveys during the 2017/2018 nesting season similar to those performed by USFWS in 2009.

Counts of migrating raptors can be useful for population indices and, in very rare circumstances, may allow almost complete censusing of a population. Hawk-watchers across the U.S.A. gather at migration bottlenecks to count migrating raptors and report those counts to the Hawk Migration Association of North America, which maintains a list of sites (www.hawkcount.org). The most productive sites (e.g., Veracruz, Mexico) are outside the GoMAMN geography.

Communal, pre-migration roosting of Swallow-tailed Kites allows avian biologists to conduct extensive surveys that capture nearly the entire U.S.A. population of the species. Carefully timed, synchronous, aerial surveys from Texas to Florida minimizes double-counting and maximizes comparability state-to-state. Region-wide surveys were most recently conducted in 2013 (Coulson and Seymour 2014). No targeted, region-wide monitoring effort in the Gulf exists for Ospreys, Short-eared Owls, American Kestrels, or Peregrine Falcons, although the non-breeders—Short-eared Owls and Peregrine Falcons—may be best monitored for status and trends on breeding grounds further north (outside the GoMAMN geography).

Determination of migratory routes, stopover sites, duration of stays, etc., of several Raptors of Conservation Concern have rapidly advanced by use of emerging technologies (Martell et. al 2001, Walls and Kenward 2007, Mojica et al. 2008, Watts et al. 2011, Martell et al. 2014, Stupik et al. 2015, Smith et al. 2017). Because migration is one of the most dangerous periods in the avian life cycle, the avian conservation community desires to understand movement of raptors at multiple scales. Such movement may be monitored several different ways such as banding and auxiliary marking (e.g., alphanumeric leg bands, patagial wing markers, feather dyeing, imping, etc.), each with their own strengths and weaknesses (Varland et al. 2007). Many tracking technologies are currently available for monitoring movement of raptors, with larger species like eagles, ospreys, kites, and larger falcons having solar powered, satellite transmitters and GPS trackers available in addition to traditional VHF tags. Smaller species such as the American Kestrel may be best tracked by light-sensitive geolocators, coded VHF tags, or by stable isotopes (Walls and Kenward 2007, Hobson et al. 2009). Bird Studies Canada's Motus Wildlife Tracking System, an international collaboration, has been well-received throughout North America and beyond, making passive (and inexpensive) VHF tracking of migratory birds a reality. Motus-compatible receiver stations are located throughout the GoM region with many more planned in the near future. The Louisiana Statewide Passive Detection for Organismal Research (SPDOR) VHF network expects to maintain 30 or more such stations in coastal Louisiana by autumn of 2020 (M. A. Seymour, personal communication). Tracking birds to identify stopover sites used by long-distance migratory species may be critical and should be priority.

Due to the spatial and temporal dependency on the validity of status and trends, the maintenance of a monitoring program for priority species is imperative. In fact, development of sound, baseline status and trend values may be the single most important responsibility of bird scientists in the GoM. Without these values, the other key pieces of monitoring—understanding management and ecology of species—cannot be fully realized. For example, success of the restoration of Swallow-tailed Kite neighborhoods (this species is a semi-colonial nester) cannot be determined without knowledge of nesting density and success, productivity, and survivorship benchmarks upon which the restoration can be compared. Similarly, if the baseline (i.e., background) levels of environmental pollutants and their derivatives in the blood of Bald Eagles or Ospreys are not established, the conservation community must wait until another indicator signals such impacts—potentially population level impacts like widespread reproductive failure.

For additional details on how the collection of relevant metrics of bird life history or habitat and other non-avian covariates affects our ability to conserve birds, see Priority Management Actions (above) and Priority Ecological Processes (below), as well as the *Raptor Research and Management Techniques* (Raptor Research Foundation 2007).

Priority Ecological Processes

The GoMAMN Raptor Working Group developed the Ecological Processes table (Table 5.4) through literature review and consultation with species experts across the U.S.A. To prioritize these processes, we used the ecological process objective hierarchy values which emphasize 1) relevance to our Raptors of Conservation Concern, 2) reduction of uncertainty in how ecological processes influence population dynamics, and 3) the maximization of our ability to predict those dynamics (Figure 2.2). Like management actions, ecological processes are best studied over a long term, if possible. Influence diagrams were used to illustrate the connectivity between ecological processes and population dynamics (Figures 5.1-5.6).

Like the other GoMAMN taxa working groups, the Raptor Working Group ranked a set of questions about how ecological processes impact our species of Conservation Concern. We considered two scoring criteria—effect size (where Unknown > High > Low) of the ecological process of interest and the uncertainty (High > Low) of that effect size. Once scored, prioritization was as follows, with a score of one being the highest priority: 1 = Unknown, High, 2 = Unknown, Low, 3 = High, High, 4 = High, Low, 5 = Low, High, and 6 = Low, Low (Effect size, uncertainty). Questions for the same species with the same rank have the same composite score of effect size and uncertainty and were not further ranked.

Many ecological processes act synergistically and often impact the magnitude of one another (e.g., climate change and sea-level rise). As a GoMAMN rule, ecological processes with direct links to management action(s) are treated in Priority Management Actions. For example, although saltwater intrusion into coastal marsh is an ecological process, the magnitude of impact may be mitigated by anthropogenic actions like freshwater diversions. That being said, concessions had to be made regarding whether or not anthropogenic climate change and its associated impacts were best ascribed to Management Action or Ecological Process; GoMAMN has chosen the latter. Similarly, our monitoring questions could affect categorization. For example, our question regarding the likelihood of spread of an AVM causing cyanobacterium is more appropriately linked to ecological process (Table 5.4); whereas, the question regarding disruption of the AVM pathway via invasive plant removal is clearly management related (Table 5.3). In addition, toxicants and harmful heavy metals released into the natural environment may affect several trophic levels, resulting in trophic cascades. Cascading effects may impact the function of entire systems (treatment of these threats may be found above). Ecological processes like animal movements and interactions may also be affected by the creation of travel and transmission corridors, wind farms, and subsidized native and introduced species; those anthropogenic impacts are discussed in Primary Threats and Conservation Challenges.

The reality of climate change and its potential impacts to GoM wildlife, fisheries, and habitats cannot be ignored. Depending on the modeled scenario and the location in the region, habitats (and their associated denizens) may be greatly degraded or eliminated altogether (Watson et al. 2015). Whether habitats will be able to migrate quickly enough is uncertain, but in some portions of the region, effects of subsidence and sea-level rise are already destroying vast acreages of marsh and other coastal habitats. Beaches and barrier islands are eroding and disappearing. Saltwater intrusion continues to make habitat inhospitable for some raptors, likely reducing available natural nest sites for Ospreys and eagles or killing active nest trees and making them unstable. Climate change may disproportionately impact trans-Gulf migrating Swallow-tailed Kites, because the birds may experience greater mortality due to an increase in storm frequency and intensity. Climate change will also affect sea temperature, which could cause decreased fitness, survival, and productivity in Peregrine Falcons on their breeding grounds, because the seabirds on which they feed will be negatively impacted by the potential loss of forage fish caused by rising temperatures (North American Bird Conservation Initiative, U.S. Committee 2010; Young et al. 2012).

The actions of ecological processes are equal in neither time nor space, requiring project managers to evaluate their effects at appropriate spatial and temporal scales. Because these processes may impact species through different mechanisms and may vary in intensity throughout seasons and life cycles, biologists should be mindful when designing projects. For example, will rising temperatures from climate change increase the depth of Ospreys' preferred fish species and will that behavior exert a greater impact during nesting season leading to decreased productivity (Table 5.4)?

SUMMARY AND MONITORING RECOMMENDATIONS

The decisions to implement conservation actions, especially those that have the potential to impact large portions of bird populations, do not and should not occur in a vacuum. Our ability to positively impact those populations relies upon the conservation community's understanding of how and why birds react to environmental conditions. Our capacity to make informed decisions requires "separating signal from noise" (P. Frederick, personal communication)—in our case, determining what patterns in the data actually drive population dynamics versus red herrings. To accomplish this, we must disentangle the effects of management from those ecological processes.

The GoMAMN Raptor Working Group recognizes the need to address several data gaps, that when filled, will greatly enhance our understanding of raptor populations in the GoM region. Data gaps include 1) demographic parameters such as productivity, nest success, survivorship of adults and juveniles and males and females, movement, and others;

Table 5.4. *Uncertainties related to how ecological processes impact populations of raptors 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]
Osprey Breeding, Non-breeding, Migration	Climatic Processes	Will increased water temperatures impact food availability?	Productivity; Adult/Juvenile Survivorship; Nest Success	Unknown magnitude of effects on fitness, reproduction	High	High
Swallow-tailed Kite Migration	Natural Distburance Regimes	To what magnitude do tropical cyclones and other extreme weather impact age classes of kites?	Adult/Juvenile Survivorship	Unknown magnitude and impacts to age classes	High	Unknown
Swallow-tailed Kite Breeding	Climatic Processes	How will climate change impact the distance, distribution, quality, and quantity of kite foraging and nesting grounds?	Productivity; Adult/Juvenile Survivorship; Population Density	Unknown to what extent climate change will occur or to what extent its impacts will be	High	High
Bald Eagle Breeding	Climatic Processes	To what extent will sea-level rise impact quantity and quality of eagle nesting and foraging grounds?	Productivity; Adult/Juvenile Survivorship; Population Density	Unknown magniture and extent	High	High
Bald Eagle Breeding	Hydrological Processes	Do saltwater intusion-killed trees impact productivity and survivorship of eagles?	Productivity; Adult/Juvenile Survivorship	Unknown impact to nesting birds	High	Low
Bald Eagle Breeding, Non-breeding, Migration	Interactions Between Organisms	What is the liklihood of spread of Avian Vacuolar Myelinopathy into novel parts of the range?	Invasive aquatic plant density; Adult/Juvenile Survivorship	Unknown magnitude of impact to populations and liklihood of spread	High	Unknown
Peregrine Falcon Non-breeding, Migration	Climatic Processes	How will climate change impact the abundance and distribution of falcon food resources?	Shorebird and Waterfowl Densities; Adult/Juvenile Survivorship	Unknown to what extent climate change will occur or to what extent its impacts will be	High	High

[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.

2) baselines and benchmarks for birds (e.g., abundance and distribution) and their environment (e.g., environmental pollutants, invasive species abundance, available natural and manmade habitat, etc.); 3) effectiveness of management treatments and habitat delivery and how to best utilize an adaptive framework for their success; and 4) magnitudes of impact and duration of ecological processes on bird populations and how to plan for uncertainties in our changing climate (e.g., increased temperature, aridity, and sea level).

The GoMAMN Raptor Working Group identified the following as priority actions requiring immediate attention:

★ Development of a monitoring program to evaluate background levels of pollutants and biotoxins in the environment with linkages to raptor population dynamics. Apex raptors like Ospreys, Bald Eagles, and Peregrine Falcons are particularly susceptible to bioaccumulated and biomagnified contaminants.

★ Creation of a question-based monitoring program to determine impacts of timber harvest on breeding and migrating raptors. Results of this monitoring should include development of Best Management Practices to guide conservation practitioners. Within the GoMAMN region, natural nest and roost sites may be limiting factors for Ospreys, Bald Eagles, Swallow-tailed Kites, and American Kestrels.

★ Evaluation of the impacts of saltwater intrusion and reduced freshwater inflow (and nutrients) on the habitats and birds of coastal marshes and forested wetlands. Saltwater intrusion and decreased freshwater inflow alter vegetation composition and structure and may change fish and aquatic insect prey communities. These changes may threaten nest tree persistence and the nesting success and productivity of the birds that rely on them. In addition, survivorship and productivity of piscivorous raptors like Ospreys and Bald Eagles may be impacted by changes in fish assemblages.

★ Development of region-wide monitoring programs that target effective surveillance of population abundance and distribution of GoMAMN's Raptors of Conservation Concern in order to better understand their status and trends. Generally, Ospreys, Swallow-tailed Kites, Bald Eagles, Short-eared Owls, American Kestrels, and Peregrine Falcons are not well monitored by existing programs such as the USGS Breeding Bird Survey. Instead, survey methodologies must be implemented that address both the spatial and temporal aspects of the species' unique life cycles. In particular, we need to a) determine distribution and abundance of the Southeastern American Kestrel throughout its life cycle, including the ratio of abundance of this subspecies to others where ranges overlap and b) develop a viable method of long term monitoring for nonbreeding Short-eared Owls.

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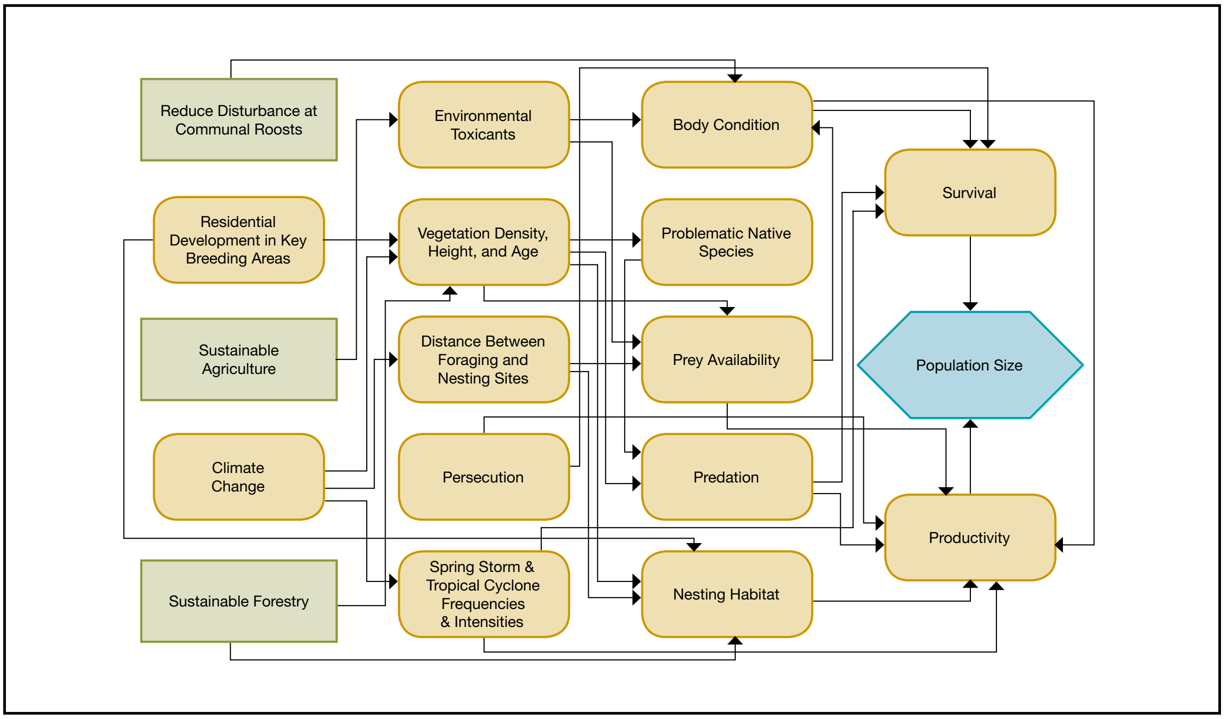
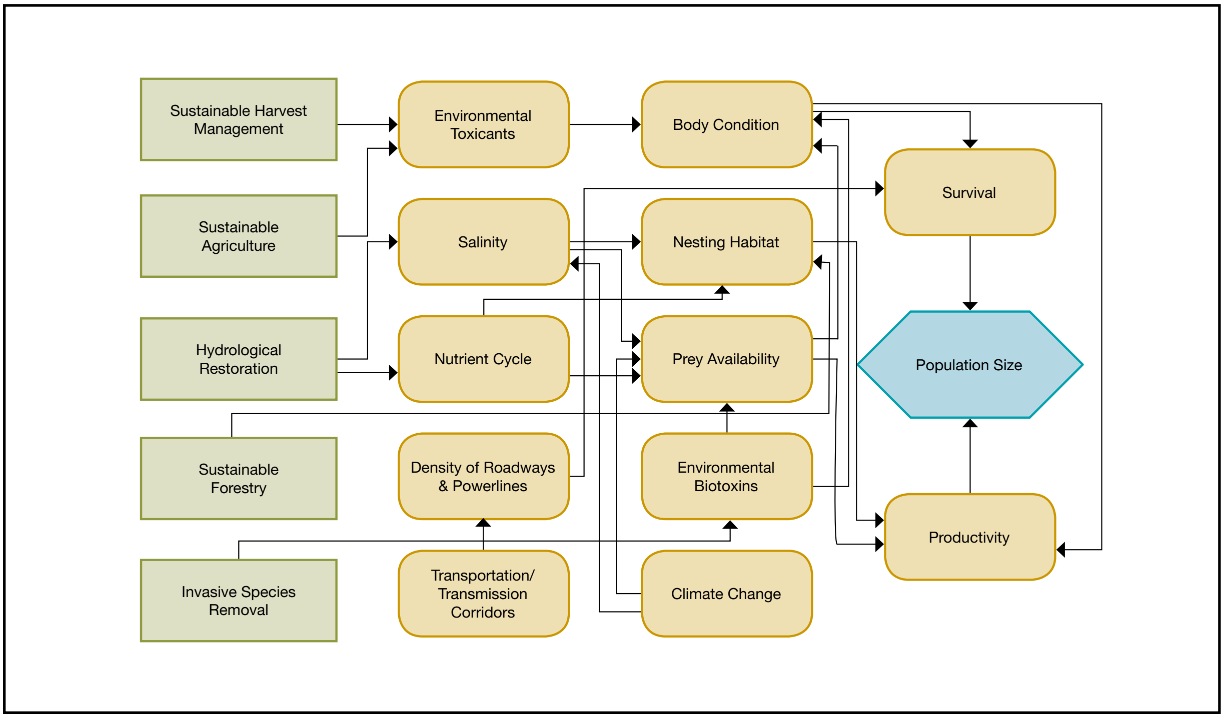
APPENDIX 5

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

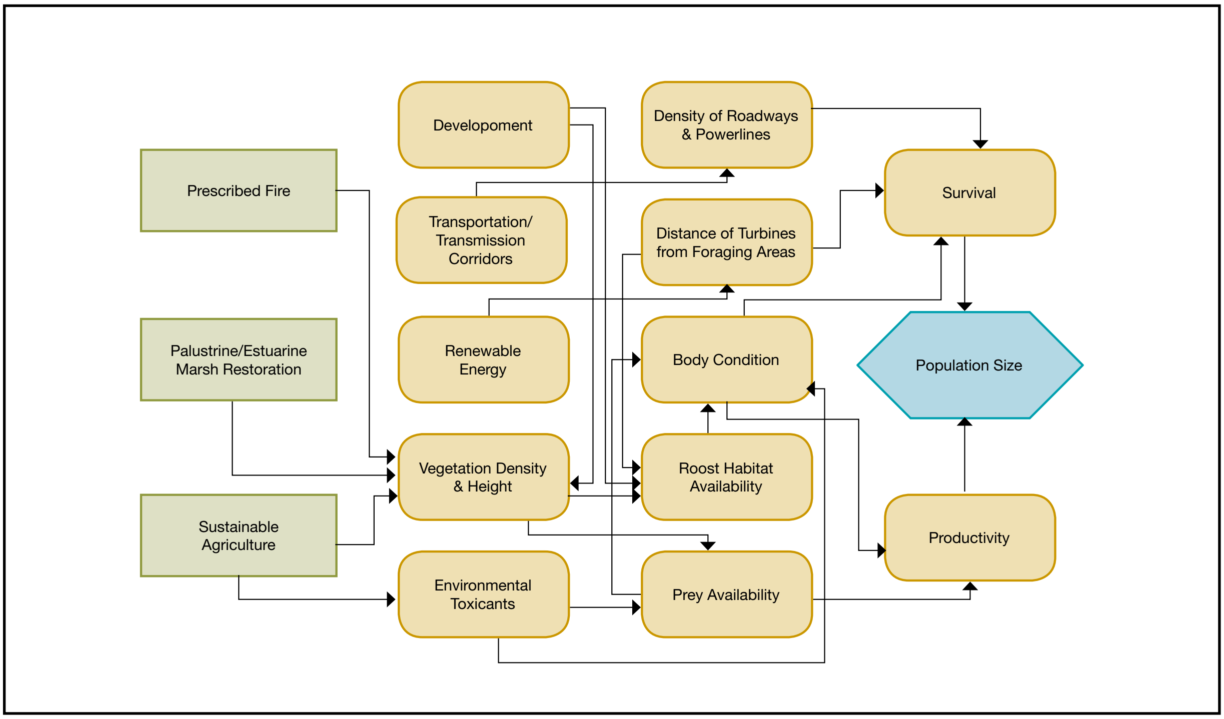


Influence diagram of the relationship between management actions (green boxes), intermediate processes (gold boxes) and population size (blue hexagon) for the ***Swallow-tailed Kite*** *(Elanoides forficatus) within the Gulf of Mexico Region.*

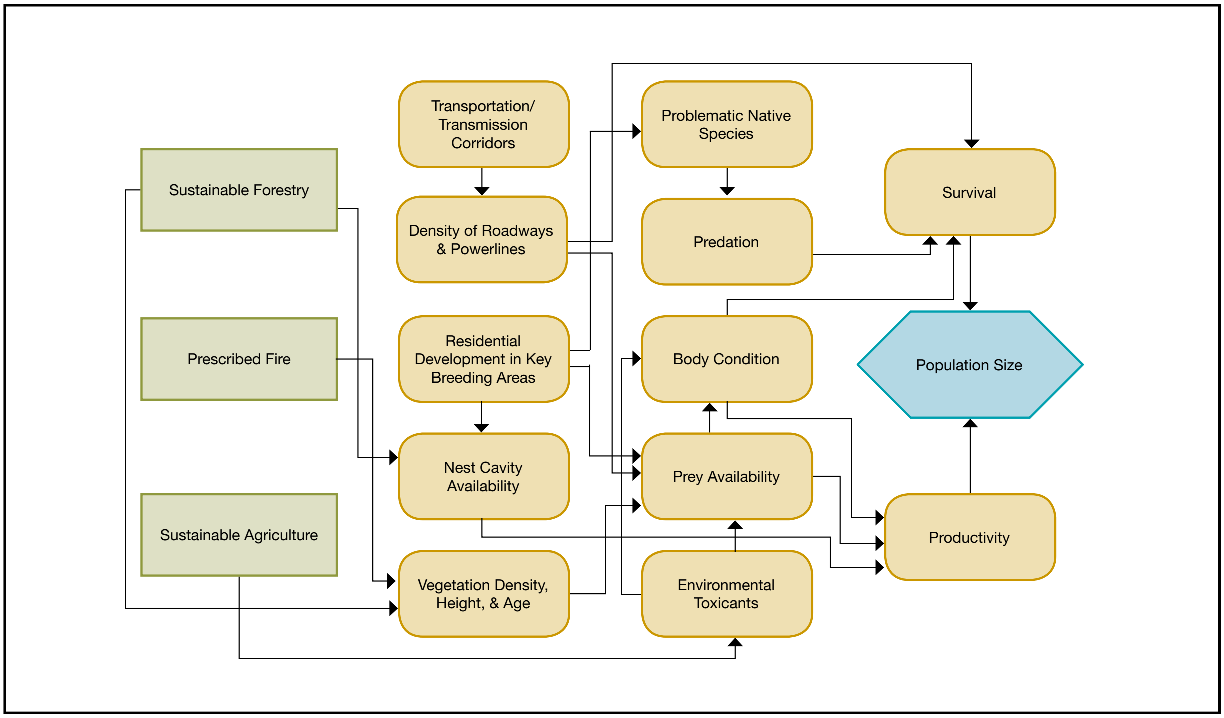
Raptors



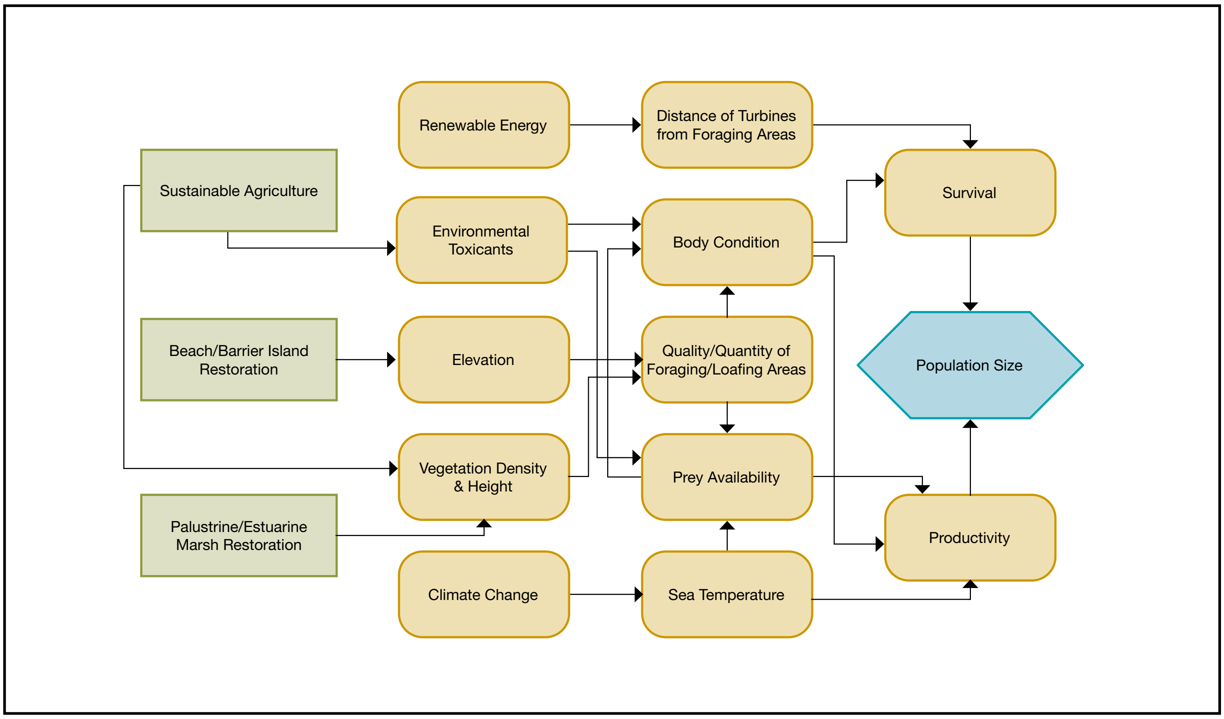
Influence diagram of the relationship between management actions (green boxes), intermediate processes (gold boxes) and population size (blue hexagon) for the ***Bald Eagle*** *(Haliaeetus leucocephalus) within the Gulf of Mexico Region.*



Influence diagram of the relationship between management actions (green boxes), intermediate processes (gold boxes) and population size (blue hexagon) for the ***Short-eared Owl*** *(Asio flammeus) 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 ***American Kestrel*** *(Falco sparverius) 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 ***Peregrine Falcon*** *(Falco peregrinus) within the Gulf of Mexico Region.*

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