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Research article

Decision support tool: Mottled duck habitat management and conservation in the Western Gulf Coast

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ABSTRACT

The Western Gulf Coast provides important habitat for migratory and resident waterfowl. The mottled duck (*Anas fulvigula*) relies on this region for all of its life-cycle events. Its relatively small population, limited worldwide range, and generally declining population trajectory has earned it a "Red" status on the Audubon WatchList and is a species of concern among state and federal agencies. The Western Gulf Coast (WGC) mottled duck population decline is believed to be primarily caused by the historical conversion and degradation of coastal wetlands and native prairie, and recent declines in cultivated rice. There is general agreement among experts that negative impacts to nesting and brood-rearing habitat are the most important threats to the WGC mottled duck population and increasing recruitment is essential to the growth and sustainability of the population.

Our goal was to use available knowledge of mottled duck nesting and brood-rearing requirements to develop a model to aid managers in targeting areas for conservation and management. We developed four spatially explicit models that: 1) identify and prioritize existing mottled duck nesting habitat for conservation (e.g., protection or maintenance); 2) identify and prioritize existing mottled duck brood-rearing habitat for conservation; 3) identify and prioritize areas for grassland establishment; and 4) identify and prioritize wetland basins for freshwater enhancement. Spatial models revealed that only 6 km^2 and 9 km^2 of nesting and brood-rearing habitat, respectively, were identified as highest priority (top 10%) for conservation in the WGC. Brood habitat was identified as potentially limiting recruitment in the Texas Mid Coast and the Laguna Madre subregions of our study area, whereas grassland habitat was potentially limiting recruitment in Chenier Plain and Mississippi River Coastal Wetlands subregions. Spatial models also revealed that there is a high density of areas of high priority for grassland establishment inland in Texas and Louisiana. Likewise, there is a high density of wetland basins of high priority for freshwater enhancement throughout coastal Louisiana and the upper Texas coast.

We used two separate measures to assess the performance of our Mottled Duck Decision Support Tool (hereafter MODU-DST) and found that it adequately identified patch suitability, as defined by our model, with ≥79% accuracy. Using data from the Cooperative Breeding Mottled Duck Survey, we also found that breeding mottled ducks were using landscapes with optimal spatial arrangement of nesting and brood-rearing habitat, which is reflected by higher mean priority rankings of nesting and brood-rearing habitat in the landscape.

1. Introduction

The Western Gulf Coast (WGC) provides valuable habitat for migratory and resident waterfowl. The mottled duck (*Anas fulvigula*) is a resident species in this region and is closely associated with coastal marsh and inland agricultural habitats, relying on these areas for all its life-cycle needs. Habitat conversion and degradation due to large-scale hydrologic alterations, urban expansion, declines in rice agriculture, and other human activities have raised concerns for the declining WGC mottled duck population. Collective evidence from available population

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data across the WGC range suggests a long-term steep decline in Texas and a stable to slightly declining trend in Louisiana (Wilson, 2007). Although other threats such as sport harvest (Raftovich et al., 2011), lead poisoning (Anderson et al., 2000; Sanderson and Bellrose, 1986), hybridization (Ford, 2015; McCracken et al., 2001), and predation (Bielefeld et al., 2010; Durham and Afton, 2003; Elsey et al., 2004; Stutzenbaker, 1988) may contribute to mottled duck population declines, loss of nesting and brood-rearing habitats is believed to be the primary cause (Wilson, 2007). Therefore, a priority for increasing the WGC mottled duck population is to increase recruitment by conserving landscapes with nesting and brood-rearing habitats in appropriate spatial configurations.

Managers and conservationists typically rely on limited resources for the protection and enhancement of habitats; thus, tools that identify areas most suitable for conservation efforts enable more efficient allocation of those resources. Decision Support Tools (DSTs) are information systems, often computer-based, that support decision-making activities (Power, 2007). In the last few decades, DSTs have become a vital component in the management of wildlife and their habitats (Bennetsen et al., 2016; Garcia and Armbruster, 1997; Kangas et al., 2000; Quinn and Hanna, 2003; Rauscher, 1999). A common drawback of historical approaches to habitat management is the inability to account for the spatial and temporal relationships between ecological variables related to a particular species (Cooperrider et al., 1986; Heinen and Cross, 1983). In recent decades, biologists have relied more heavily on ecological models for environmental decision support (Jones et al., 2016; Naugle et al., 2001; Robinson et al., 2016; Thorne et al., 2015). Ecological Decision Support Tools integrate available biological and ecological knowledge, expert opinion, and empirical data to develop tools that aid the decision-making process.

Our goal was to develop a spatially explicit DST for mottled duck habitat conservation in the WGC, prioritized for targeting conservation of nesting and brood-rearing habitat. Additionally, following the Strategic Habitat Conservation framework (Opdam et al., 2002; Schmolke et al., 2010; USFWS, 2008) we used an independent dataset to assess model performance and utility (Brooks, 1997; Schmolke et al., 2010) and inform future refinements.

Our specific objectives were to: 1) use recommendations in the Gulf Coast Joint Venture (GCJV) Mottled Duck Conservation Plan (Wilson, 2007) and input from regional stakeholders as the basis for a DST to inform delivery of conservation actions to establish, enhance, and protect/maintain coastal marshes, inland wetlands, and grasslands to positively impact key reproductive rates for WGC mottled ducks; 2) use the DST to generate spatial priorities for specific conservation actions of interest (establishment, enhancement, and protection/maintenance), with model outcomes based on target biological objectives (e.g., nest success and brood survival); and 3) assess the performance of the DST in identifying suitable habitat patches, and its ability to effectively prioritize patches.

2. Methods

2.1. Study area

Mottled ducks are managed as two distinct populations, one in peninsular Florida (Johnson et al., 1991) and the other in the WGC, which stretches from the eastern coast of Tamaulipas, Mexico into coastal Alabama (Baldassarre, 2014; Sincock et al., 1964; Stutzenbaker, 1988). Our focus was on the WGC population. Within this region we restricted the study area to Texas and Louisiana because > 99% of the GCJV population target for WGC mottled ducks occurs in these states (Wilson, 2007).

The WGC, inclusive of the Texas and Louisiana coasts (Fig. 1), stretches over 1200 km along the Gulf of Mexico and is bordered by about 12,000 km of shoreline (GSHHG, 2017; Wessel and Smith, 1996). Climate varies greatly across this region, as precipitation decreases from 1590 mm/year along the Louisiana coast, to 1390 mm/year along the upper Texas coast, to a low of 640 mm/year along the lower Texas coast (Chabreck et al., 1989; Stutzenbaker and Weller, 1989). Throughout the WGC, summers are generally hot (mean high 33 °C and mean low 24 °C; NOAA, 2011) and humid, and winters are mild (mean high 18 °C and mean low 8 °C; NOAA, 2011). The WGC is also affected by periodic tropical storm activity, which can impact vital waterfowl habitats (Couvillion et al., 2011). Agriculture consists primarily of sorghum, corn, cotton, and rice cultivation (USDA, 2014a,b). Nesting and brood-rearing habitat characteristics in the coastal marsh and agricultural landscapes differ in their structure and spatial arrangement, as well as their utility to mottled ducks (Wilson, 2007). The majority of agricultural and pasture lands occur adjacent to and inland from coastal marshes. To accommodate these differences, we identified nesting habitats in coastal zones differently than in inland (i.e., agricultural) zones. We defined the coastal zone as the combined extent of the Texas-Louisiana Coastal Marshes, Mid-Coast Barrier Islands and Coastal Marshes, Texas-Louisiana Coastal Marshes, and the Deltaic Coastal Marshes and Barrier Islands Level IV Eco-regions (U.S. Environmental Protection Agency, 2013). We further restricted development of the DST to the mottled duck range in Texas and Louisiana as described by Wilson (2007), which corresponds roughly to the geographic extent of GCJV Initiative Areas in these states (Fig. 1).

2.2. Currently available nesting and brood-rearing habitat model

We convened a comprehensive stakeholder meeting prior to initiation of model development to discuss the objectives of the development process, the appropriate biological parameters and their thresholds to include in the models, and to present a preliminary concept of the DST. Attendees included biologists, resource managers, Joint Venture staff, and academic researchers that work with mottled ducks and their habitats. Attendees provided vital feedback through open discussions and a questionnaire for the development of the DST. Regular meetings to report progress and obtain feedback were made with Gulf Coast Joint Venture and Gulf Coast Prairie Landscape Conservation Cooperative staff throughout the project.

Our model was parameterized using patch and landscape variables deemed critical for identifying currently available mottled duck nesting and brood-rearing habitat. Variables that affect mottled duck nest success and brood survival were chosen through review of appropriate literature and discussions with waterfowl habitat managers, mottled duck researchers, and other conservation stakeholders in the WGC. Vegetation type (Boryan et al., 2011), patch size, patch shape, and distance to nearest brood-rearing habitat were considered essential in identifying nesting habitat for mottled ducks (Table 1). The process for identifying nesting habitat in the coastal and inland zones was similar, with a few changes to variable thresholds to accommodate ecological and land use differences between the two landscapes. In coastal zones of Texas and Louisiana, mottled ducks nest primarily in dense stands of cordgrass (*Spartina* spp.), but will also utilize other tall grasses (Finger et al., 2003; Holbrook et al., 2000; Stutzenbaker, 1988; Walters et al., 2001). In inland areas, mottled ducks nest in idle fields and pastures (Durham and Afton, 2003). Successful nests are typically associated with higher plant diversity and vegetation density (Durham and Afton, 2003). Like most ground-nesting ducks, mottled ducks rely on vegetation structure around the nest to provide security from nest depredation. All spatial model building and analysis was conducted in ArcGIS software (ESRI, 2011). We used a step by step process and several models to identify nesting habitat in the inland and coastal zones that met all of the requirements and thresholds for suitability (Table 1; see Appendices A–F in Krainyk and Ballard, 2014 for more detail) and then converted the spatial layer into raster format for subsequent prioritization.

During the brood-rearing period, mottled ducks require low salinity, vegetated, relatively shallow wetlands in close proximity to nesting