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2017 Coastal Master Plan

Attachment C3-6: Gadwall, *Anas strepera*, Habitat Suitability Index Model

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Coastal Protection and Restoration Authority

This document was prepared in support of the 2017 Coastal Master Plan being prepared by the Coastal Protection and Restoration Authority (CPRA). CPRA was established by the Louisiana Legislature in response to Hurricanes Katrina and Rita through Act 8 of the First Extraordinary Session of 2005. Act 8 of the First Extraordinary Session of 2005 expanded the membership, duties and responsibilities of CPRA and charged the new authority to develop and implement a comprehensive coastal protection plan, consisting of a master plan (revised every five years) and annual plans. CPRA's mandate is to develop, implement and enforce a comprehensive coastal protection and restoration master plan.

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Executive Summary

The 2012 Coastal Master Plan utilized Habitat Suitability Indices (HSIs) to evaluate potential project effects on wildlife species. Even though HSIs quantify habitat condition, which may not directly correlate to species abundance, they remain a practical and tractable way to assess changes in habitat quality from various restoration actions. As part of the legislatively mandated five year update to the 2012 master plan, the wildlife habitat suitability indices were updated and revised using literature and existing field data where available. The outcome of these efforts resulted in improved, or in some cases entirely new suitability indices. This report describes the development of the habitat suitability indices for gadwall, *Anas strepera,* for use in the 2017 Coastal Master Plan modeling effort.

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List of Abbreviations

CPRA	Coastal Protection and Restoration Authority
HSI	Habitat Suitability Index
ICM	Integrated Compartment Model
LDWF	Louisiana Department of Wildlife and Fisheries
SAV	Submerged Aquatic Vegetation
SI	Suitability Index
USFWS	United States Fish and Wildlife Service
wd	Water depth

1.0 Species Profile

The gadwall (*Anas strepera*) is a migratory duck, occurring most commonly in Louisiana in the late fall, winter, and early spring (Figure 1). It is an important game species and is the second most abundant duck recorded in Louisiana Department of Wildlife and Fisheries (LDWF) surveys of wintering waterfowl in coastal habitats. Although populations declined during the middle portion of the last century, the species has experienced large increases in numbers in recent decades (Leschack et al., 1997).

Gadwall reproduce at one year of age (Leschack et al., 1997). Pair formation occurs during the southward migration, and by November, 84% of gadwall in Louisiana are in pairs (Paulus, 1980). The species reproduces in the north-central United States and south-central Canada. Breeding habitats include prairies, parklands, and subarctic deltas (Leschack et al., 1997). For a description of brood rearing habitat see Walker et al. (2013), whereas Sousa (1985) developed a Habitat Suitability model (HSI) for the breeding grounds. Males provide no parental care; females incubate eggs and brood the hatchlings. The clutch size varies between seven and 12 eggs and incubation takes approximately 26 days (Leschack et al., 1997).

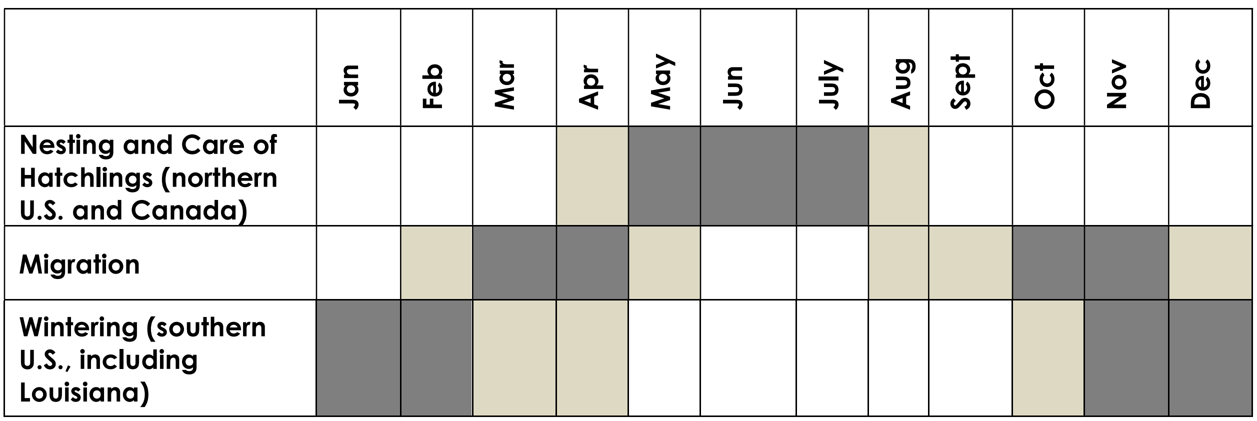

Figure 1: Seasonal Activities of the Gadwall. White cells indicate the life stage/activity is generally not present, light grey cells indicate the life stage is at moderate abundance, dark grey cells indicate times of highest life stage activity.

The gadwall commonly winters in the southern United States, Mexico, and the Caribbean Islands. During the months of November - February (Figure 1), Louisiana hosts a large portion of the wintering population of this species (Leschack et al., 1997). Some features associated with gadwall wintering habitat use are described in Table 1.

Wintering gadwall use coastal marshes, beaver ponds, farm ponds, and reservoirs (Leschack et al., 1997). In Louisiana, gadwalls use intermediate marsh more than fresh or brackish marsh (Bolduc, 2002). Saline marsh is used less frequently than other marsh types (Gray, 2010). Paulus (1984) noted that natural marshes provided better foraging habitats than did impoundments in Louisiana, but this conclusion was not supported by Bolduc (2002). Gadwall may use flooded forested areas (Fredrickson & Heitmeyer, 1987), but the usage appears to be more limited than that of marshes. In a reservoir in Texas, gadwalls used flooded forests much less than other marsh types and at lower rates than expected by their availability (Johnson & Swank, 1981). This species also used scrub-shrub habitat near this Texas reservoir (Johnson & Swank, 1981); however, shrub densities did not appear to be high and were of different species than are being modeled in the master plan.

Gadwall are more dependent on submerged aquatic vegetation (SAV) than many other dabbling ducks (White, 1975; Leschack et al., 1997; Hartke et al., 2009). Plant matter makes up 95-97% of the diet on the wintering grounds (Leschack et al., 1997). The occurrences of gadwall in different marsh types are probably tied to nearby SAV. White (1975) found that foraging was most common in areas with 70-100% SAV coverage. There was little use of areas with less than 30% SAV coverage. In Louisiana, the diet is comprised of algae, dwarf spike rush (*Eleocharis parvula*), widgeon grass (*Ruppia maritima*), Eurasian water milfoil (*Myriophyllum spicatum*), and coontail (*Ceratophyllum demersum*; Paulus, 1982).

Gadwall tend to use fairly deep water for foraging, compared to other dabbling ducks (Bolduc, 2002). The most commonly used areas had water depths of 18 to 36 cm. Use declined at lesser or greater depths; gadwalls were rarely found in areas were the depths were <6 cm or >85 cm.

Table 1: Characteristics Associated with Gadwall Habitat Used in the HSI Model.

Characteristic	Optimum	Suboptimum
Vegetation Type[1]	Intermediate Marsh followed by Freshwater Marsh	Brackish marsh followed by forested wetlands
Percent SAV coverage[2]	$\geq$70%	Declining with SAV coverage to 30%
Water depth[3]	18 – 36 cm	6 – 17 cm or > 36 cm

[1] Based on Bolduc, 2002; Gray, 2010; Fredrickson and Heitmeyer, 1987; and Johnson and Swank, 1981.

[2] Based on White, 1975 and White and James, 1978.

[3] Based on Bolduc, 2002 and Bolduc and Afton, 2004.

2.0 Approach

The 2017 Coastal Master Plan gadwall HSI model was modified from the gadwall model developed for the 2012 Coastal Master Plan (Nyman et al., 2013). The vegetation variable in the 2017 model differs from the similar variable in the 2012 model due to the addition of new habitat use data and a restructuring of the way vegetation is modeled to eliminate a recently detected problem with the original formulation. The variable related to SAV abundance is unchanged. The water depth variable is now based on the proportion of a cell with a given water depth rather than the proportion of time a cell has a given average water depth. The months used in the calculation of this variable have also been modified to better reflect the period of greatest numbers of gadwall on the Louisiana coast.

Model variables were selected as a result of a literature review, updated for the current effort, which attempted to identify important variables associated with habitat used by wintering gadwall. In addition, estimates of gadwall in different marsh types were obtained from LDWF (Larry Reynolds, unpublished data).

Habitat characteristics were assigned values between 0 and 1, with a value of 1 being assigned to the most preferred habitat state (United States Fish and Wildlife Service [USFWS], 1981). Quantitative measures of habitat use for an environmental variable were divided by the value for the variable state that had the highest value. This placed all the values of the variable on a scale from 0 to 1. Additional procedures are discussed for the individual variables. The HSI index values were obtained by taking the geometric means of the suitability indices of the individual variables (USFWS, 1981).

To validate the model, outputs from the 2012 Coastal Master Plan models, generated with the software EverView, were obtained for sites were the author had made field observations suggesting gadwall were common, uncommon, or absent. Outputs were applied to the habitat suitability model, and the HSI estimates were compared to the authors' field observations. In general, observations of gadwall abundance corresponded to HSI estimates. However, gadwall were sometimes observed in areas of greater water depths than those indicated as habitat in an earlier draft of this model, so the suitability index related to water depth was modified.

3.0 Habitat Suitability Index Model for Gadwall

The HSI for gadwall in a model cell is the geometric mean of three suitability index (SI) variables, each scaled from 0–1, where is the most suitable. The resulting HSI will be a value between 0 and 1. Cells with values near 1 should be the most suitable for the species whereas cells with values near 0 are unsuitable.

$HSI = (SI_1 \times SI_2 \times SI_3)^{1/3}$

Where:

SI_1 = Dominant emergent vegetation (V_1)

SI_2 = Proportion of open water with SAV (V_2)

SI_3 = Average water depth during the months of October – April (V_3).

3.1 Applicability of the Model

This model applies to adult gadwall wintering in coastal Louisiana.

3.2 Response and Input Variables

V_1 – Proportion of emergent vegetation and associated open water.

V_1 is the proportion of a cell that is wetland and associated open water. This variable should be calculated yearly. When there is no emergent vegetation in a cell, the cell should be assigned to one of following vegetation types based on average annual salinity:

Fresh Attached Marsh if salinity is < 1.5 ppt
Intermediate Marsh if salinity is $\geq$ 1.5 and < 4.5 ppt
Brackish Marsh if salinity is $\geq$ 4.5 and < 9.5 ppt
Saline Marsh if salinity is $\geq$ 9.5 ppt.

These thresholds are taken from Appendix D-4 of the 2012 Coastal Master Plan Report (Visser et al., 2012).

$SI_1 = (0.68 * V_{1a}) + (1.00 * V_{1b}) + (0.5 * V_{1c}) + (0.09 * V_{1d}) + (0.25 * V_{1e}) + (0.0 * V_{1f})$
When: V_{1a} = proportion of Fresh Attached or Fresh Floating Marsh

V_{1b} = proportion of Intermediate Marsh
V_{1c} = proportion of Brackish Marsh
V_{1d} = proportion of Saline Marsh
V_{1e} = proportion of Swamp or Bottomland Forest
V_{1f} = proportion of Non-wetland Habitat

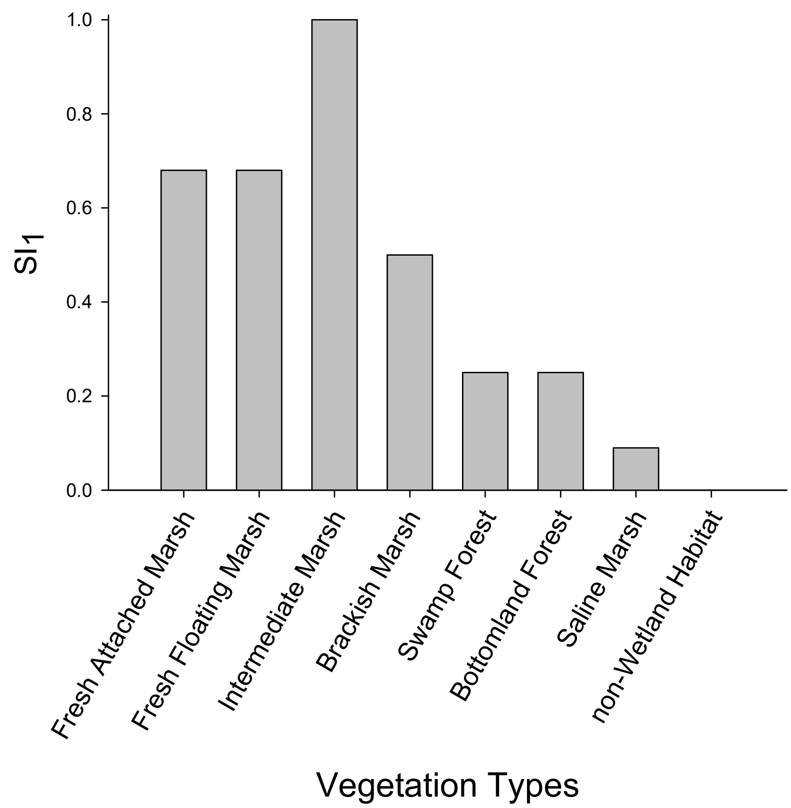

Figure 2: Relative Values (SI_1) of Different Types of Emergent Vegetation Types as Habitat for Gadwall.

Rationale: Gadwall abundance has been shown to vary among marsh types in Louisiana (Bolduc, 2002; Gray, 2010; LDWF aerial surveys of wintering waterfowl). For marsh types, this index is based on an average of the relative use based on estimates from Bolduc (2002), LDWF waterfowl surveys, and radio-telemetry observations from Gray (2010). These studies took place in southern Louisiana. There was not much resolution beyond freshwater marsh, intermediate marsh, and brackish marsh; LDWF and Gray (2010) collected data on saline marshes but Bolduc (2002) did not. Bolduc (2002) presented habitat specific densities; the LDWF data set consisted of counts of birds observed in different marsh types. Because the LDWF survey did not sample the same amount of each habitat type, the number of gadwall observed in a habitat was adjusted by the amount of habitat surveyed. Gray (2010) reported proportional use of habitat types based on radio-telemetry observations; values reported for habitat use outside of hunting season were used in this model.

For each of these data sets, the relative value of a vegetation type as gadwall habitat was determined by dividing the measure of use (density, area-adjusted counts, or proportional use) for that vegetation type by the highest value of use for gadwall observed in any vegetation type. This process set the value of the habitat type with the highest gadwall use to 1.0 (= optimal habitat), scaling the other use values by the highest value. The scaled values from the three data sets were then averaged for each habitat. These values were again rescaled, so that the habitat receiving the highest average relative use has a value of 1; these rescaled averages were used as the weights for the various habitat types. Based on the average of the relative use of marsh habitats obtained from these studies, gadwall most frequently use intermediate marsh, followed by fresh marsh, brackish marsh and saline marsh (Figure 2).

A value of 0 was assigned to cells with no wetland or open water habitat, based on information from Leschack et al. (1997). None of the studies from Louisiana estimated use in flooded bottomland forest or swamp forest. Gadwall are known to use flooded forests for portions of the winter (Fredrickson & Heitmeyer, 1987); however, the relative habitat use of this species needs additional investigation. Baker (LDWF, personal communication) suggested a value of 0.25 for forested wetlands, which is used above (Figure 2).

For those cases when there is no emergent vegetation (the cell is 100% occupied by some combination of open water and SAV) that cell would be assigned to one of the dominant vegetation categories based on its average salinity. Vegetation types are associated with salinity (Visser et al., 1998), so it is reasonable to use average salinity and vegetation as surrogates for one another. Assigning cells without emergent vegetation to one of the vegetation classes is necessary to prevent assignment of a zero value to cells with SAV, an important variable in gadwall habitat use (see variable 2).

V_2: Proportion of cell that is water with SAV

Variable 2 (V_2) is the proportion of the cell that is open water with SAV. This variable should be calculated yearly.

$SI_2 =$ 0.08 for $V_2 < 0.30 (2.3 * V_2)$
- 0.61 for $0.30 \leq V_2 < 0.70$
1.0 for $V_2 \geq 0.70$

Rationale: Gadwall use of habitats is heavily dependent on the presence of SAV (White, 1975; Leschack et al., 1997). This index is developed from observations by White (1975) and is based on the distribution of gadwall foraging in Texas coastal wetlands. The distribution of percent SAV was divided into classes and the most utilized class was assigned an index of 1 (= optimal SAV coverage). Classes that were used to a lesser extent received proportionally lower values of SI_2. The change of the index value was then converted into a linear function to de-emphasize the influence of small changes in the environmental variable on the index value (Figure 3).

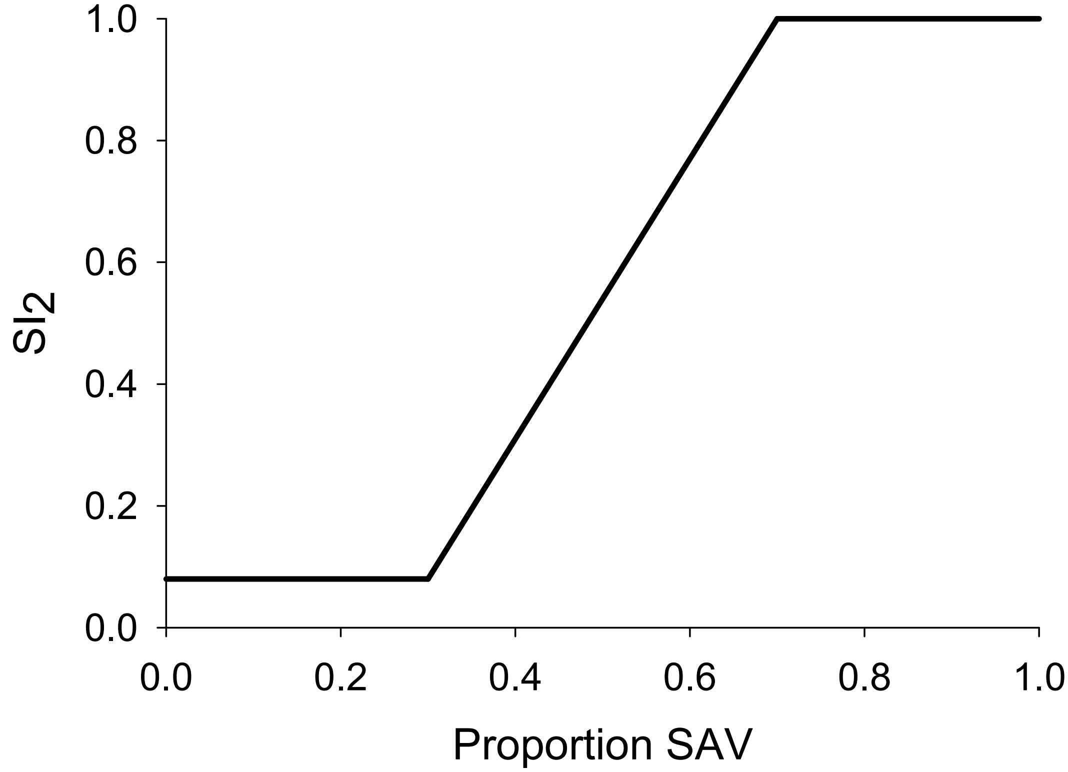

Figure 3: Relative Values (SI_2) of Sites as Habitat for Gadwall as a Function of the Proportion of the Cell Containing SAV.

V_3: Average water depth

Variable 3 (V_3) is the proportion of pixels in a cell where the average October-April water depth (in cm) provides suitable foraging habitat. This variable should be calculated once per year for the period between October and April.

$SI_3 = (0.05 * V_3a) + (0.15 * V_3b) + (0.35 * V_3c) + (0.60 * V_3d) + (0.83 * V_3e) + (1.0 * V_3f) + (0.86 * V_3g) + (0.61 * V_3h) + (0.37 * V_3i) + (0.20 * V_3j) + (0.10 * V_3k) + (0.05 * V_3l)$

When:

V_3a = the proportion of pixels in a cell where the average water depth (wd) for the period of October-April is ≤ 4 cm (weight = 0.05)

V_3b = the proportion of pixels in a cell where wd for the period of October-April is $4 < wd \leq 8$ cm (weight = 0.15)

V_3c = the proportion of pixels in a cell where wd for the period of October-April is $8 < wd \leq 12$ cm (weight = 0.35)

V_3d = the proportion of pixels in a cell where wd for the period of October-April is $12 < wd \leq 18$ cm (weight = 0.60)

V_3e = the proportion of pixels in a cell where wd for the period of October-April is $18 < wd \leq 22$ cm (weight = 0.83)

V_3f = the proportion of pixels in a cell where wd for the period of October-April is 22 < wd ≤ 28 cm (weight = 1.00)

V_3g = the proportion of pixels in a cell where wd for the period of October-April is 28 < wd ≤ 32 cm (weight = 0.86)

V_3h = the proportion of pixels in a cell where wd for the period of October-April is 32 < wd ≤ 36 cm (weight = 0.61)

V_3i = the proportion of pixels in a cell where wd for the period of October-April is 36 < wd ≤ 40 cm (weight = 0.37)

V_3j = the proportion of pixels in a cell where wd for the period of October-April is 40 < wd ≤ 44 cm (weight = 0.20)

V_3k = the proportion of pixels in a cell where wd for the period of October-April is 44 < wd ≤ 78 cm (weight = 0.10)

V_3l = the proportion of pixels in a cell where wd for the period of October-April is 78 < wd ≤ 150 cm (weight = 0.05)

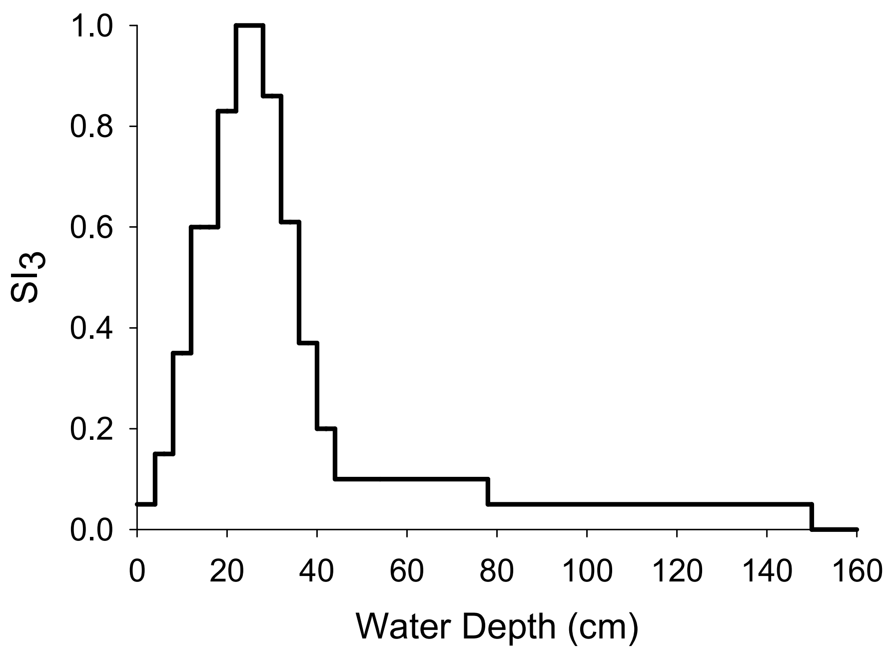

Figure 4: Relative Values (SI_3) of Sites as habitat for gadwall based on water depth. Because cells can have varying combinations of different categories, the figure represents suitability index values for cells comprised entirely of the category represented on the horizontal axis**.**

Rationale: Gadwall habitat use has been shown to vary by water depth (Bolduc, 2002; Bolduc & Afton, 2004). This species forages in deeper water than many other dabbling ducks of the genus *Anas* (Leschack et al., 1997). This index is based on the nonparametric regressions of habitat use developed by Bolduc (2002). Depth was divided into classes and the most utilized class was assigned an index of 1.0 = optimal water depth (Figure 4). Depths that were used to a lesser extent received proportionally lower values of SI_3. Water depth classes with similar values of SI_3 were combined. Bolduc (2002) did not provide estimates of habitat use by water depth beyond 81 cm. Because gadwall will occasionally use ponds and reservoirs in the winter, Bolduc's (2002) estimate for gadwall use for water depths of 81 cm was extended to water depths up to 150 cm. The assessment of water depth was limited to the fall, winter, and spring, when gadwall would be most likely be found in south Louisiana.

4.0 Model Verification and Future Improvements

To help ensure the distributions and patterns of HSI scores were realistic relative to current knowledge of the distribution of gadwall, a verification exercise was conducted. In order to generate HSI scores across the coast, the HSI models were run using calibrated and validated Integrated Compartment Model (ICM) spin-up data to produce a single value per ICM grid cell. Given the nature of a coast wide model, the ICM spin-up data may not reflect 'real-world' conditions in all areas of the coast. For example, some areas known to have wetland vegetation were classified as non-wetland habitat resulting in low HSI scores when high scores would otherwise be expected. In these instances, no improvements could be made to the HSI as these issues reside in other ICM subroutines (i.e., vegetation). As a result, the accuracy of the verification exercise is contingent on these inconsistencies.

In general, cells known to have high concentrations of gadwall had the highest HSI values, but values were generally lower than expected, with only a few cells having high values for the HSI. As the HSI is a relative index, this pattern is of little concern. However, in trying to explain it, several cells that should have had high index values based on high values for marsh type (SI_1) and SAV (SI_2) had unreasonably low values for the index related to water depth (SI_3). This finding is difficult to understand, because SAV should only occur within water depths at which gadwall feed. It appears that this discrepancy results from the low spatial resolution of the hydrology model. As a result of this issue, the amount of suitable gadwall habitat is under-estimated. In the future, improving the spatial resolution of the hydrology model should improve the model's predictions of gadwall habitat.

The collection of additional data on gadwall use of different habitat types is recommended. Aerial surveys and radio-telemetry studies only examined differences between major marsh types; there are no data exploring how vegetation communities within those marsh types might affect gadwall abundance. There are little data on waterfowl use of floating fresh marsh relative to emergent marsh. For our purposes, this habitat type was assigned the same value as emergent fresh marsh; however, the value of floating fresh marsh to waterfowl needs investigation. Estimates of the relative use of flooded forests and swamps by the species would also improve this model.

If possible, vegetation model outputs concerning SAV should be modified to provide information on the types of SAV predicted to be at a site. There are data showing variation in gadwall use among different types of SAV; however, currently available outputs identify only that SAV is present or absent. The data for the suitability index related to SAV are based on a Texas study site in freshwater marsh. The veracity of the assumption that the same relationships hold for Louisiana coastal marshes with varying salinities is untested.

There is a possibility that an interaction exists between water depth and salinity based on Bolduc's (2002) work in impounded and un-impounded wetlands; however, insufficient data are available to assess the effects of water depth in different habitats. Additional study of the influence of water depth on habitat use by gadwall in common coastal habitats would be of value.

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