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Floristic Quality Index and Forested Floristic Quality Index: Assessment Tools for Restoration Projects and Monitoring Sites in Coastal Louisiana

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Chapter 4.5.2

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Chapter Outline

INTRODUCTION

In 2003, the Coastwide Reference Monitoring System (CRMS) program was established in coastal Louisiana marshes and swamps to assess the effectiveness of individual coastal restoration projects and the cumulative effects of multiple projects at regional and coastwide scales (Steyer et al., 2003). In order to make these assessments, analytical teams were assembled for each of the primary data types sampled under the CRMS program, including vegetation, hydrology, landscape, and soils. These teams consisted of scientists and support staff from the US Geological Survey and other federal agencies, the Coastal Protection and Restoration Authority of Louisiana, and university academics. Each team was responsible for developing or identifying parameters, indices, or tools that can be used to assess coastal wetlands at various scales. The CRMS Vegetation Analytical Team has developed a Floristic Quality Index (FQI) for coastal Louisiana to determine the quality of a wetland based on the composition and abundance of its herbaceous plant species (Cretini et al., 2012). The team has also developed a Forested Floristic Quality Index (FFQI) that uses basal area by species to assess the quality and quantity of the overstory at forested wetland sites in Louisiana (Wood et al., 2017). Together these indices can provide an estimate of wetland vegetation health in coastal Louisiana marshes and swamps.

The FQI has been developed and used for several regions throughout the United States to provide an objective assessment of the vegetation quality or biological integrity of wetland plant communities. The FQI was first developed as a weighted average of the native plant species at a site (Swink and Wilhelm, 1979). It is based on a coefficient of conservatism (CC) score that is scaled from 0 to 10 and is applied to each plant species in a local flora. The score reflects a species' tolerance to disturbance and specificity to a particular habitat type. Species adapted to disturbed

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areas are often not habitat specific and, as such, have a low CC score. In contrast, habitat-specific species are generally not tolerant to disturbances and, as such, have a high CC score. A group of experts on local plants agrees upon and assigns CC scores.

The FFQI, which is similar to the FQI, was developed to evaluate ecosystem structural changes among forested wetland sites. The FFQI will be used to (1) evaluate forested wetland sites on a continuum from severely degraded to healthy, (2) assist in defining areas where forested wetland restoration is needed, and (3) determine the effectiveness of future restoration projects aiming to return degraded forested wetlands to healthy ecosystems. While the FQI is based on the percent cover of emergent herbaceous species, the FFQI uses this emergent herbaceous layer data in conjunction with the basal area at a species level and canopy cover. As such, the FFQI is a natural extension of the FQI and can be used in conjunction with the FQI of the understory herbaceous community in forested wetland systems, as there is typically an inverse relation between tree and herbaceous layer vegetation dominance in Louisiana's coastally restricted forested wetlands that represents natural succession (Conner and Day, 1992a; Shaffer et al., 2009; Nyman, 2014). As environmentally driven temporal shifts occur in the ecosystem, the FFQI contains valuable information that depicts a trajectory in system function. Generally, coastal flooded forested wetlands have transitioned to shrub-scrub; fresh, floating, and intermediate marshes; and open water. Conversely, in a few select locations, such as the Atchafalaya River Delta, the natural deltaic cycle causes the reversal of this trend. In this emerging deltaic environment, the succession of fresh marsh is transitioning into young forested wetlands populated by low value pioneer and disturbance woody species, leading to the development of fledgling swamps (Johnson et al., 1985; Shaffer et al., 1992). These two contrasting successional trajectories occurring within the same coastal system and same monitoring network highlight the need for a multivariable and index approach to site and restoration assessment.

METHODS

Coefficients of Conservatism

A comprehensive list of wetland plant species occurring in coastal Louisiana was first compiled from previous work by the authors and then distributed to a group of 40 Louisiana coastal vegetation experts. The panel of experts then assigned CC scores to each species by using the descriptions in Table 4.5.2.1. A group of eight local experts from the larger group met and (1) combined the scores, (2) resolved inconsistencies in scoring from the larger group, (3) amended the original list of species to include additional species, and (4) by consensus assigned CC scores to the additional species. Groups of plants—including floating or submerged aquatics and nonrooting parasitic plants—are not routinely assigned percent-cover values within coastal Louisiana monitoring projects and programs (e.g., CRMS; Folse et al., 2014). Therefore, species within these groups were excluded from the analysis and were not assigned CC scores. A total of 849 plants were assigned CC scores (Cretini et al., 2012).

TABLE 4.5.2.1 Criteria for Assigning Coefficient of Conservatism (CC) Scores to Plant Species for Coastal Louisiana

CC Score	Louisiana Description
0	Nonnative plant species
1–3	Plants that are opportunistic users of disturbed sites
4–6	Plants that occur primarily in less vigorous coastal wetland communities
7–8	Plants that are common in vigorous coastal wetland communities
9–10	Plants that are dominants in vigorous coastal wetland communities

Nonnative status according to USDA PLANTS Database (USDA, 2008). Vigorous implies that a coastal wetland community is composed generally of native species and that it is minimally influenced by disturbance.

Modified from Swink, F., Wilhelm, G.S., 1979. Plants of the Chicago Region, third ed., Revised and Expanded Edition with Keys. The Morton Arboretum, Lisle, IL; Swink, F., Wilhelm, G.S., 1994. Plants of the Chicago Region, fourth ed. The Morton Arboretum, Lisle, IL; Andreas, B.K., Lichvar, R.W., 1995. Floristic Index for Assessment Standards: A Case Study for Northern Ohio (Wetlands Research Program Technical Report WRP-DE-8). U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Herbaceous FQI

The FQI was modified from the standard equation developed by Swink and Wilhelm (1979, 1994; see Eq. (1) in Fig. 4.5.2.1) for coastal Louisiana herbaceous vegetation, (1) to include percent cover (see Folse et al., 2014 for sampling protocol); (2) to include all plant species (native and nonnative); and (3) to scale the score from 0 to 100 (Cretini et al., 2012). The modified FQI (see Eqs. (2), (3) in Fig. 4.5.2.1) was applied to the herbaceous vegetation data collected annually from monitoring stations within the CRMS sites (Fig. 4.5.2.2). These stations are distributed within swamp forests and marshes (fresh, intermediate, brackish, and saline) in coastal Louisiana.

Eq. (2) is used when $TOTAL\ COVER_t$ is 100 or less. By using Eq. (2), a lower FQI score will be calculated in cases where the area including the monitoring station consists of species found in vigorous wetlands (i.e., CC score is 7–10), but the amount of cover is low because of environmental stressors such as drought or prolonged flooding. Eq. (3) is used when the percent cover ($TOTAL\ COVER_t$) in the area including the monitoring station exceeds 100 because of overlapping canopies (i.e., carpet, herbaceous, shrub, tree layers). After computation, FQI scores are scaled from 0 to 100. FQI scores are

$$FQI_{std} = \left(\frac{\sum (CC_i)}{\sqrt{N_{native\ \ species}}} \right) \qquad \text{Eq. (1)}$$

$$FQI_{\mathrm{mod}\,t} = \left(\frac{\sum (COVER_{it} \times CC_i)}{100} \right) \times 10 \qquad \text{Eq. (2)}$$

$$FQI_{\mathrm{mod}t} = \left(\frac{\sum (COVER_{it} \times CC_i)}{\sum (TOTAL\ \ COVER_t)} \right) \times 10 \qquad \text{Eq. (3)}$$

CC_i is the coefficient of conservatism for species i;

$N_{native\ species}$ is the total number of native species within a monitoring station;

$COVER_{it}$ is the percent cover for a given species i at a monitoring station at a given time t; and

$TOTAL\ COVER_t$ is the cumulative percent species cover within a monitoring station.

FIG. 4.5.2.1 Equations used to calculate the Floristic Quality Index (FQI). Eq. (1) is the standard equation developed by Swink and Wilhelm (1979). Eqs. (2), (3) are the modified FQI developed for coastal Louisiana wetlands. Eq. (2) is used when percent cover ($TOTAL\ COVER_t$) is 100 or less. Eq. (3) is used when $TOTAL\ COVER_t$ in a monitoring station exceeds 100 because of overlapping canopies.

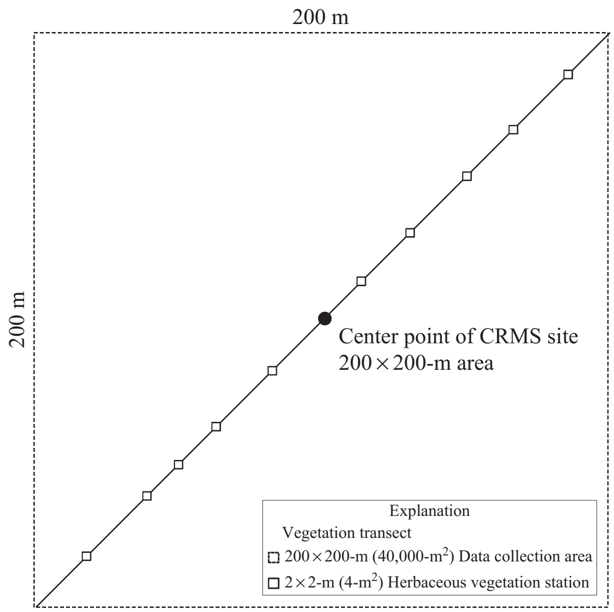


FIG. 4.5.2.2 A typical vegetation station layout within a CRMS herbaceous wetland site. CRMS data used to develop the Floristic Quality Index (FQI) for the CRMS network were collected from each of the 10, 2 × 2 m vegetation stations. The FQI is calculated for each station and then averaged to determine a site FQI. *(Recreated from Folse, T.M., Sharp, L.A., West, J.L., Hymel, M.K., Troutman, J.P., McGinnis, T., Weifenbach, D., Boshart, W.M., Rodrigue, L.B., Richardi, C.C., Wood, W.B., Miller, C.M., 2014. A Standard Operating Procedures Manual for the Coastwide Reference Monitoring System-Wetlands: Methods for Site Establishment, Data Collection, and Quality Assurance/Quality Control. Louisiana Coastal Protection and Restoration Authority, Office of Coastal Protection and Restoration, Baton Rouge, LA, 228 p.)*

calculated annually for herbaceous vegetation monitoring stations (Fig. 4.5.2.2). FQI scores for other spatial scales (e.-g., CRMS site, restoration project, hydrologic basin) are calculated by averaging modified FQI scores of monitoring stations that occur within the desired geographic boundary.

Forested FQI

A base FFQI score (see Eq. (1) in Fig. 4.5.2.3) was developed for coastal Louisiana forested wetlands (Wood et al., 2017) using, (1) CC scores provided by a panel of experts (Cretini et al., 2012), and (2) species-specific basal area within CRMS forested monitoring stations (Fig. 4.5.2.4). Based on a literature review, a basal area of 80 m^2/ha was considered to be the total possible basal area occurring in healthy Louisiana coastal forested wetlands (Table 4.5.2.2). Where the sum of basal areas by species at an overstory station within a CRMS site (Fig. 4.5.2.4) at time t is less than or equal to 80 m^2/ha, the base FFQI (Eq. (1) in Fig. 4.5.2.3) was calculated. This equation allows for stations containing sparse cover with vigorous (high CC score) trees and stations containing dense cover with less desirable (low CC score) species to have a similarly low index value. Highly dense stands (i.e., basal areas greater than 80 m^2/ha) were lacking from the CRMS data and as such an equation was not developed for these stands.

The diameter at breast height of all trees larger than 5 cm within the three overstory stations was measured to calculate the species-specific basal area (m^2/ha). The basal area for each tree species is collected a minimum of every 3 years. The basal area was multiplied by the species-specific CC score ranging from 0 to 10. The calculated species-specific base FFQI value was then summed across the station and divided by 80 m^2/ha, which was found to be greater than the maximum basal

FIG. 4.5.2.3 Equations used to calculate the Forested Floristic Quality Index (FFQI). Eq. (1) is the base FFQI developed in Wood et al., 2017 and based on a literature review of maximum basal area reported for coastal Louisiana forested wetlands. Eq. (2) is the modified FFQI that incorporates annual changes in herbaceous percent cover and canopy cover at the CRMS site.

$$BaseFFQI_t = \left(\frac{\sum(BASAL\ AREA_{it} * CC_i)}{80}\right) * 10 \qquad \text{Eq. (1)}$$

$$FFQI_t = CCM * BaseFFQI_t * ISM \qquad \text{Eq. (2)}$$

$BASAL\ AREA_{it}$ is the sum of basal area for species i at an overstory station within a CRMS site at time t;

CC_i is the coefficient of conservatism for species i;

CCM = 0.75 + 0.005 * *Percent Canopy Cover;*

ISM = 0.75 + 0.0025 * *Percent Net Indicator Species.*

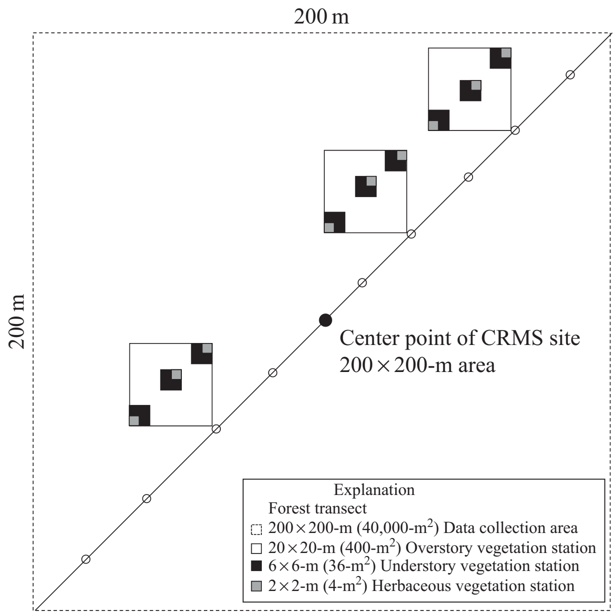


FIG. 4.5.2.4 A typical vegetation station layout within a Coastwide Reference Monitoring System (CRMS) forested wetland site. CRMS data used to develop the Forested Floristic Quality Index (FFQI) for the CRMS network were collected from overstory vegetation stations at each of the 20 × 20 m stations and the 2 × 2 m herbaceous layer vegetation stations.

TABLE 4.5.2.2 Literature Review of Maximum Basal Area Reported for Coastal Louisiana Forested Wetlands

Maximum Basal Area (m^2/ha)	Source
81.6	Conner and Brody (1989)
71.6	Conner et al. (1986)
68*	Shaffer et al. (2009)
65*	Hesse et al. (1998)
54.4	Conner et al. (2002)
70.6	Krauss et al. (2009)
45*	Visser and Sasser (1995)
38.3	Conner and Day (1992b)
35*	Conner et al. (1981)

Values with *asterisk* estimated from publication figures.

area among the CRMS forested wetland sites in Louisiana. This value was multiplied by 10 to scale the final product from 0 to 100. The CRMS station level base FFQI (Eq. (1) in Fig. 4.5.2.3) scores were then modified on the basis of both the station-specific canopy cover and the herbaceous layer vegetation present at the forest floor to incorporate habitat characteristics that quickly respond to stimuli on an annual basis. The canopy cover modifier (CCM) and a herbaceous layer indicator species modifier (ISM) were given equal weight to affect the final FFQI value at each CRMS station (Eq. (2) in Fig. 4.5.2.3).

Canopy cover was recorded annually via a spherical densiometer on a scale from 0.0 to 100.0 at the center of each 20×20 m station. This measurement was recorded in duplicate by separate personnel and not finalized until separate readings were within 20% of one another (Folse et al., 2014). The CCM ranged linearly from fully closed canopy multiplying the base FFQI by 1.25 times to an open absent canopy reducing the station base FFQI by as much as 0.25 (Fig. 4.5.2.5).

$$CCM = 0.75 + 0.005^{*}\ Percent\ Canopy\ Cover$$

The live herbaceous layer vegetation was measured inside three 2×2 m plots per station embedded diagonally in the larger 20×20 m overstory plot (Fig. 4.5.2.4). Species-specific percent cover, total cover, height of the dominant species, and

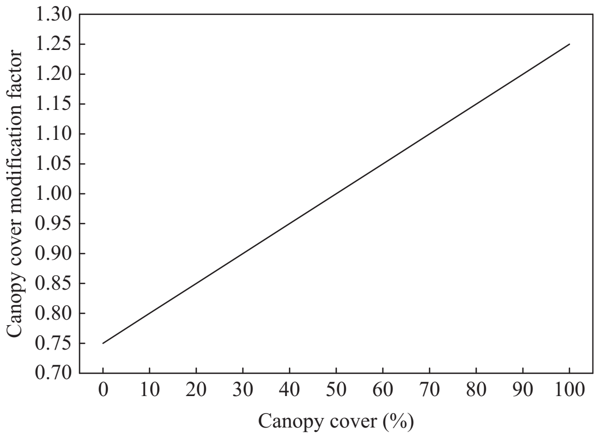


FIG. 4.5.2.5 The relation between the Forested Floristic Quality Index (FFQI) canopy cover modification factor and canopy cover. A modification factor of 1.25 was applied to the station level FFQI for fully closed canopies (100% canopy cover value), where station level FFQI for open canopies was reduced by a modification factor of 0.25.

percent cover of the nonvegetated surface were recorded in each 2×2 m plot (Folse et al., 2014). Species-specific percent covers were estimated by no fewer than two observers agreeing to the nearest whole number from 0 to 100. These data were used in concert with a list of indicator species (Table 4.5.2.3) developed by a panel of Louisiana wetland forest experts and species-specific salinity scores developed for a marsh type assignment algorithm (Visser et al., 2002). This indicator species list consists of two main groups: (1) positive indicator species often seen in association with healthy swamp ecosystems, and (2) negative indicator species common to floating, intermediate, brackish, and saline marshes and disturbed forested wetlands (Table 4.5.2.3). The individual species within a single 2×2 m plot were categorized into positive, negative, or inert percentages of indicator type present and then averaged at the plot level and then again at the 20×20 m station level to spatially correspond to the other constituents of the FFQI. The indicator species cover theoretically ranged from 100% positive to 100% negative with all possible intermediate states.

The ISM was given the same weight as the CCM with 100% positive indicator species modifying the base FFQI by 1.25, whereas a 100% cover of negative indicator species would reduce the base FFQI by as much as 25% (Fig. 4.5.2.6). After the base FFQI was modified via the CCM and the ISM, the new FFQI scores were rescaled by the maximum station level value, thereby creating a 0–100 FFQI scale.

$$ISM = 0.75 + 0.0025^{*}\, Percent\, Net\, Indicator\, Species$$

This approach allows the FFQI to change annually even as basal area and species composition of the overstory plots remain fixed for 3 years, by using the yearly collected canopy cover and herbaceous layer indicator species data.

DISSEMINATION

Herbaceous FQI

FQI scores are calculated annually for each of the 334 CRMS marsh sites and the 58 swamp sites. Scores for each year are displayed graphically, along with species composition data, on the CRMS website (http://www.lacoast.gov/crms2/Home.aspx). These graphical displays can be done for one site at one time (year), for one site across time, for a site compared to scores of the same marsh type and within the same hydrologic basin, and as a report card. These scores can also be displayed spatially with a mapping feature available on the website. This versatility allows managers to view the data from various extents and to compare sites and/or restoration projects. The FQI is an important component of a suite of indices and tools that allows informed management decisions to be made based on observations from the monitoring network compared across various spatial and temporal scales.

The CRMS site-level FQI scores during the 2016 survey year ranged from 0.00 to 92.00. The range of scores displayed on a map of the Louisiana coast and classified by quartiles gives a visual representation of scores across the coast (Fig. 4.5.2.7). CRMS sites with FQI scores of 38.00 and lower are within the 25th quartile and are regarded as poor (triangles), scores greater than 38.00 and less than or equal to 71.00 are regarded as fair (squares), and scores greater than 71.00 are regarded as sites with healthy vegetation (circles). It appears that each quartile comprises sites spread across the coast without regard to basin or marsh type.

The CRMS site FQI scores can be used to assess vegetation condition over a temporal scale. For example, Figs. 4.5.2.8 and 4.5.2.9 show annual FQI scores for a specific site (CRMS1024 and CRMS0178, respectively) along with the annual species composition at the sites. CRMS1024 is located in a saline marsh with high cover values of *Spartina alterniflora* (Fig. 4.5.2.8) and as such has a high FQI score because *Spartina alterniflora* is a dominant species in coastal marshes. By comparison, CRMS0178, which is also located in a saline marsh, has lower cover values of *Spartina alterniflora* and other species with lower CC scores (Fig. 4.5.2.9); this is reflected in the FQI score.

The CRMS site FQI score can also be used to assess vegetation condition across various spatial scales. Figs. 4.5.2.10 and 4.5.2.11, for example, show the 2016 FQI scores for sites CRMS1024 and CRMS0178, respectively, in comparison to other sites in the same marsh type (saline), in the same hydrologic basin (Pontchartrain), and all other CRMS sites. CRMS0124 scores well when compared to other sites (Fig. 4.5.2.10) and is within the 75th quartile of FQI scores while CRMS0178 scores lower than other saline marsh site scores and most sites within the same hydrologic basin (Fig. 4.5.2.11), as it is between the 25th and 75th quartiles.

TABLE 4.5.2.3 Indicator Taxa That Modify Base Forested Floristic Quality Index (FFQI) Scores

Positive Indicator Taxa	Negative Indicator Taxa
Acer rubrum var. *drummondii* (Drummond's maple)	Saltwater intrusion
Boehmeria cylindrica (smallspike false nettle)	*Distichlis spicata* (saltgrass)
Crinum americanum (seven sisters)	*Iva frutescens* (Jesuit's bark)
Fraxinus caroliniana (Carolina ash)	*Panicum repens* (torpedo grass)
Fraxinus profunda (pumpkin ash)	*Schoenoplectus americanus* (chairmaker's bulrush)
Hymenocallis occidentalis var. *occidentalis* (Northern spiderlily)	*Bolboschoenus robustus* (sturdy bulrush)
Iris virginica (Virginia iris)	*Spartina alterniflora* (smooth cordgrass)
Juncus effusus (common rush)	*Spartina patens* (saltmeadow cordgrass)
Nyssa aquatica (water tupelo)	*Symphyotrichum subulatum* (eastern annual saltmarsh aster)
Nyssa biflora (swamp tupelo)	*Symphyotrichum tenuifolium* (perennial saltmarsh aster)
Phanopyrum gymnocarpon (savanna-panicgrass)	All other species with a salinity score of 2.75 and above (Visser et al., 2002)
Quercus sp. (oak)	Flood stress
Sagittaria latifolia (broadleaf arrowhead)	*Bacopa monnieri* (herb of grace)
Saururus cernuus (lizard's tail)	*Bidens laevis* (smooth beggartick)
Tradescantia ohiensis (bluejacket)	*Habenaria repens* (waterspider bog orchid)
Taxodium distichum (bald cypress)	*Hydrocotyle ranunculoides* (floating marshpennywort)
	Ludwigia peploides (floating primrose-willow)
	Pontederia cordata (pickerelweed)
	Sacciolepis striata (American cupscale)
	Schoenoplectus californicus (California bulrush)
	Typha L. (cattail)
	Zizaniopsis miliacea (giant cutgrass)
	Disturbance/transition to marsh
	Amaranthus australis (southern amaranth)
	Cephalanthus occidentalis (common buttonbush)
	Eleocharis sp. (spikerush)
	Ludwigia sp. (primrose-willow)
	Salix nigra (black willow)
	Sesbania drummondii (poisonbean)
	Sesbania herbacea (bigpod sesbania)
	Triadica sebifera (Chinese tallow)

Positive indicator taxa are often observed in association with healthy forested wetland ecosystems. Negative indicator taxa are common in floating, intermediate, brackish, and saline marsh types and in disturbed forested wetlands.

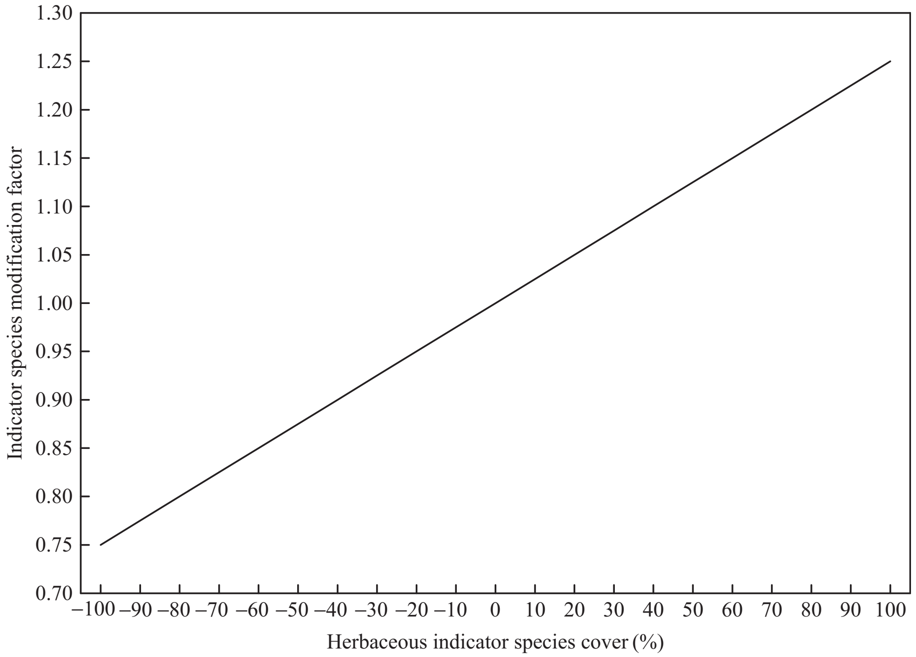


FIG. 4.5.2.6 The relation between the herbaceous indicator species cover and the Forested Floristic Quality Index (FFQI) canopy cover modification factor. The canopy cover modifier with 100% positive indicator species modified the base FFQI by a modification factor of 1.25, and 100% cover of negative indicator species reduced the base FFQI by a modification factor of 0.25.

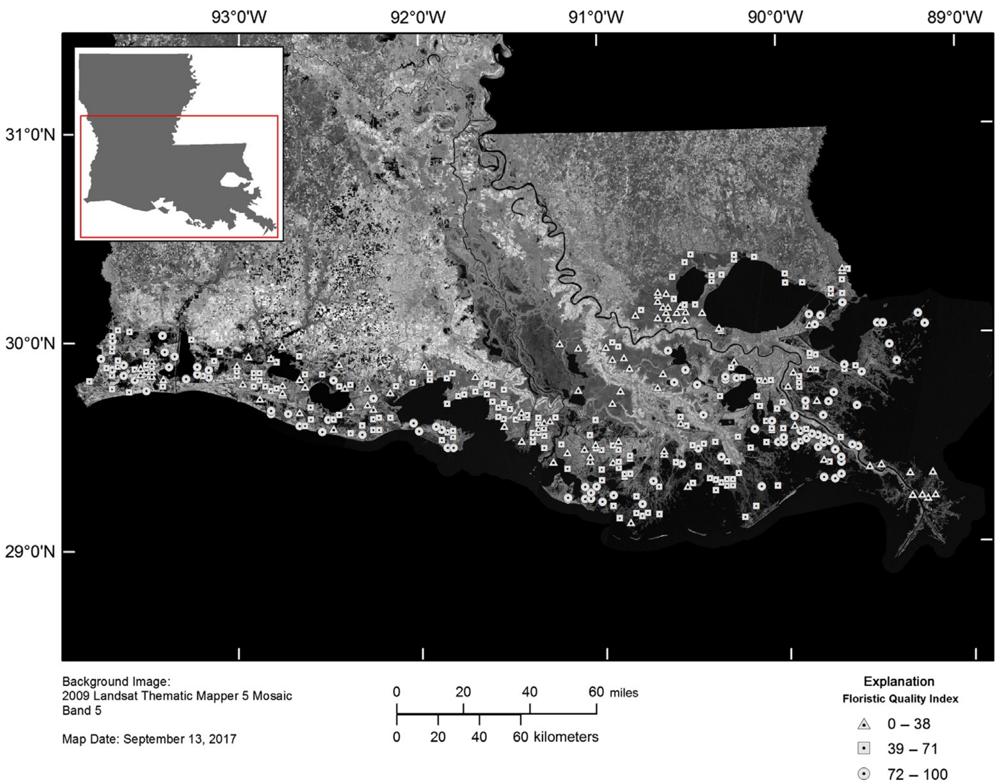


FIG. 4.5.2.7 Map showing the Floristic Quality Index (FQI) scores for 2016 from CRMS herbaceous vegetation data (includes CRMS sites in both marsh and swamp) separated into the 25th and 75th quartiles. Site FQI scores in the 25th quartile, designated as triangles, are below 39.00. Site FQI scores between the 25th and 75th quartiles are designated as squares and site FQI scores in the 75th quartile are designated as circles (FQI scores greater than 71.00).

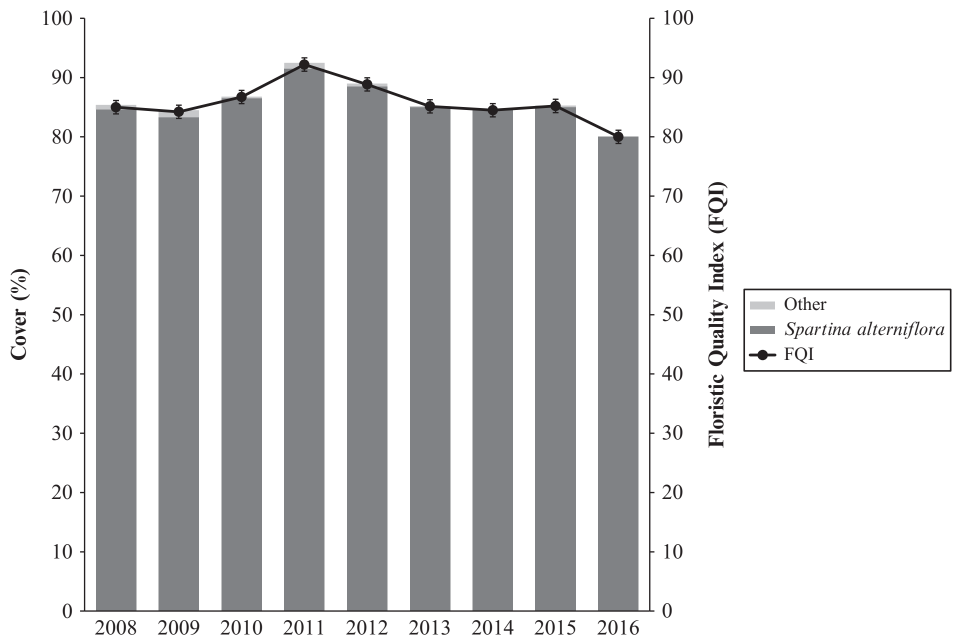


FIG. 4.5.2.8 Floristic Quality Index (FQI) scores for saline marsh site CRMS1024 by year shown with the percent cover values of the species present at the site.

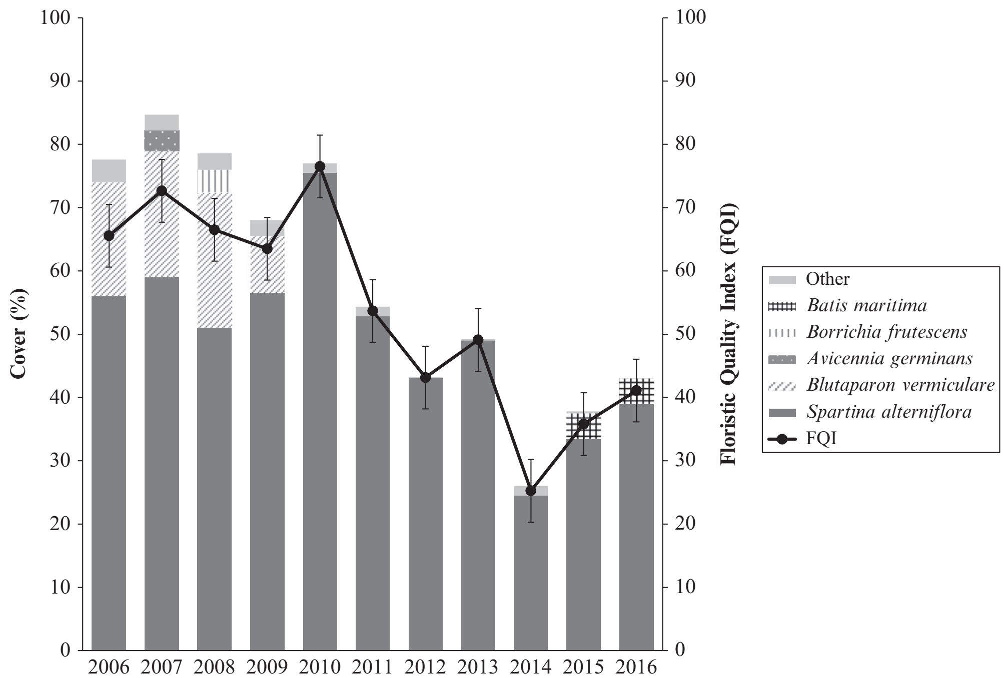


FIG. 4.5.2.9 Floristic Quality Index (FQI) scores for saline marsh site CRMS0178 by year shown with the percent cover values of the species present at the site.

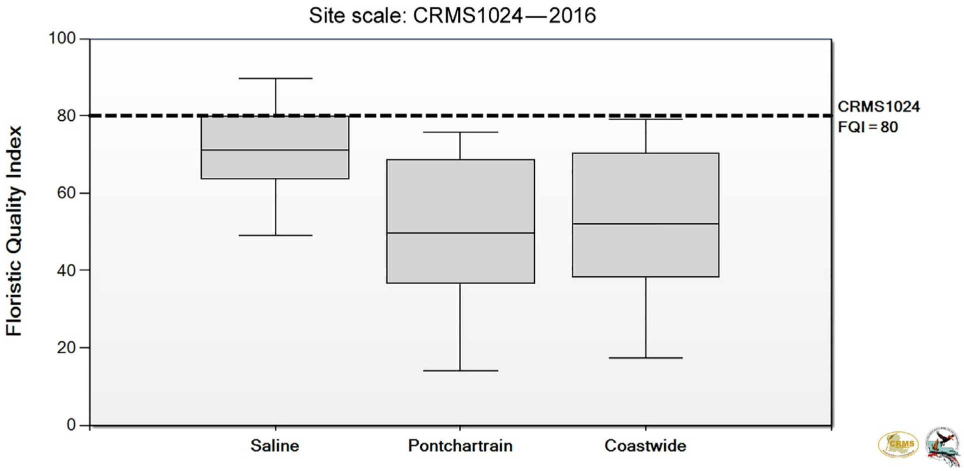


FIG. 4.5.2.10 The Floristic Quality Index (FQI) score for a saline marsh site (CRMS1024) in 2016 compared to the distribution of scores for all coastwide sites within the same marsh type (saline), within the same hydrologic basin (Pontchartrain), and across the entire Louisiana coastal zone (coastwide).

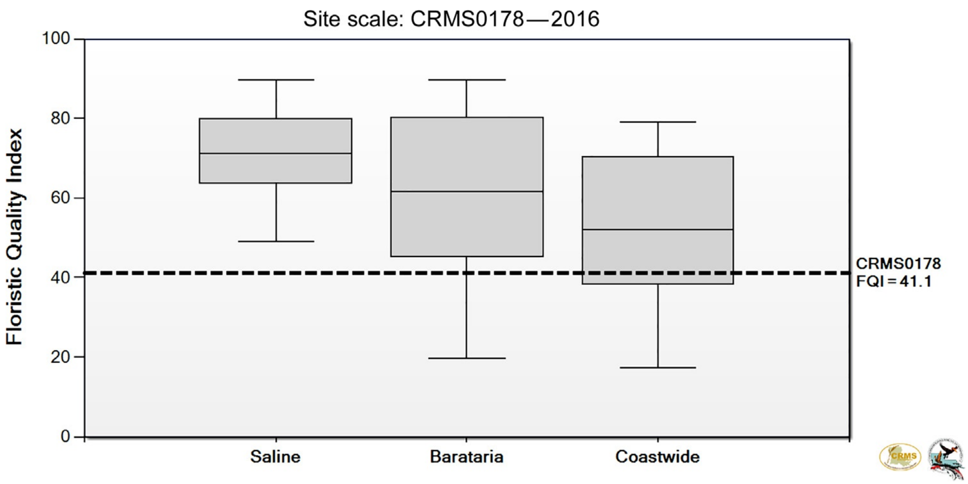


FIG. 4.5.2.11 Floristic Quality Index (FQI) score for a saline marsh site (CRMS0178) in 2016 compared to the distribution of scores for all coastwide sites within the same marsh type (saline), within the same hydrologic basin (Barataria), and across the entire Louisiana coastal zone (coastwide).

Forested FQI

The CRMS site level FFQI scores during the 2015 survey year ranged from 0.39 to 78.01 with an average score of 33.02 (SE = 3.05) across all sites surveyed. The 25th quartile of the FFQI scores ($n = 14$) was below 11.27 and contained both emergent and degraded locations in the Atchafalaya Delta/Teche-Vermilion and Pontchartrain Basins, respectively (triangles, Fig. 4.5.2.12). Most of the developing forested wetland sites in the lower Atchafalaya Delta/Teche-Vermilion Basin scored in the 25th quartile, which contrasted with sites within the Pontchartrain Basin, where the sites varied from some of the highest scores coastwide to the lowest (Fig. 4.5.2.12). The 75th quartile ($n = 14$) had FFQI scores greater than 52.08 and comprised sites spread across the coastal forested wetlands (circles, Fig. 4.5.2.12). Sites within the lower quartile represent both poorly functioning CRMS forested wetland sites and newly emergent sites. The sites between the 25th and 75th quartiles ($n = 29$) were generally in a low to moderate state of deterioration (squares, Fig. 4.5.2.12).

The varying nature of forested wetland degradation coastwide is evident in the continuum that exists in the FFQI scores throughout the Louisiana coastal zone. CRMS sites transition between the quartiles as the physical characteristics of the local environment change, which in many cases is evident in the appearance of the forest structure at each CRMS site (Fig. 4.5.2.13). The 25th through 50th quartile grouping illustrates the general lack of a complete overstory canopy, typically with ample herbaceous layer vegetation (Fig. 4.5.2.13B). The more densely wooded 75th quartile maintains

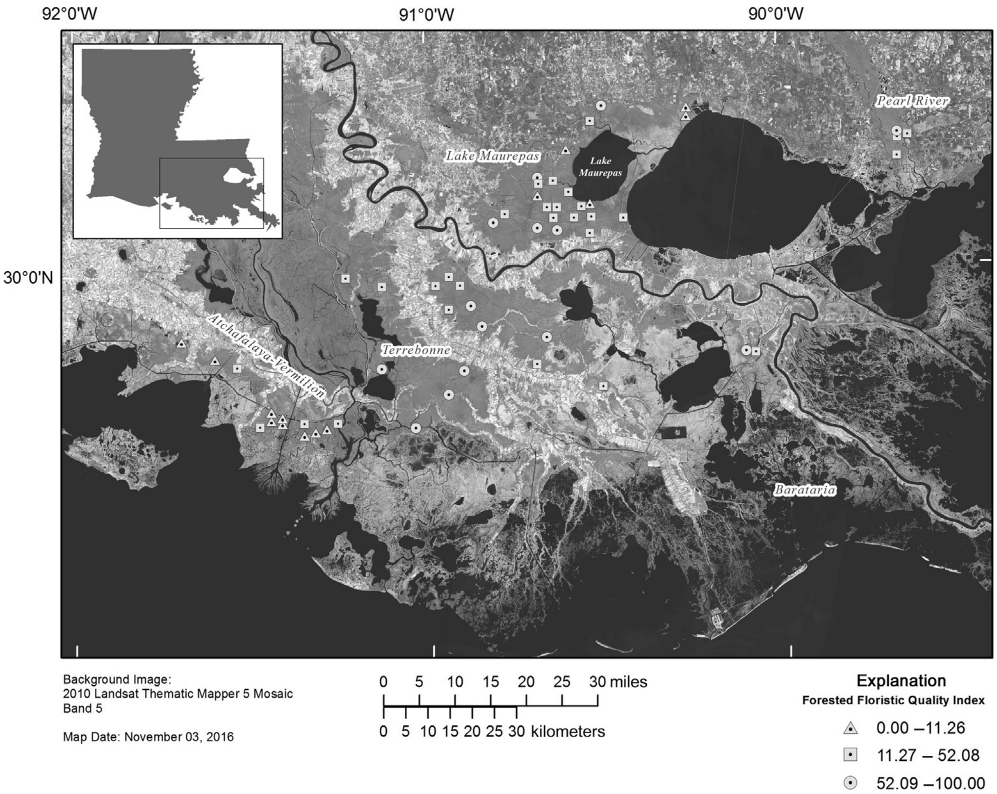


FIG. 4.5.2.12 Map showing the Forested Floristic Quality Index (FFQI) scores for 2015 from CRMS forested wetland sites separated into the 25th and 75th quartiles. Most sites in the lower Atchafalaya-Vermilion Basin scored in the 25th percentile because of low basal area and presence of early successional species. Contrast this with the Lake Maurepas Basin, where the sites varied from some of the highest scores coastwide to the lowest as saltwater intrusion, nutrient limitation, and impoundments near Lake Maurepas degrade the forest structure.

noticeably larger canopy structure, reducing the amount of growing season sunlight at the forest floor (Fig. 4.5.2.13C). The more open 25th quartile has a savanna-like visual aspect that generally contains relic individual overstory trees and isolated clusters of overstory trees in areas of increased elevations, often along waterways (Fig. 4.5.2.13A).

The site-level FFQI can be computed annually as canopy cover and indicator species data are collected by using the previously collected (every 3 years) basal area by species, which is typically very stable on an annual basis. The average annual percent cover of positive and negative indicator species in the forested plots can display trends in the understory community composition as it relates to forest persistence. These individual CRMS sites can be tracked annually through time as data are collected to determine what specific vegetative attribute is generating change in the site FFQI score, whether basal area and species composition are static (Figs. 4.5.2.14–4.5.2.16). However, as the Louisiana coastal zone does contain active delta formation and deterioration, the FFQI alone cannot differentiate between newly forming forests and severely degrading habitat.

FQI vs. FFQI

A simple linear regression shows the inverse relation between the FFQI and the corresponding herbaceous-only FQI at the same CRMS forested wetland sites (Fig. 4.5.2.17). A degraded forested site, CRMS6209 (Fig. 4.5.2.13A), had an FFQI score of 0.39 in 2015 and an FQI score of 55.82. CRMS0089 (Fig. 4.5.2.13B) had an FFQI score of 30.41 in 2015 and an FQI score of 37.93. In 2015 the densely wooded forested site, CRMS5672 (Fig. 4.5.2.13C), had FFQI and FQI scores of 53.16 and 4.43, respectively.

The FFQI and FQI are inversely correlated to one another when a continuum of forested wetland degradation is assessed, as basal area and stable late stage successional woody species are replaced with more disturbance-oriented shrubs

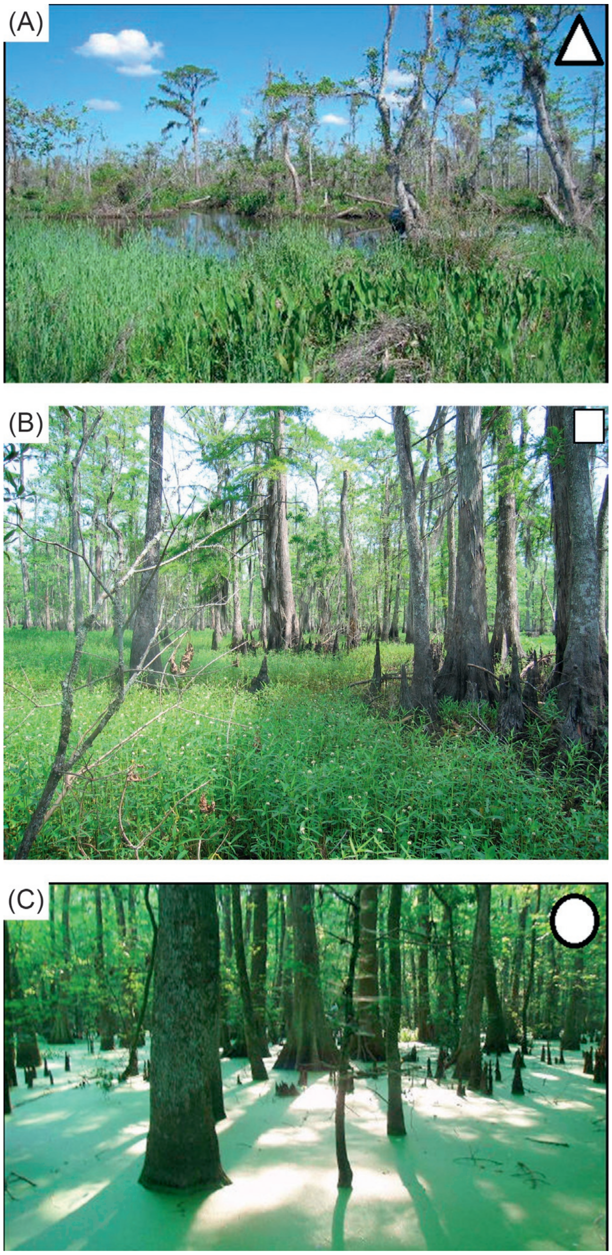


FIG. 4.5.2.13 Coastwide Reference Monitoring System (CRMS) forested wetland sites and their associated 2015 Forested Floristic Quality (FFQI) scores. (A) Site CRMS6209 and (B) site CRMS0089 are located in the Lake Maurepas Basin and scored 0.39 (25th quartile) and 30.41 (25th–75th quartile), respectively. (C) Site CRMS5672 is located within the Barataria Basin and received an FFQI score of 53.16 (75th quartile).

and multiple herbaceous vegetation communities that change depending on the cause of habitat transition and light availability. There are also many subtle relations between the two indices on a specific scale. For example, an upward trend in FQI coupled with a stable FFQI score over time may indicate that the location is losing sapling and midstory stems while maintaining the overstory stress, thereby beginning the transition toward more herbaceous vegetation. Alternatively, sites with low but increasing FFQI scores may be indicative of a succession from a marsh or shrub-scrub community toward a forested wetland, either through natural processes or as a consequence of restoration activities. A steady decrease in FQI and stable FFQI scores could suggest that herbaceous vegetation quality in an area is declining, either through natural succession toward a mature forested community or through disturbance and/or restoration activities meant to encourage tree colonization and growth.

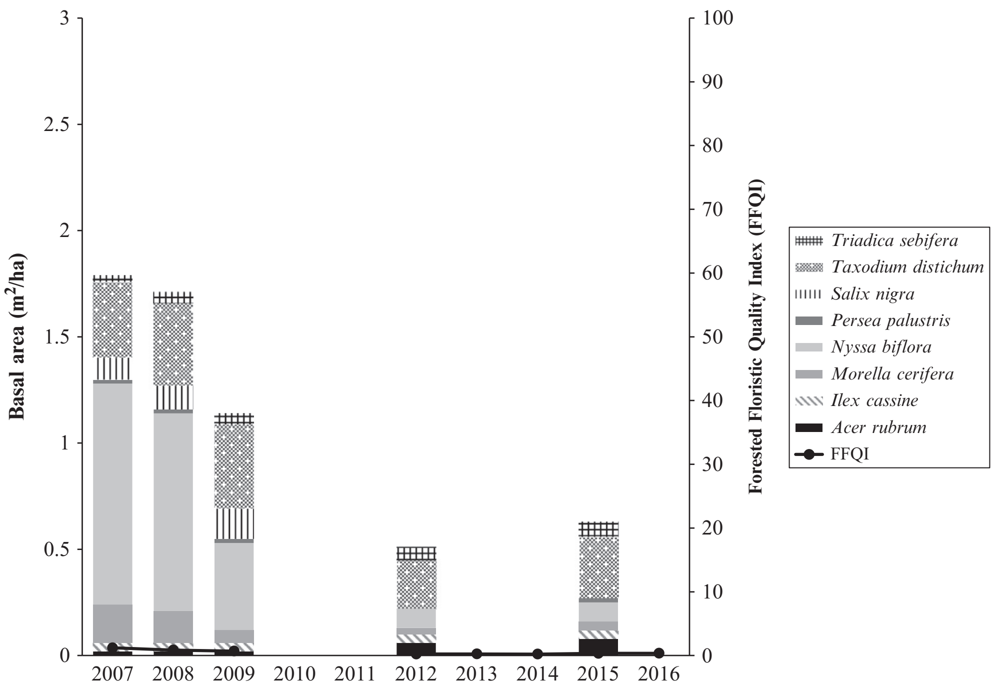


FIG. 4.5.2.14 Forested Floristic Quality Index (FFQI) scores for forested site CRMS6209 by year shown with the basal area (m^2/ha) of the overstory species present at the site.

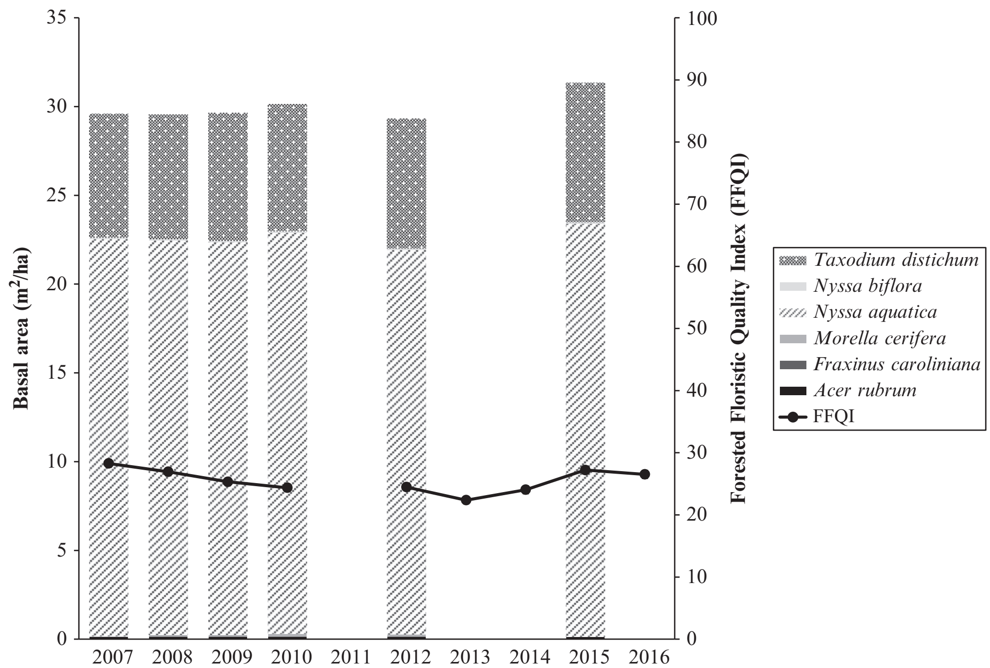


FIG. 4.5.2.15 Forested Floristic Quality Index (FFQI) scores for forested site CRMS0089 by year shown with the basal area (m^2/ha) of the overstory species present at the site.

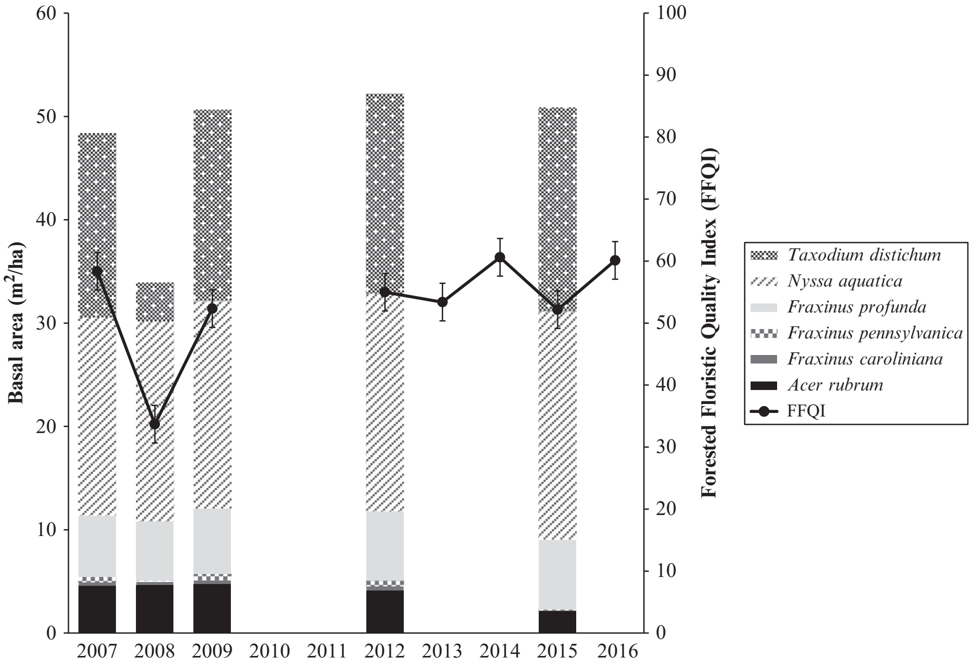
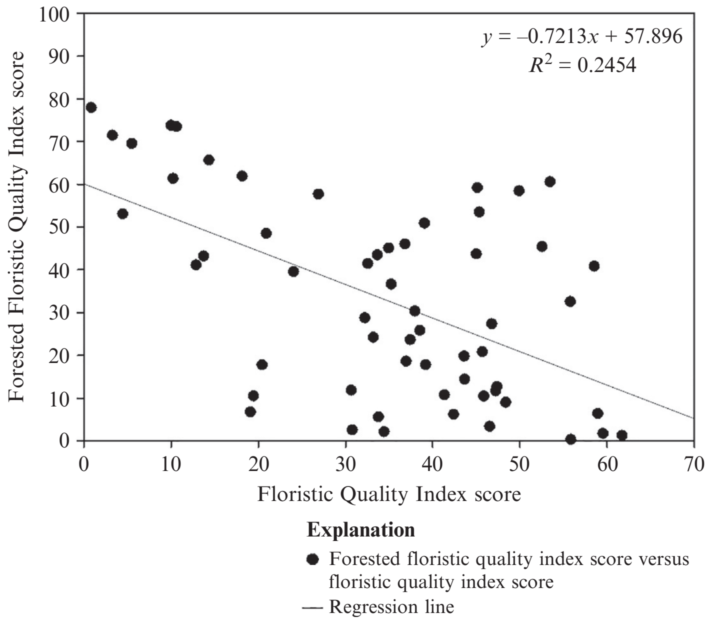


FIG. 4.5.2.16 Forested Floristic Quality Index (FFQI) scores for forested site CRMS5672 by year shown with the basal area (m^2/ha) of the overstory species present at the site.

FIG. 4.5.2.17 The relation between the Forested Floristic Quality Index (FFQI) score and the Floristic Quality Index (FQI) score. A significant negative correlation exists between the two vegetation indices: as the FFQI decreases, the FQI increases, thereby depicting a transitional habitat.



By using the FFQI, FQI, and other CRMS indices, project managers, team members, and the public will be able to evaluate areas to determine if restoration projects are performing as designed. Although both the FQI and FFQI were developed for applications to CRMS data, they have the utility to be modified for many coastal marsh and forested wetland systems worldwide.

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