Chapter 14

Conclusions and Recommendations

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In

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Multiple priorities and recommendations emerged for the mapping and monitoring of Florida's coastal wetlands during the preparation of this report and as outcomes of CHIMMP workshops that convened statewide coastal wetland experts and stakeholders. Region-specific priorities and needs were addressed at the end of each regional chapter in this report. Several priorities and needs were consistently identified as important for the effective management, mapping, and monitoring of coastal wetlands across Florida.

Recommendations for ecosystem management of Florida's coastal habitats

- **Protect and restore coastal habitats:** Protect existing coastal wetlands from development or degradation and prioritize wetland connectivity to minimize segmentation. Restoration efforts should target a diversity of habitat types across elevation and salinity gradients to improve ecosystem resilience to climate change and sea-level rise. Protecting and restoring previously altered areas are central to sustaining critical ecosystem services such as carbon storage, water filtration, shoreline protection, and habitat provision for wildlife.

- **Establish landward buffer zones:** Salt marshes and mangroves can migrate inland in response to sea-level rise if adjacent habitat buffer zones with appropriate elevation are available. However, pervasive shoreline development reduces the area available for these buffer zones and restricts landward migration of coastal wetlands, particularly in areas with shoreline hardening and heavy coastal development (Borchert et al. 2018). Federal, state, and local governments and nonprofit groups must collaborate to create and maintain connectivity among preserved lands and to establish or maintain buffer zones for landward migration of coastal wetlands.

- **Restore natural hydrology and preserve freshwater flow:** Surface water drainage structures concentrate freshwater flow into canals, culverts, and rivers, which reduces sheet flow across wetlands and causes variable flow and salinity in tidal creeks and coastal waters. Additionally, sea-level rise and reduced surface and groundwater flow due to increasing freshwater demand by agricultural and urban areas result in saltwater intrusion in surface and porewaters. Reduced freshwater flow or evaporation of seawater can stress and kill coastal wetland plants if salt concentrations exceed their tolerances (Jimenez et al. 1985, Silliman et al. 2005). Increased salinity can lead to habitat shifts from salt marshes to salt barrens, or oligohaline marsh to salt marsh. Additionally, sulfate in seawater can increase the rates of soil organic matter decomposition in oligohaline wetlands previously exposed to low-salinity conditions, which makes it more difficult for coastal wetlands to increase soil elevation in the face of sea-level rise (Snedaker 1993, Cahoon et al. 2006). Peat collapse due to vegetation mortality and the subsequent loss of living root structure can further stress ecosystems and lead to subsidence (DeLaune et al. 1994, Chambers et al. 2019). Reliable freshwater flow lessens saltwater intrusion and its subsequent consequences in coastal wetlands. The reestablishment or protection of natural sheet flow and tidal connectivity allows for slower changes and less variability in the salinity of coastal wetlands.

- **Enforce existing regulations:** Coastal development and wetlands are often close to and at odds with each other. This proximity necessitates strategic planning to maintain or establish appropriate hydrology, water quality, natural shorelines, buffer areas for upslope migration, and enforcement of mangrove trimming regulations. Strict enforcement of the no-net-loss policy and 1996 Mangrove Trimming and Preservation Act is critical for coastal wetlands; however, mitigation evaluations should also include ecosystem function in addition to acre-for-acre mitigation.

- **Identify and mitigate stress:** Some regions in Florida have experienced localized die-offs in salt marshes and mangroves due to stressors such as erosion, pollution, and altered hydrology. Reduced tidal flushing or water drainage can cause dry down or stagnant water, which are stressful to vegetation and wildlife (Lewis III et al. 2016). Stressed vegetation is more vulnerable to secondary stressors such as fungal infections, parasites, and herbivory (Silliman et al. 2005, Elmer et al. 2012). Many human-induced stressors, such as altered hydrology and pollution, develop gradually and should be mitigated as soon as possible (see examples in Chapter 7).

- **Form public-private partnerships and educate and engage the community:** Effective coastal wetland management requires collaboration among government agencies, non-profit organizations, and private landowners. Partnerships can facilitate habitat protection, restoration, and stewardship on private lands where formal management is limited. In addition, engaging local communities through citizen science, educational programs, and volunteer restoration activities promotes long-term awareness and involvement in wetland conservation, and enhances both ecological and societal outcomes.

- **Remove invasive vegetation:** Invasive vegetation, particularly Brazilian pepper (*Schinus terebinthifolius*) and Australian pines (*Casuarina* spp.), can encroach on the upper boundaries of coastal wetlands, hinder landward migration, and compete for resources. Preventing the further spread of established invasives and early detection of new invasive species requires constant effort and vigilance, and occasional intervention.

Mapping priorities and recommendations

- **Map expansion of mangroves:** Traditional land classification schemes are designed to identify distinct salt marsh or mangrove ecosystems individually, but land cover categories are not well equipped to identify areas where these types of vegetation coexist. Categorical classification systems and large minimum mapping units (the smallest area that is delineated on a map) hinder tracking of the rates and range of mangrove expansion, as mangroves in transitional areas often occur as individuals or clusters scattered in a salt marsh (Figure 14.1). Mapping classifications for intermittent mangrove coverage or presence/absence mapping (or monitoring) are needed to accurately track the expansion of mangrove habitat northward and landward in Florida.

- **Map invasive vegetation:** Invasive vegetation is seldom mapped in traditional land cover efforts unless they merit their own land-cover category, making it difficult

Figure 14.1. Mangroves and salt marsh often co-occur within the same mapping unit, which makes it challenging for large-scale land cover maps to distinguish these complex habitats.

to quantify the extent and spread of invasives using traditional maps. Rather than incorporating invasive vegetation into general habitat classifications alongside native vegetation, different categories for invasive vegetation should be used in land cover maps to highlight their presence.

- **Increase ground-truthing efforts:** Land cover maps are generally created from aerial or satellite imagery, then classified using supervised or unsupervised classification techniques. Ground-truthing is essential to verify accuracy, correct misclassifications, and improve confidence (see Chapter 6 for example in Charlotte Harbor). Although these efforts can be time-consuming and expensive, ground-truthing data can reveal significant differences compared to land-use maps created exclusively from airborne or satellite remote sensing data.

- **Employ consistent mapping techniques and land-cover categories:** Many land cover datasets are available for Florida and most use land cover classification schemes that distinguish salt marsh and mangroves (full descriptions available in Chapter 1). However, differences in the methods among and within mapping efforts hinder temporal and spatial comparisons.

For instance, water management district (WMD) land use/land cover (LULC) datasets were used to present areal extent and distribution data for many regions in this report. These data sets provide continuous coverage of land cover in Florida, with many data sets spanning decades. However, they are not without limitations. The large minimum mapping units used in WMD maps are not sensitive to mixtures of vegetation and changes in annual vegetation boundaries, which commonly occur with mangrove expansion. Thus, shifts in mangrove boundaries are not always captured by WMD maps. Additionally, while WMD maps can be compiled for every region in Florida, they are not always directly comparable. Temporal data resolution, minimum mapping units, and pixel size in aerial photography vary widely among WMDs. Even within WMDs, the methods used have varied from year to year, so some temporal changes in habitat area are presumably methodological rather than true changes in land cover.

In this report, time-series data were excluded for much of the South Florida Water Management District (SFWMD) due to drastic fluctuations in areal extent caused largely by methodological differences. For example, salt marsh extent in the Everglades appears to have increased five-fold from 1995 to 1999 (see Table 14.1; 2009 data are not included due to insufficient coverage of the Everglades). The time-series data indicate similar changes around Biscayne Bay (Table 14.2) and suggest salt marsh extent increased ten-fold from 2005 to 2009. These increases are a result of areas previously classified as freshwater marshes, tidal flats, or mangroves being reclassified as salt marsh. While small annual changes in salt marsh and mangrove extent do occur due to restoration projects, mangrove encroachment into salt marshes, and small amounts of permitted development, changes of such magnitude indicate incongruence in mapping methods.

The LULC categories used by the WMDs were also modified over time, particularly during early WMD mapping efforts. For instance, the mixed scrub–shrub wetland classification (FLUCCS code 6460) was absent from 1994–1995 Northwest Florida Water Management District LULC data but proliferated in mapping data thereafter (NWFWMD 2010). Florida is fortunate to have so many available data sets describing coastal wetland extent, but variability in the methods and classification require careful attention and interpretation by the end user to avoid misrepresentation.

Table 14.1. Areal extent of mangrove and salt marsh in the Everglades CHIMMP region, per SFWMD LULC data (SFWMD 2023), showing large variation among years.

Year	Mangrove (ac)	Mangrove (ha)	Salt marsh (ac)	Salt marsh (ha)
1995	296,372	119,937	8,144	3,296
1999	345,908	139,984	45,188	18,287
2005	348,018	140,838	45,335	18,346
2016	427,364	172,948	55,618	22,508
2023	422,864	171,127	59,098	23,916

Table 14.2. Areal extent of mangrove and salt marsh in Biscayne Bay according to SFWMD LULC data (SFWMD 2023), showing large variation among years.

Year	Mangrove (ac)	Mangrove (ha)	Salt marsh (ac)	Salt marsh (ha)
1995	14,526	5,878	1,155	467
1999	16,261	6,581	641	259
2005	15,184	6,145	586	237
2009	17,455	7,064	5,623	2,276
2016	32,564	13,178	4,700	1,902
2023	30,896	12,503	4,700	1,902

Monitoring priorities and recommendations

- **Improve cross-project comparability:** As described in the introduction of this report, more than a dozen monitoring methods are commonly used in Florida's coastal wetlands, which limits direct comparisons between different monitoring efforts and among sites or regions. Data compilation efforts, such as the Florida Department of Environmental Protection's Statewide Ecosystem Assessment of Coastal and Aquatic Resources (SEACAR), compile monitoring data to facilitate cross-project comparisons in order to evaluate long-term trends. Inclusion of standardized metrics (such as the SEACAR coastal wetland indicators of acreage and species composition) and georeferenced, publicly available datasets are needed to facilitate cross-project comparisons.

- **Increase long-term monitoring:** Monitoring efforts are often short-term due to funding limitations. However, to understand the effects of climate change, long-term statewide monitoring is needed to track responses such as mangrove expansion, salt marsh migration, and sediment accretion in coastal wetlands.

- **Make use of both in-situ and remote methods:** Monitoring in salt marshes and mangroves is inherently challenging because these habitats are naturally difficult to access. Dense trunks and prop roots restrict foot access, while vegetation trampling in salt marshes complicates non-destructive sampling. However, in-situ monitoring is critical to understanding the variety of abiotic and biotic factors that contribute to the productivity of a wetland and also enables early detection of stress. While satellite imagery is increasingly useful as a mapping tool for coastal wetlands, certain metrics can only be acquired through field measurements. Alternative methods such as the use of drones, LiDAR, or citizen scientists can address some monitoring and ground-truthing needs as a complement to field-based monitoring.

- **Monitor ecosystem resistance and resilience:** Metrics that quantify vegetation mortality and recovery should be monitored after disturbances, such as hurricanes, in order to evaluate ecosystem resistance and resilience. This helps to identify stressed areas that may benefit from proactive management or restoration. These metrics may vary depending on whether wetlands are natural, restored, or actively managed, as well as on the type and intensity of disturbance or ecosystem stress experienced.

Conclusion

The Coastal Habitat Integrated Mapping and Monitoring Program will continue efforts to facilitate collaboration and address data and research gaps in coastal habitat mapping and monitoring programs in Florida. The information compiled in this report is not only designed to facilitate decision-making for the mapping and monitoring of coastal wetland habitats, but also to recommend priorities for the adaptive management of these unique coastal ecosystems and the numerous threatened and endangered species that depend on them. Knowledge of the region-specific extent, trends, and threats to salt marshes and mangroves is crucial for the long-term management of these economically and ecologically valuable habitats.

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