Critical Coastal Habitat Vulnerability Assessment for the Tampa Bay Estuary: Projected Changes to Habitats due to Sea Level Rise and Climate Change

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EXECUTIVE SUMMARY

The impacts of rising sea-level on habitats in the Tampa Bay area will depend on both the rate and magnitude of the rise. Initial estimates of the impacts of climate change and sea level rise on coastal habitats in Florida were developed by Glick and Clough (2006) using the Sea Level Affecting Marshes Model (SLAMM v.4). Results from that assessment indicated significant reductions in salt marsh (-86%) and oligohaline marsh (-59%) habitats, while mangroves were projected to increase by 166% by 2100 (Glick and Clough 2006). If these estimates were realized, then the current "Restoring the Balance" goals and targets for these habitat types would be profoundly unrealistic to achieve in the near- or long-term. Further complicating these forecasted estimates was the lack of consideration for societal adaption strategies that would protect currently developed dry land or areas with significant infrastructure and assets. The goal of this project was to update the initial estimates of Glick and Clough (2006) with more recent data and sea-level rise information from the IPCC (2007a), and compare the anticipated critical coastal habitat acreage changes with the existing "Restoring the Balance" goals for Tampa Bay. Additionally, the effects of different adaptation strategies (i.e. protecting dry land vs. allowing coastal habitat migration) were evaluated within the context of the "Restoring the Balance" goals for Tampa Bay.

Overall, total critical coastal habitat acreage within the Tampa Bay watershed is estimated to decline with the impending effects of sea level rise by 2100. While overall total acreage losses are estimated regardless of whether two alternative adaptation strategies are implemented within the region (i.e., protecting currently developed dry land vs. allowing coastal habitats to migrate upslope), mangrove habitat acreages are expected to increase at the expense of losses to other critical coastal habitats. Coastal freshwater wetlands, salt marsh and salt barren habitats are expected to decline by 2100 with coastal freshwater wetlands expected to experience the greatest total acreage losses.

For salt marsh and salt barren habitats, significant regress in achieving the current targets established in Tampa Bay (Robison, 2010) is expected. Although significant progress towards achieving gains in both salt marsh and salt barren habitats has been reported for these habitats in Tampa Bay over the 1995-2007 period (Robison, 2010), the impending effects of climate change and sea level rise is likely to create a greater disparity in "restoring the balance" of these habitats within the Tampa Bay estuary. Again, these results are expected regardless of whether the two alternative adaptation strategies would be implemented within the region to combat sea level rise impacts on critical coastal habitats by 2100. Expansion or succession of mangrove habitats within Tampa Bay is estimated to significantly skew critical coastal habitat ratios toward a more mangrove-dominated estuarine type system.

Mangrove acreage contributions to the estuarine habitat complex are estimated to increase to 85-89% of the total critical coastal habitat acreage (currently ~74%). As first detailed in the original "restoring the balance" document (Lewis and Robison, 1996), this has the potential to create "bottlenecks" in available habitat for specific guilds of estuarine-dependent biota currently present within the Tampa Bay estuary. Furthermore, losses in salt marsh and salt barren habitat acreages are estimated to reduce the percent contribution of these habitats to the overall critical coastal habitat acreages to 10-14% and <1%, respectively (currently 24% and 2%, respectively). This too could have confounding effects on estuarine biota habitat requirements within the Tampa Bay estuary.

Based on these results and as resource managers within the Tampa Bay region prepare for the impending effects of future climate change and sea level rise, it is important to consider that significant changes to the critical coastal habitats that support the rich diversity of biota within the Tampa Bay estuary is likely. Local and regional efforts to sustain, restore and provide adaptation strategies for the continued benefit and enhancement of these resources is paramount for the Tampa Bay region. Given that the Tampa Bay region is currently one of the most densely populated coastal communities in the Gulf of Mexico and that population within the region is expected to increase well into the future, efforts to incorporate adaptation strategies that promote habitat resiliency and sustainability into future land use planning practices is imperative.

Based upon the results and potential implications of climate change on coastal habitats within Tampa Bay, the following amendments and updates are recommended for inclusion in the Tampa Bay Estuary Program's Comprehensive Conservation and Management Plan for Tampa Bay. This list of updates should be considered a draft until fully vetted through the TBEP Technical Advisory Committee, the Tampa Bay Habitat Restoration Partnership, and the TBEP's Management and Policy Boards.

BH-XX Re-evaluate critical coastal habitat restoration targets and priorities to take into account the effects of climate change and sea level rise

- **STATUS:**
  New actions to be integrated into 2012 CCMP amendments.
- **BACKGROUND:**
  As stated above and in the context of this report.
- **STRTEGY 1:** Identify current acreage estimates for critical coastal habitats without targets (e.g., oysters, oligohaline marshes, coastal freshwater wetlands, etc.), update acreage estimates for those habitats with targets (e.g. salt marsh, salt barrens and seagrass), and establish any new draft paradigm concepts / targets for next HMP update

  Responsible Parties: Tampa Bay Habitat Restoration Partnership, TBEP, SWFWMD SWIM, Other TBEP partners
  Schedule: Present – 2020 (incorporate into 2020 HMP Update)

STRATEGY 2: Develop a long-term monitoring program to assess the status, trends and ecological function of the mosaic of critical coastal habitats in

Tampa Bay. The purpose of the program should be to: 1) detect any changes due to natural and indirect anthropogenic impacts, including sea level rise and climate change; and 2) improve the future management of these habitats.

Responsible Parties: Tampa Bay Habitat Restoration Partnership, TBEP, SWFWMD SWIM, Other TBEP partners
Schedule: Present – 2020 (incorporate into 2020 HMP Update)

STRATEGY 3: Identify and prioritize new site inventories that offer opportunities for coastal habitat protection, acquisition, ecosystem restoration, and habitat refugia in the face of sea level rise including the identification of any new mechanisms that may be required to better foster public-private partnerships to accomplish this action

Responsible Parties: Tampa Bay Habitat Restoration Partnership, TBEP, SWFWMD SWIM, Other TBEP partners
Schedule: Present – 2020 (incorporate into 2020 HMP Update)

STRATEGY 4: Initiate new research initiatives that investigate habitat restoration techniques that could be implemented to combat climate change and sea level rise impacts to improve coastal habitat resiliency (e.g. physical management of vulnerable habitats, hydrologic restoration of tidally-influenced confluences, beneficial use of dredged material to aid in wetland accretion, etc.).

Responsible Parties: Tampa Bay Habitat Restoration Partnership, TBEP, SWFWMD SWIM, Other TBEP partners
Schedule: Present – 2020 (incorporate into 2020 HMP Update)

STRATEGY 5: Better educate the public and Tampa Bay coastal communities on the anticipated impacts of sea level rise and encourage future home owner practices that provide for coastal habitat resiliency into the future (e.g. alternatively replacing dilapidated sea walls with living shorelines, creating shoreline vegetative buffers, etc.)

Responsible Parties: Tampa Bay Habitat Restoration Partnership, TBEP, FL Sea Grant, Other TBEP partners
Schedule: Present – 2020

STRATEGY 6: Work with the Tampa Bay planning community to identify needed land use code changes that incorporate coastal habitat resiliency requirements and utilize new web-based, sea level rise visualization tools into their planning activities

Responsible Parties: Tampa Bay Regional Planning Council, One Bay Partnership, ABM, Tampa Bay Habitat Restoration Partnership, TBEP
Schedule: Present – 2020

INTRODUCTION

In August 2010, the Tampa Bay Estuary Program's Management and Policy Boards approved updated coastal habitat protection and restoration goals for the Tampa Bay estuary (Table 1). These updated goals continue to incorporate the management paradigm of "Restoring the Balance" of these habitats to proportions observed in the 1950s (Lewis and Robison, 1996; Robison, 2010). Paramount to achieving these targets in the future is the maintenance of existing estuarine habitat acreages. Global climate change and the anticipated rise in sea level associated with increasing temperatures have the potential to impact the distribution and acreage of existing and restored critical coastal habitats in the Tampa Bay estuary (IPCC, 2007a; Robison, 2010).

Table 1: Updated critical coastal habitat targets approved by the Tampa Bay Estuary Program's Management and Policy Boards in August 2010.

Habitat Type	2010 Critical Coastal Habitat Targets			
	1996 Acreages	**2007-2008 Acreages**	**Future Acreage Priorities to "Restore the Balance"**	**Total Protection and Restoration Acreage Goal (2010 Master Plan Update)**
Seagrass	26,916 acres	29,647 acres	8,353 acres	38,000 acres
Mangrove[1]	14,760 acres	15,139 acres	Protect existing acreage	15,139 acres (Opportunistically restore)
Salt Marsh[2]	4,343 acres	4,395 acres	1,918 acres	6,313 acres
Salt Barren	445 acres	447 acres	840 acres	1,287 acres

[1]Includes predominately mangrove forests and pioneer marsh habitats
[2]Includes predominately lower salinity salt marsh habitats

Anthropogenic climate change is now widely regarded as one of the most pressing challenges facing society. Its potential consequences are profound and far-reaching: melting terrestrial and polar ice, rising sea level contributing to coastal flooding and erosion, increased frequency of severe weather, increases in ocean temperature and acidification, and rising incidences of marine diseases and harmful algal blooms that can devastate fisheries (IPCC, 2007a; Florida Oceans and Coastal Council (FOCC), 2009). With 1,200 miles of coastline and billions of dollars invested in coastal real estate and tourism, a warming climate with higher sea levels places Florida at significant risk (First American Corp., 2009). Higher average sea temperatures and changing precipitation patterns may have dramatic and widespread effects on coastal property and habitats. One possible result could be the development of more frequent and intense hurricanes (Elsner, 2006) and hurricane-related flooding.

Climate change has already been documented in Florida. Average air temperatures have risen by about 2°F in parts of Florida since the 1960s, with precipitation decreasing in southern Florida and increasing in central Florida and the Panhandle regions (USEPA, 1997). By 2100, summer temperatures in Florida could rise an additional 3 to 7°F (Twilley et al., 2001). Warmer temperatures are expected to shift the geographic areas in which freezes occur, enabling subtropical plant species such as mangroves, several of which cannot tolerate freezing temperatures, to expand their ranges northward.

Perhaps more threatening to the fringing coastal habitats that occur within Tampa Bay are potential impacts associated with the rise in global sea-level. Global sea-level rose by about 120 m during the several millennia that followed the end of the last ice age (approximately 21,000 years ago). Sea level then stabilized, between 3,000 and 2,000 years ago, at a level that did not change substantially until the mid-19th century (Bindoff et al., 2007). Sea level began rising once again during the 19th century, and during the 20th century it is estimated to have risen at a rate of about 1.7 mm per year. Since 1993 sea-level has been rising at a faster rate — approximately 3 mm per year — and is projected to rise at somewhat higher rates throughout the 21st century (Bindoff et al., 2007). Given a range of plausible greenhouse gas emission scenarios, global simulation models suggest that by 2100 average sea-level may rise to about 0.6 m above 1980-1990 levels. However, these simulations do not address a number of uncertainties (such as changes in the melting rates of the Greenland and Antarctic ice sheets) that could potentially produce greater increases, and "the upper values of the ranges given are not to be considered upper bounds for sea-level rise" (Bindoff et al., 2007). In addition, sea-level rise is expected to continue for centuries, even if greenhouse gas emissions are stabilized, due to the time scales of climate processes.

The impacts of rising sea-level on habitats in the Tampa Bay area will depend on both the rate and magnitude of the rise. The current rate is about an inch a decade, based upon long-term, NOAA tide gage data from St. Petersburg, FL (Figure 1). As summarized by the FOCC (2009) and references therein, it appears probable that water depths will continue to increase within the bay's current shoreline, and the shoreline itself will migrate landward in areas where manmade structures such as seawalls and bulkheads are not present to prevent such movement. Depending on the rate of sea-level rise, emergent tidal wetlands and other coastal habitats may be able to persist by accreting vertically, migrating landward, or both. For instance, mangrove forests may be able to keep up with sea-level rise through accretion processes up to a rate of about 25cm of rise per 100 years (Ellison, 1993); however, other confounding processes related to climate change may affect their ability to adapt to sea-level rise up to these levels (Gilman, et al. 2008). Furthermore, if sea-level increases more rapidly than the biota can respond, these adaptive responses may not even be possible. Coastal habitats may also be lost in areas where manmade structures prevent landward migration (Williams et al., 1997; FOCC, 2009).

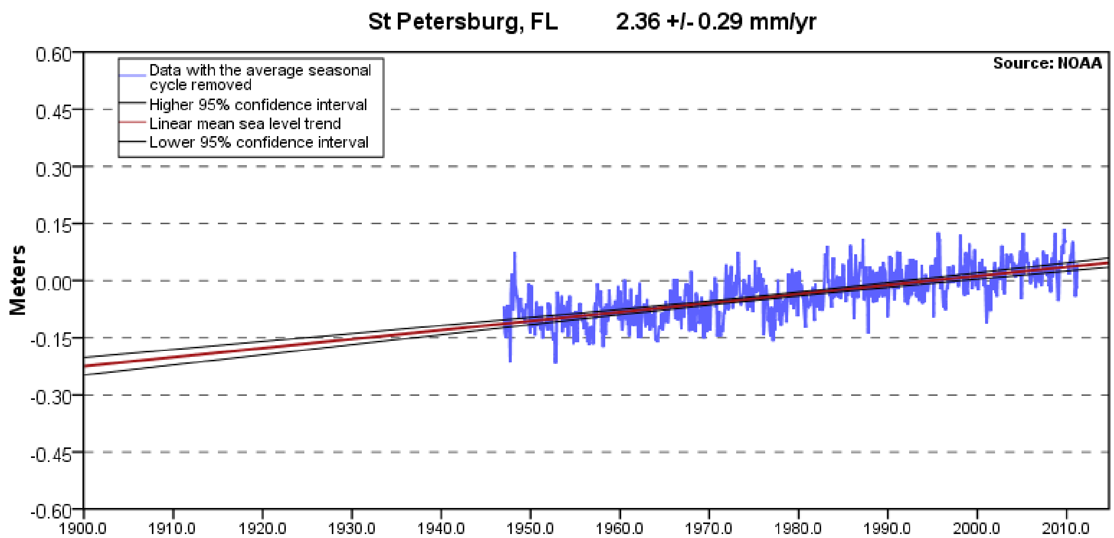

Figure 1: Mean sea level trend for the long-term NOAA tide station located in St. Petersburg, FL (8726520). Source: NOAA.

Initial estimates of the impacts of climate change and sea level rise on coastal habitats in Florida were developed by Glick and Clough (2006) using the Sea Level Affecting Marshes Model (SLAMM v.4). Results from that assessment indicated significant reductions in salt marsh (-86%) and oligohaline marsh (-59%) habitats, while mangroves were projected to increase by 166% by 2100 (Glick and Clough 2006). If these estimates were realized, then the current "Restoring the Balance" goals and targets for these habitat types would be profoundly unrealistic to achieve in the near- or long-term. Further complicating these forecasted estimates was the lack of consideration for societal adaption strategies that would protect currently developed dry land or areas with significant infrastructure and assets. If an adaptation strategy to protect developed upland were employed in the Tampa Bay region, then it is likely that all critical coastal habitats, even mangroves, would be negatively impacted in the future. In effect, all coastal habitats would likely be prevented from landward migration under this strategy. Likely coastal areas where an upland protection strategy would be employed were initially developed by the Tampa Bay Regional Planning Council (Appendix A; TBRPC 2006).

The goal of this project was to update the initial estimates of Glick and Clough (2006) using the most recent land use (SWFWMD, 2007), elevation (TBRPC, 2009), and sea level rise scenarios (Bindoff et al., 2007) available for the Tampa Bay region using the Sea Level Affecting Marshes Model (SLAMM v.6). Once these initial estimates were developed, a comparison of the anticipated critical coastal habitat changes with the existing "Restoring the Balance" goals for Tampa Bay was conducted. Additionally, the effects of different adaptation strategies (i.e. protecting dry land vs. allowing coastal habitat migration) were evaluated within the context of the "Restoring the Balance" goals for Tampa Bay.

METHODS

Data Used & Processed in Assessment

Land Use/Land Cover & Wetlands Inventory Data

At the time of study, the most recent Southwest Florida Water Management District (SWFWMD) land use/land cover (2007), seagrass coverage (2006), and US Fish and Wildlife Service National Wetland Inventory (NWI; 1971-1992) GIS data were obtained from the SWFWMD and incorporated into the SLAMM model inputs (SWFWMD 2002, 2006, 2007). The three vector shapefiles were merged together in ArcGIS 9.3 and recoded to represent the SLAMM land-cover classes according to FLUCCSCODES and NWI codes (see Appendix B). The recoded data were visually inspected and corrected for classification accuracy based on spatial location. A final 10m ASCII raster was exported from the merged dataset using the ArcGIS Spatial Analyst tool for the Tampa Bay project area.

Digital Elevation and Slope Model Inputs

An improved digital elevation model (DEM) for the Tampa Bay region based on corrected LiDAR data was obtained from the Florida Division of Emergency Management (TBRPC, 2009). The DEM was developed to produce 2-foot contours with a vertical accuracy of 0.6-feet RMSE. A final 10m DEM ASCII raster was exported from the original dataset in metric format using the ArcGIS Spatial Analyst tool for the Tampa Bay project area. This final 10m DEM raster was then used to derive a final 10m ASCII raster depicting slope using the ArcGIS Spatial Analyst tool for the Tampa Bay project area. Both the final 10m DEM and slope ASCII rasters were used as SLAMM 6 inputs.

Dike Information & Data

Information on SWFWMD-operated control structures was obtained from the SWFWMD (2002). Additional weir or salinity barrier structures were identified within the region based on local knowledge. A 10m dike ASCII raster was developed from these combined data sources using the ArcGIS Spatial Analyst tool for the Tampa Bay project area. Raster cells were coded as either 1 or 0 depending on whether a structure was present or not, respectively, within the modeling domain.

Overall Modeling Approach

The Sea Level Affecting Marshes Model (SLAMM v. 6.0.1) was used to determine coastal habitat conversions and shoreline modifications in the Tampa Bay watershed. The base year for comparisons was 2007 and both fixed (i.e. 0.5-m, 1.0-m, 1.5-m, 2.0-m) and varying IPCC (2007a; i.e. mean A1B, A1F1, A1T, A2, B1, B2; see Appendix C for descriptions) sea level rise scenarios were modeled to the year 2100. Table 2 summarizes the SLAMM input parameters used in the analysis.

Model output for the year 2100 was summarized for the fixed sea level rise scenarios relative to current conditions (2007). Total acreages and comparative ratios of critical coastal habitats were developed for all of Tampa Bay and for the seven major bay segments recognized by TBEP.

Table 2: Input parameters used in the Sea Level Affecting Marshes Model (SLAMM v. 6.0.1) for the Tampa Bay watershed [based in part on information from NOAA tide gage St. Petersburg (8726520)]. Accretion and erosion rates were adapted from Glick and Clough (2006).

Parameter	Value
Wetlands/NWI Photo Date (YYYY)	2007
DEM Date (YYYY)	2007
Direction Offshore [n,s,e,w]	West
Historic Trend (mm/yr)	2.4
MTL-NAVD88 (m)	-0.1
GT Great Diurnal Tide Range (m)	0.7
Salt Marsh Elevation (m above MTL)	0.5
Marsh Erosion Rate (horz. m /yr)	2
Swamp Erosion Rate (horz. m /yr)	1
Tidal Flat Erosion Rate (horz. m /yr)	0.5
Regularly Flood Marsh Accretion Rate (mm/yr)	1.6
Irregularly Flooded Marsh Accretion Rate (mm/yr)	2.25
Tidal Freshwater Marsh Accretion Rate (mm/yr)	3.75
Beach Sedimentation Rate (mm/yr)	1.5
Frequency of Overwash (years)	10
Use Elevation Pre-processor [True,False]	FALSE

RESULTS

Tampa Bay

On the whole, total critical coastal habitat acreage within the Tampa Bay watershed is estimated to decline with the impending effects of sea level rise by 2100. While overall total acreage losses are estimated regardless of whether two alternative adaptation strategies are implemented within the region (i.e., protecting currently developed dry land vs. allowing coastal habitats to migrate upslope), mangrove habitat acreages are expected to increase at the expense of losses to other critical coastal habitats (Figure 2). Coastal freshwater wetlands, salt marsh and salt barren habitats are expected to decline by 2100 (Figure 2) with coastal freshwater wetlands expected to experience the greatest total acreage losses (Table 3; Figure 2).

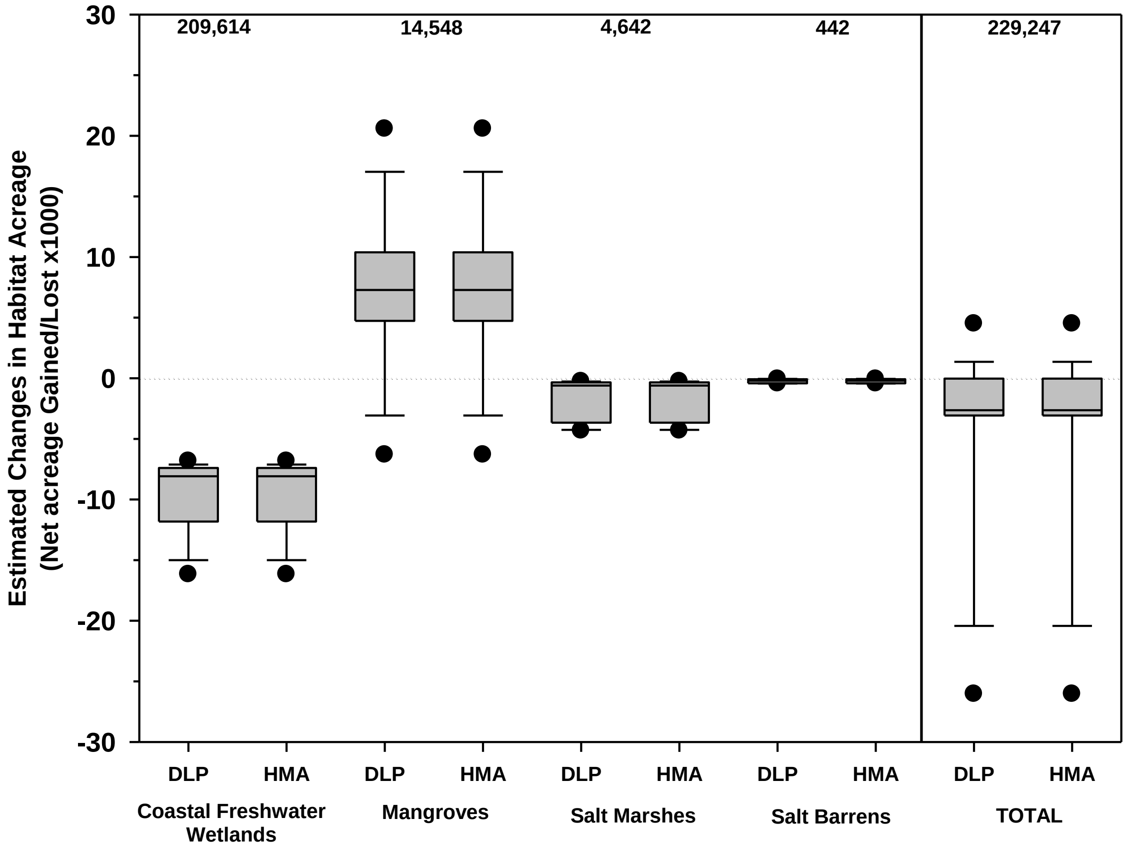

Figure 2: Box plots depicting the range of estimated changes in critical coastal habitat acreages based on SLAMM scenarios of 0.5-m, 1.0-m, 1.5-m, 2.0-m, mean A1B, mean A1F1, mean A1T, mean A2, mean B1, and mean B2 sea level rise by 2100 within the Tampa Bay estuary. A net increase in acreage is displayed with box plots above the dotted zero line and a net decrease is displayed vice-versa. Two adaptation strategies were considered in the SLAMM scenario runs (DLP = Currently Developed Land Protected and HMA = Coastal Habitat Migration Allowed to occur). Numbers arranged along the vertical border of the graph represent the current (2007) estimated acreage of each habitat.

For salt marsh and salt barren habitats, significant regress in achieving the current targets established in Tampa Bay (Robison, 2010) is expected (Table 2; Figure 3). Although progress towards achieving gains in both salt marsh and salt barren habitats has been reported for these habitats in Tampa Bay over the 1995-2007 period (Robison, 2010), the impending effects of climate change and sea level rise is likely to create a greater disparity in “restoring the balance” of these habitats within the Tampa Bay estuary (Figure 3). Again, these results are expected regardless of whether the two alternative adaptation strategies would be implemented within the region to combat sea level rise impacts on critical coastal habitats by 2100.

Table 3: Summary of critical coastal habitat acreages and targets as estimated under current conditions (2007) and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land) for all of Tampa Bay.

		Coastal Freshwater Wetlands	Devia-tion	Mangroves	Devia-tion	Salt Marshes	Devia-tion	Salt Barrens	Devia-tion
2010 Habitat Master Plan Update Target		**Not Defined**		**15,139**		**6,313**		**1,287**	
2007 Current Condition		**209,614**		**14,548**		**4,642**		**442**	
Adaptation Strategy	**SLAMM Scenario**								
	0.5-m SLR by 2100	200,900	*(8,715)*	25,311	*10,762*	3,930	*(712)*	174	*(268)*
	1.0-m SLR by 2100	197,599	*(12,015)*	35,316	*20,767*	974	*(3,668)*	25	*(417)*
	1.5-m SLR by 2100	195,224	*(14,391)*	30,959	*16,411*	389	*(4,253)*	14	*(428)*
	2.0-m SLR by 2100	193,389	*(16,225)*	31,647	*17,099*	390	*(4,252)*	12	*(430)*
Habitats Allowed to Migrate	Mean - A1B	201,730	*(7,885)*	22,947	*8,399*	4,256	*(386)*	357	*(85)*
	Mean - A1F1	200,932	*(8,683)*	25,592	*11,044*	3,936	*(706)*	175	*(267)*
	Mean - A1T	201,879	*(7,736)*	22,447	*7,899*	4,309	*(333)*	368	*(75)*
	Mean - A2	201,464	*(8,151)*	23,835	*9,287*	4,148	*(494)*	312	*(130)*
	Mean - B1	202,278	*(7,336)*	21,382	*6,833*	4,390	*(252)*	388	*(54)*
	Mean - B2	201,952	*(7,662)*	22,281	*7,733*	4,322	*(320)*	371	*(71)*
Mean of All Scenarios		199,735	*(9,880)*	26,172	*11,623*	3,104	*(1,538)*	220	*(223)*
Mean Deviation from Target		-	*NA*	-	*11,033*	-	*(3,209)*	-	*(1,067)*
Adaptation Strategy	**SLAMM Scenario**								
	0.5-m SLR by 2100	201,522	*(8,092)*	21,006	*6,458*	3,925	*(717)*	174	*(268)*
	1.0-m SLR by 2100	198,399	*(11,215)*	23,234	*8,686*	981	*(3,661)*	25	*(417)*
	1.5-m SLR by 2100	196,189	*(13,426)*	10,688	*(3,860)*	395	*(4,247)*	14	*(428)*
	2.0-m SLR by 2100	194,543	*(15,072)*	8,122	*(6,427)*	318	*(4,324)*	12	*(430)*
Currently Developed Dry Land Protected	Mean - A1B	202,292	*(7,322)*	19,505	*4,957*	4,247	*(395)*	357	*(85)*
	Mean - A1F1	201,545	*(8,070)*	21,036	*6,488*	3,931	*(711)*	175	*(267)*
	Mean - A1T	202,436	*(7,178)*	19,209	*4,660*	4,297	*(345)*	368	*(75)*
	Mean - A2	202,050	*(7,565)*	20,023	*5,475*	4,140	*(502)*	312	*(130)*
	Mean - B1	202,807	*(6,808)*	18,563	*4,015*	4,376	*(266)*	388	*(54)*
	Mean - B2	202,501	*(7,113)*	19,115	*4,567*	4,310	*(332)*	371	*(71)*
Mean of All Scenarios		200,428	*(9,186)*	18,050	*3,502*	3,092	*(1,550)*	220	*(223)*
Mean Deviation from Target		-	*NA*	-	*2,911*	-	*(3,221)*	-	*(1,067)*

Expansion or succession of mangrove habitats within Tampa Bay is estimated to significantly skew critical coastal habitat ratios toward a more mangrove-dominated estuarine type system (Figure 3). Mangrove acreage contributions to the estuarine habitat complex are estimated to increase to 85-89% of the total critical coastal habitat acreage (currently ~74%; Figure 3). As first detailed in the original "restoring the balance" document (Lewis and Robison, 1996), this has the potential to create "bottlenecks" in available habitat for specific guilds of estuarine-dependent biota currently present within the Tampa Bay estuary. Furthermore, losses in salt marsh and salt barren habitat acreages are estimated to reduce the percent contribution of these habitats to the overall critical coastal habitat acreages to 10-14% and <1%, respectively (currently 24% and 2%, respectively). This too could have confounding effects on estuarine biota habitat requirements within the Tampa Bay estuary.

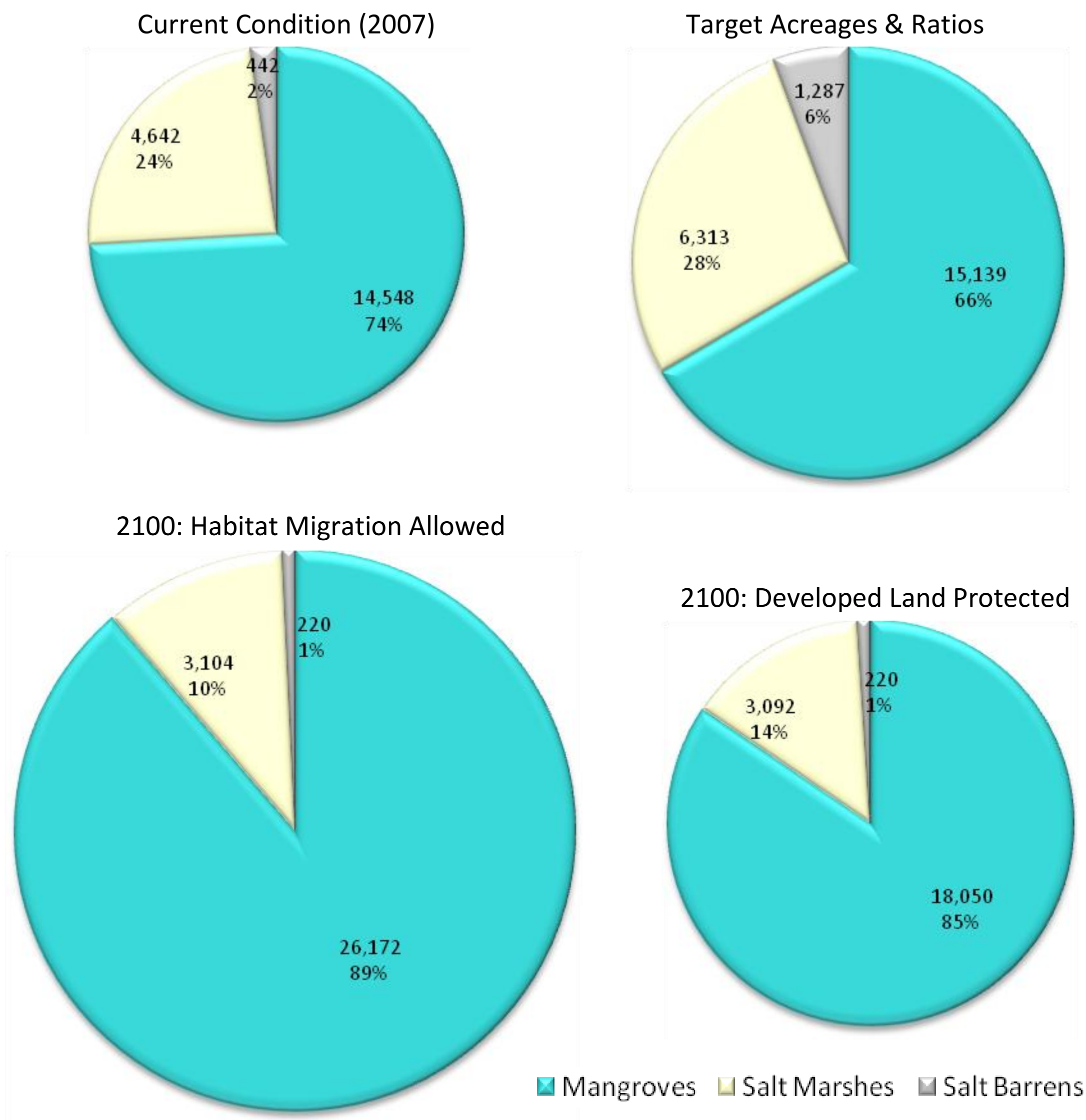

Figure 3: Pie charts depicting the critical coastal habitat acreages and percentages in Tampa Bay currently (2007), under target conditions, and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land). The 2100 plots use the mean result of all SLAMM runs, as depicted in Table 3. The size of each chart is proportional to the total acreages under each case.

Old Tampa Bay

For the Old Tampa Bay segment, changes in critical coastal habitats are expected to occur at slightly different rates than Tampa Bay as a whole. Coastal freshwater wetland, salt marsh, and salt barren habitats are expected to decline with impending sea level rise regardless of adaptation strategies employed in the region (Figure 4). However, mangroves are expected to increase and offset the losses predicted for the other three critical coastal habitats (Figure 4).

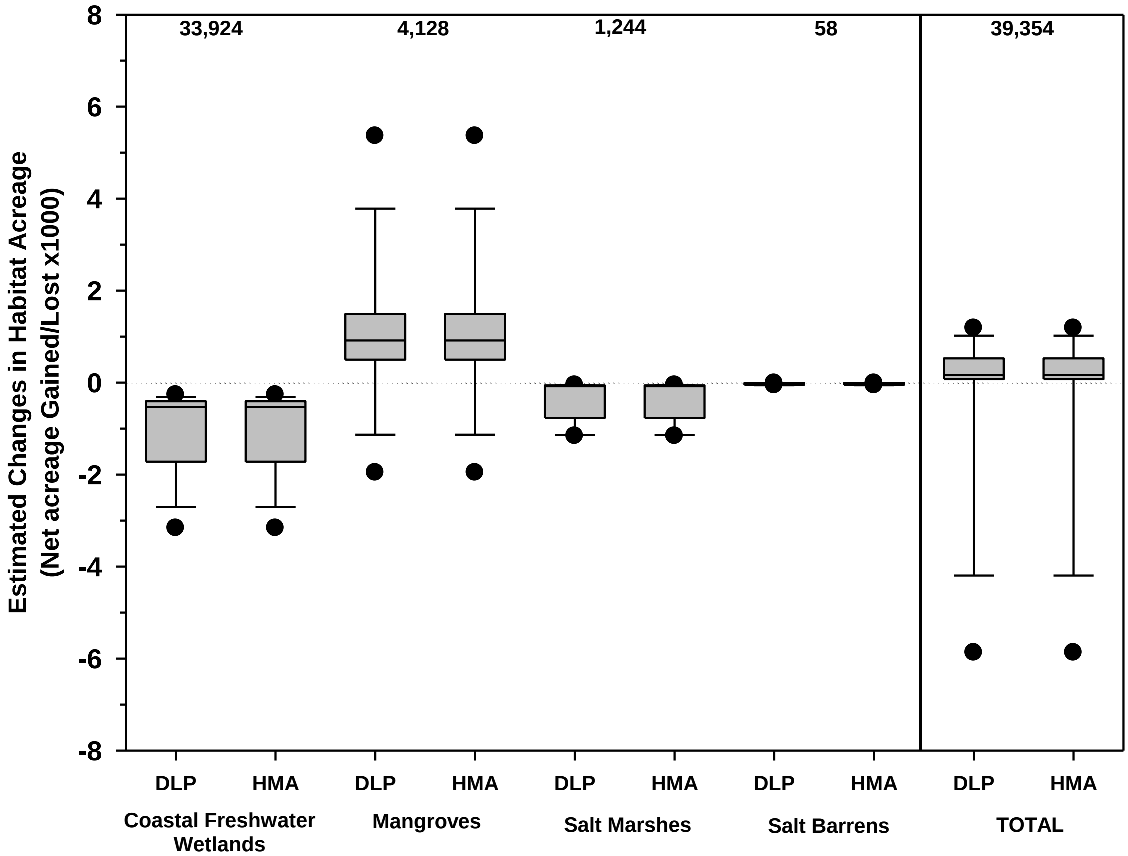

Figure 4. Box plots depicting the range of estimated changes in critical coastal habitat acreages based on SLAMM scenarios of 0.5-m, 1.0-m, 1.5-m, 2.0-m, mean A1B, mean A1F1, mean A1T, mean A2, mean B1, and mean B2 sea level rise by 2100 within the coastal Old Tampa Bay watershed. A net increase in acreage is displayed with box plots above the dotted zero line and a net decrease is displayed vice-versa. Two adaptation strategies were considered in the SLAMM scenario runs (DLP = Currently Developed Land Protected and HMA = Coastal Habitat Migration Allowed to occur). Numbers arranged along the vertical border of the graph represent the current (2007) estimated acreage of each habitat.

While specific "restoring the balance" target acreages have never been proposed for individual bay segments, an estimate of the expected target acreages from the baywide target (Robison, 2010) was developed and compared to the SLAMM scenarios (Table 4). Losses to both salt marsh and salt barren habitats in Old Tampa Bay are expected to skew habitat proportions to a more mangrove-dominated system, as was also seen at the baywide scale (Table 4 & Figure 5).

Table 4: Summary of critical coastal habitat acreages and targets as estimated under current conditions (2007) and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land) for Old Tampa Bay.

		Coastal Freshwater Wetlands	Devia-tion	Mangroves	Devia-tion	Salt Marshes	Devia-tion	Salt Barrens	Devia-tion
Adapted Habitat Master Plan Target		**Not Defined**		**4,128**		**1,721**		**351**	
2007 Current Condition		**33,924**		**4,128**		**1,244**		**58**	
Adaptation Strategy	**SLAMM Scenario**								
Habitats Allowed to Migrate	0.5-m SLR by 2100	33,191	*(733)*	5,625	*1,497*	1,156	*(88)*	41	*(17)*
	1.0-m SLR by 2100	32,129	*(1,795)*	7,935	*3,807*	471	*(773)*	11	*(47)*
	1.5-m SLR by 2100	31,408	*(2,516)*	7,700	*3,571*	164	*(1,080)*	2	*(56)*
	2.0-m SLR by 2100	30,739	*(3,185)*	9,572	*5,443*	99	*(1,145)*	0	*(58)*
	Mean - A1B	33,375	*(548)*	5,222	*1,094*	1,181	*(63)*	48	*(10)*
	Mean - A1F1	33,200	*(724)*	5,658	*1,530*	1,156	*(88)*	41	*(17)*
	Mean - A1T	33,402	*(521)*	5,143	*1,015*	1,185	*(58)*	48	*(10)*
	Mean - A2	33,316	*(607)*	5,361	*1,233*	1,174	*(70)*	47	*(11)*
	Mean - B1	33,474	*(449)*	4,972	*844*	1,194	*(50)*	48	*(10)*
	Mean - B2	33,418	*(506)*	5,119	*991*	1,187	*(57)*	48	*(10)*
Mean of All Scenarios		32,765	*(1,158)*	6,231	*2,103*	897	*(347)*	33	*(25)*
Mean Deviation from Target		-	*NA*	-	*2,103*	-	*(825)*	-	*(318)*
Adaptation Strategy	**SLAMM Scenario**								
Currently Developed Dry Land Protected	0.5-m SLR by 2100	33,419	*(504)*	4,891	*763*	1,156	*(88)*	41	*(17)*
	1.0-m SLR by 2100	32,432	*(1,492)*	5,608	*1,480*	493	*(751)*	11	*(47)*
	1.5-m SLR by 2100	31,774	*(2,150)*	2,827	*(1,301)*	181	*(1,063)*	2	*(56)*
	2.0-m SLR by 2100	31,197	*(2,727)*	2,137	*(1,991)*	83	*(1,161)*	0	*(58)*
	Mean - A1B	33,577	*(347)*	4,659	*531*	1,179	*(65)*	48	*(10)*
	Mean - A1F1	33,426	*(498)*	4,902	*773*	1,156	*(87)*	41	*(17)*
	Mean - A1T	33,601	*(323)*	4,615	*487*	1,182	*(61)*	48	*(10)*
	Mean - A2	33,532	*(391)*	4,736	*607*	1,172	*(72)*	47	*(11)*
	Mean - B1	33,661	*(263)*	4,523	*395*	1,190	*(54)*	48	*(10)*
	Mean - B2	33,613	*(311)*	4,602	*474*	1,184	*(60)*	48	*(10)*
Mean of All Scenarios		33,023	*(901)*	4,350	*222*	897	*(346)*	33	*(25)*
Mean Deviation from Target		-	*NA*	-	*222*	-	*(824)*	-	*(318)*

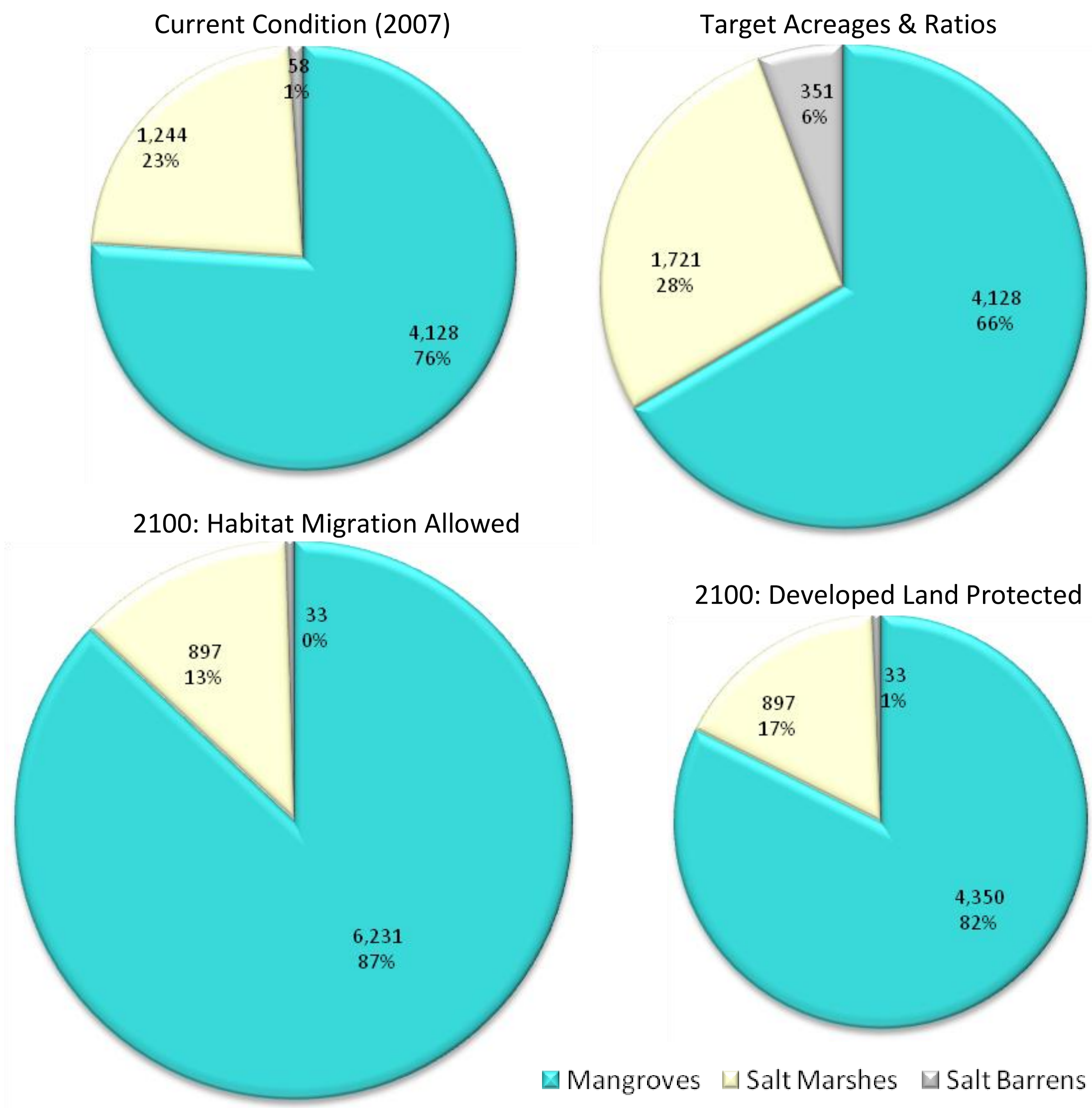

Figure 5: Pie charts depicting the critical coastal habitat acreages and percentages in Old Tampa Bay currently (2007), under target conditions, and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land). The 2100 plots use the mean result of all SLAMM runs, as depicted in Table 4. The size of each chart is proportional to the total acreages under each case.

Hillsborough Bay

For the Hillsborough Bay segment, changes in critical coastal habitats were most pronounced in terms of estimated losses to coastal freshwater wetlands (Figure 6). Salt marsh and salt barren habitats are also expected to decline with impending sea level rise regardless of adaptation strategies employed in the region (Figure 4). As was the case in the Old Tampa Bay segment, mangroves in Hillsborough Bay are expected to increase; however, they are not predicted to offset the losses estimated for the other three critical coastal habitats (Figure 6).

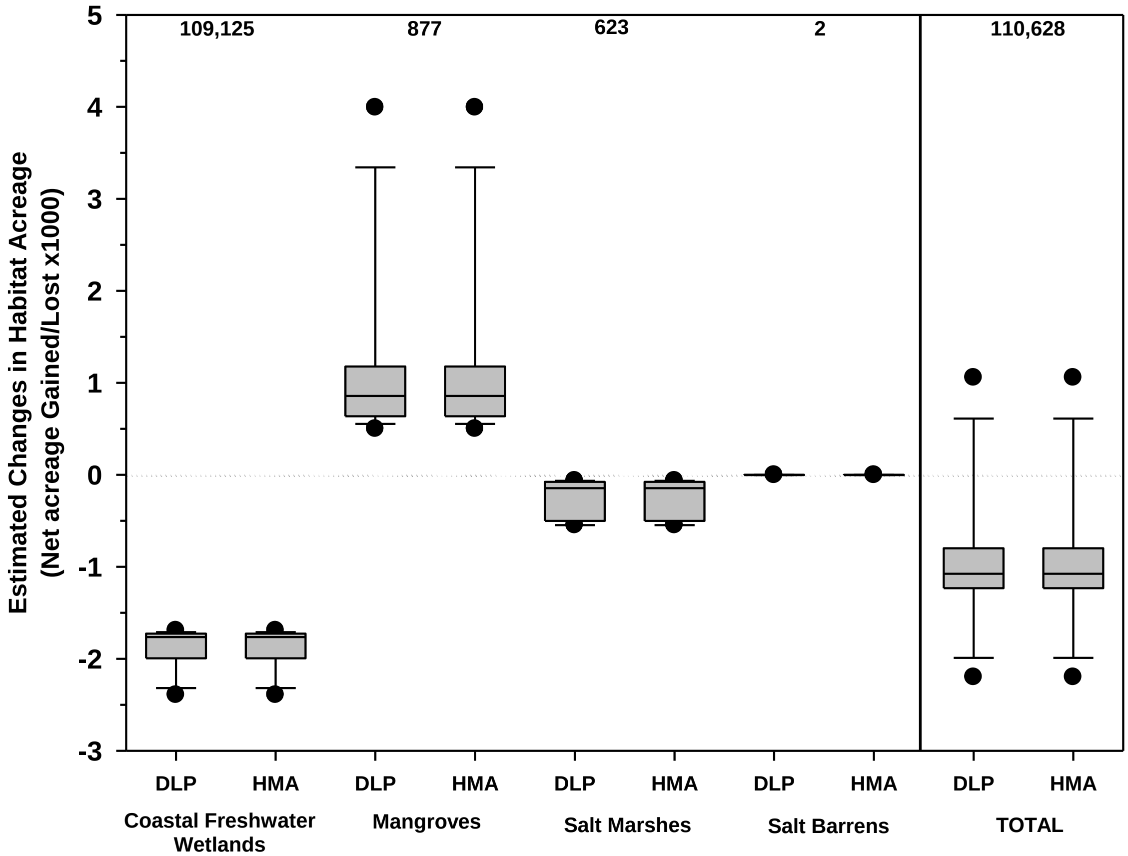

Figure 6. Box plots depicting the range of estimated changes in critical coastal habitat acreages based on SLAMM scenarios of 0.5-m, 1.0-m, 1.5-m, 2.0-m, mean A1B, mean A1F1, mean A1T, mean A2, mean B1, and mean B2 sea level rise by 2100 within the coastal Hillsborough Bay watershed. A net increase in acreage is displayed with box plots above the dotted zero line and a net decrease is displayed vice-versa. Two adaptation strategies were considered in the SLAMM scenario runs (DLP = Currently Developed Land Protected and HMA = Coastal Habitat Migration Allowed to occur). Numbers arranged along the vertical border of the graph represent the current (2007) estimated acreage of each habitat.

"Restoring the balance" target acreages have never been proposed for Hillsborough Bay, but an estimate of the expected target acreages from the baywide targets was developed and compared to the SLAMM scenarios (Robison, 2010; Table 5). Losses to both salt marsh and salt barren habitats in Hillsborough Bay are expected to skew habitat proportions to a more mangrove-dominated system, as was also seen at the baywide and Old Tampa Bay segment-scale (Table 4 & Figure 5).

Hillsborough Bay represents the largest segment in terms of total coastal habitat acreages (Table 5), and substantial loss of coastal freshwater wetlands (1,857 - 1,889 acres) is estimated for this bay segment.

Table 5: Summary of critical coastal habitat acreages and targets as estimated under current conditions (2007) and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land) for Hillsborough Bay.

		Coastal Freshwater Wetlands	Deviation	Mangroves	Deviation	Salt Marshes	Deviation	Salt Barrens	Deviation
Adapted Habitat Master Plan Target		**Not Defined**		**877**		**623**		**75**	
2007 Current Condition		**109,125**		**877**		**623**		**2**	
Adaptation Strategy	**SLAMM Scenario**								
Habitats Allowed to Migrate	0.5-m SLR by 2100	107,332	*(1,793)*	2,057	*1,180*	447	*(176)*	0	*(2)*
	1.0-m SLR by 2100	107,122	*(2,003)*	3,293	*2,415*	122	*(501)*	0	*(2)*
	1.5-m SLR by 2100	106,906	*(2,219)*	4,324	*3,446*	88	*(535)*	0	*(2)*
	2.0-m SLR by 2100	106,730	*(2,395)*	4,900	*4,022*	75	*(548)*	0	*(2)*
	Mean - A1B	107,378	*(1,747)*	1,851	*974*	530	*(93)*	1	*(1)*
	Mean - A1F1	107,334	*(1,791)*	2,093	*1,215*	448	*(175)*	0	*(2)*
	Mean - A1T	107,388	*(1,738)*	1,794	*916*	547	*(76)*	1	*(1)*
	Mean - A2	107,364	*(1,761)*	1,935	*1,058*	508	*(115)*	1	*(1)*
	Mean - B1	107,414	*(1,711)*	1,691	*814*	560	*(63)*	2	*(0)*
	Mean - B2	107,393	*(1,733)*	1,778	*900*	549	*(74)*	2	*(1)*
Mean of All Scenarios		107,236	*(1,889)*	2,572	*1,694*	387	*(236)*	1	*(1)*
Mean Deviation from Target		-	*NA*	-	*1,695*	-	*(236)*	-	*(74)*
Adaptation Strategy	**SLAMM Scenario**								
Currently Developed Dry Land Protected	0.5-m SLR by 2100	107,358	*(1,768)*	1,624	*746*	447	*(176)*	0	*(2)*
	1.0-m SLR by 2100	107,157	*(1,969)*	2,047	*1,169*	122	*(502)*	0	*(2)*
	1.5-m SLR by 2100	106,965	*(2,160)*	1,508	*631*	89	*(534)*	0	*(2)*
	2.0-m SLR by 2100	106,796	*(2,330)*	1,551	*673*	75	*(548)*	0	*(2)*
	Mean - A1B	107,401	*(1,724)*	1,478	*601*	530	*(93)*	1	*(1)*
	Mean - A1F1	107,359	*(1,767)*	1,630	*753*	448	*(175)*	0	*(2)*
	Mean - A1T	107,411	*(1,714)*	1,441	*563*	546	*(78)*	1	*(1)*
	Mean - A2	107,387	*(1,738)*	1,533	*655*	508	*(115)*	1	*(1)*
	Mean - B1	107,435	*(1,690)*	1,374	*497*	559	*(64)*	2	*(0)*
	Mean - B2	107,415	*(1,710)*	1,430	*552*	548	*(75)*	2	*(1)*
Mean of All Scenarios		107,268	*(1,857)*	1,562	*684*	387	*(236)*	1	*(1)*
Mean Deviation from Target			*NA*	-	*685*	-	*(236)*	-	*(74)*

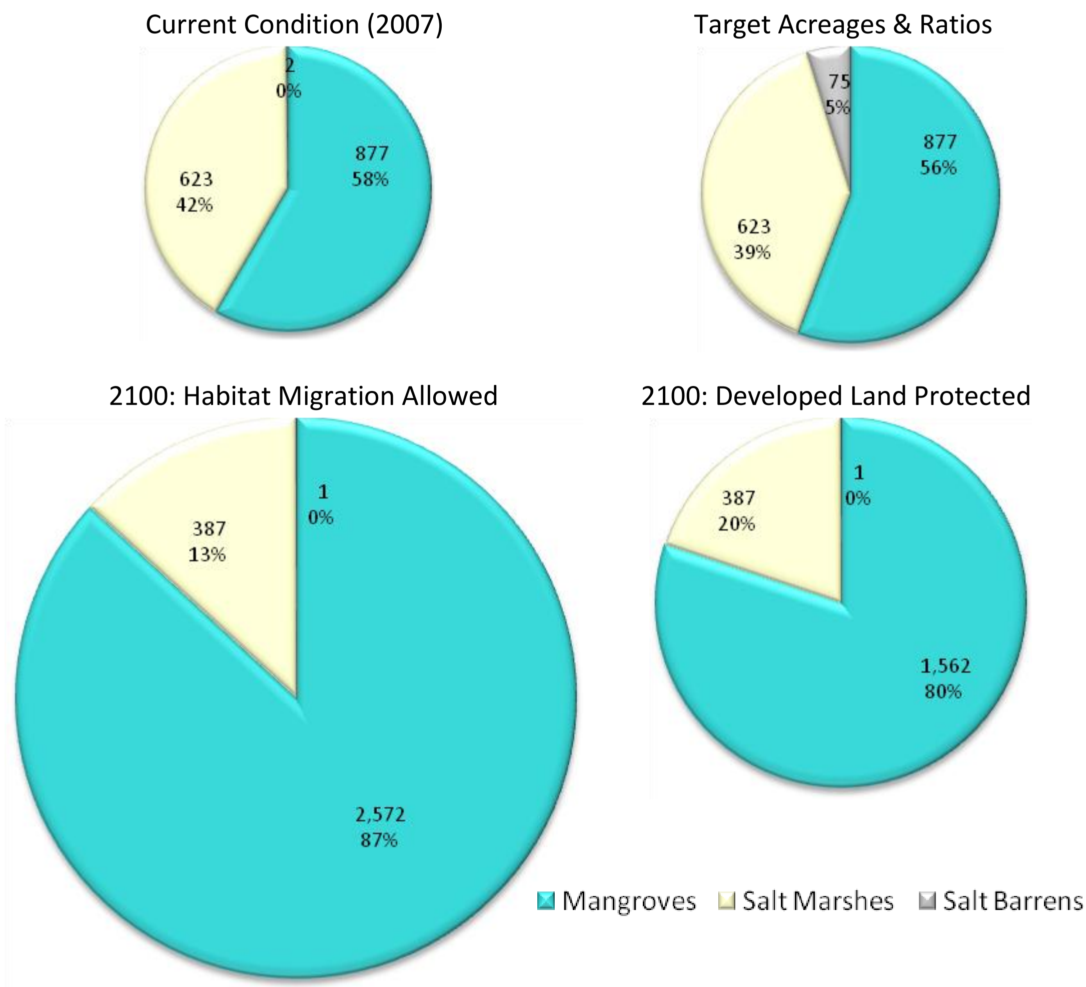

Figure 7: Pie charts depicting the critical coastal habitat acreages and percentages in Hillsborough Bay currently (2007), ideally under target conditions, and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land). The 2100 plots use the mean result of all SLAMM runs, as depicted in Table 5. The size of each chart is proportional to the total acreages under each case.

Middle Tampa Bay

For the Middle Tampa Bay segment, changes in critical coastal habitats mirrored what was estimated for the Old Tampa Bay segment. Coastal freshwater wetlands, salt marsh and salt barren habitats are all expected to decline with impending sea level rise regardless of the adaptation strategies employed in the region (Figure 8). Mangroves in Middle Tampa Bay are expected to increase, and similar to the Old Tampa Bay segment, they are predicted to offset the losses estimated for the other three critical coastal habitats in Middle Tampa Bay (Figure 8).

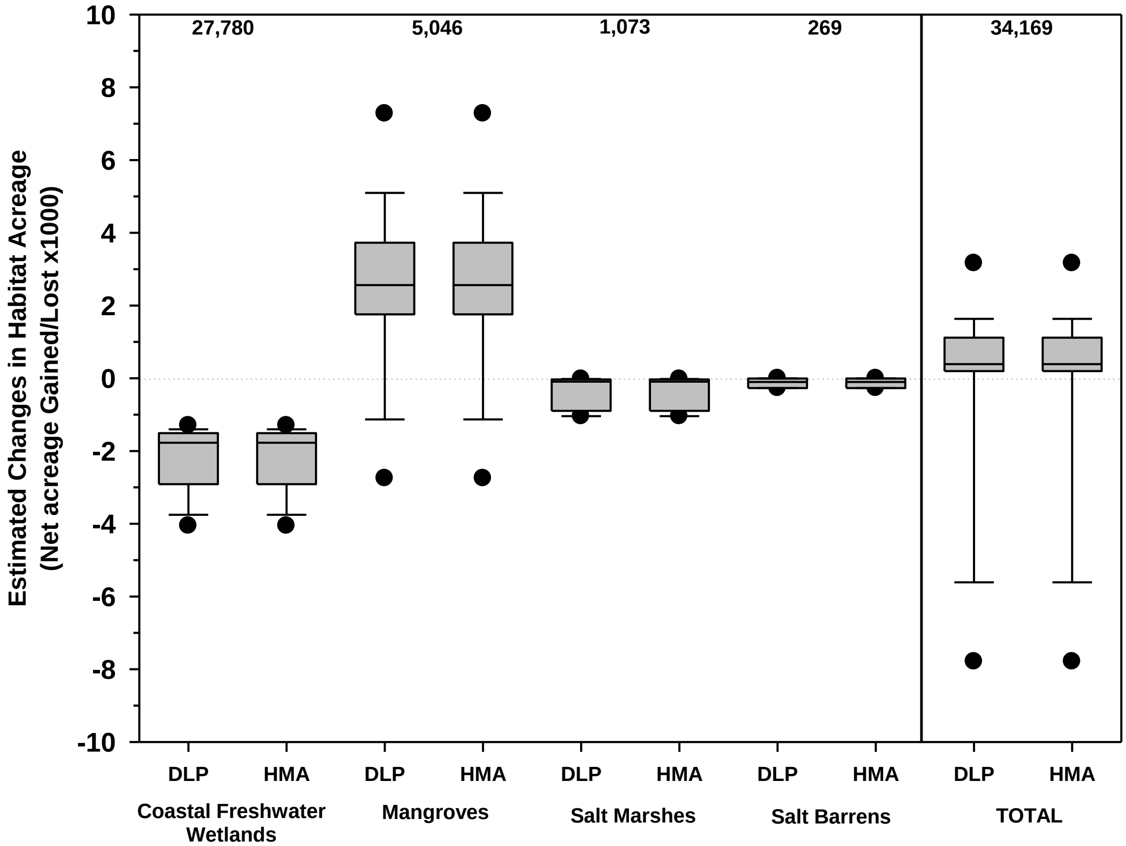

Figure 8. Box plots depicting the range of estimated changes in critical coastal habitat acreages based on SLAMM scenarios of 0.5-m, 1.0-m, 1.5-m, 2.0-m, mean A1B, mean A1F1, mean A1T, mean A2, mean B1, and mean B2 sea level rise by 2100 within the coastal Middle Tampa Bay watershed. A net increase in acreage is displayed with box plots above the dotted zero line and a net decrease is displayed vice-versa. Two adaptation strategies were considered in the SLAMM scenario runs (DLP = Currently Developed Land Protected and HMA = Coastal Habitat Migration Allowed to occur). Numbers arranged along the vertical border of the graph represent the current (2007) estimated acreage of each habitat.

The estimated losses in salt marsh and salt barren habitats in Middle Tampa Bay are expected to make achieving the “restoring the balance” estimated targets for this bay segment difficult to achieve into the future (Table 6 and Figure 9). The Middle Tampa Bay segment is estimated to become a more mangrove-dominated system into the future regardless of the adaptation strategies employed within the region with proportional composition of mangroves reaching 88-91% in this bay segment (Figure 9).

As was seen in Hillsborough Bay, significant loss of coastal freshwater wetlands (2,056 – 2,286 acres) is expected for the Middle Tampa Bay segment (Table 6).

Table 6: Summary of critical coastal habitat acreages and targets as estimated under current conditions (2007) and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land) for Middle Tampa Bay.

		Coastal Freshwater Wetlands	Deviation	Mangroves	Deviation	Salt Marshes	Deviation	Salt Barrens	Deviation
Adapted Habitat Master Plan Target		**Not Defined**		**5,046**		**2,104**		**429**	
2007 Current Condition		**27,780**		**5,046**		**1,073**		**269**	
Adaptation Strategy	**SLAMM Scenario**								
	0.5-m SLR by 2100	25,785	*(1,995)*	8,852	*3,806*	962	*(111)*	106	*(163)*
	1.0-m SLR by 2100	24,805	*(2,975)*	12,432	*7,385*	177	*(897)*	1	*(268)*
	1.5-m SLR by 2100	24,141	*(3,639)*	10,249	*5,203*	28	*(1,045)*	0	*(269)*
	2.0-m SLR by 2100	23,709	*(4,071)*	9,182	*4,136*	54	*(1,020)*	0	*(269)*
Habitats Allowed to Migrate	Mean - A1B	26,091	*(1,689)*	7,932	*2,885*	1,032	*(41)*	258	*(12)*
	Mean - A1F1	25,796	*(1,984)*	8,945	*3,898*	964	*(110)*	107	*(162)*
	Mean - A1T	26,145	*(1,635)*	7,754	*2,708*	1,041	*(32)*	264	*(6)*
	Mean - A2	26,004	*(1,776)*	8,264	*3,218*	998	*(75)*	226	*(43)*
	Mean - B1	26,290	*(1,490)*	7,371	*2,325*	1,057	*(17)*	268	*(1)*
	Mean - B2	26,174	*(1,606)*	7,697	*2,651*	1,043	*(30)*	265	*(4)*
Mean of All Scenarios		25,494	*(2,286)*	8,868	*3,821*	736	*(338)*	150	*(120)*
Mean Deviation from Target		-	*NA*	-	*3,822*	-	*(1,369)*	-	*(279)*
Adaptation Strategy	**SLAMM Scenario**								
	0.5-m SLR by 2100	26,004	*(1,776)*	7,514	*2,467*	963	*(111)*	106	*(163)*
	1.0-m SLR by 2100	25,060	*(2,720)*	8,543	*3,497*	177	*(897)*	1	*(268)*
	1.5-m SLR by 2100	24,420	*(3,360)*	3,623	*(1,423)*	28	*(1,045)*	0	*(269)*
	2.0-m SLR by 2100	24,013	*(3,767)*	2,226	*(2,820)*	52	*(1,021)*	0	*(269)*
Currently Developed Dry Land Protected	Mean - A1B	26,299	*(1,481)*	6,886	*1,839*	1,032	*(41)*	258	*(12)*
	Mean - A1F1	26,012	*(1,768)*	7,518	*2,471*	964	*(109)*	107	*(162)*
	Mean - A1T	26,351	*(1,429)*	6,779	*1,732*	1,040	*(34)*	264	*(6)*
	Mean - A2	26,215	*(1,565)*	7,088	*2,042*	998	*(75)*	226	*(43)*
	Mean - B1	26,488	*(1,292)*	6,539	*1,493*	1,055	*(19)*	268	*(1)*
	Mean - B2	26,377	*(1,402)*	6,744	*1,698*	1,042	*(32)*	265	*(4)*
Mean of All Scenarios		25,724	*(2,056)*	6,346	*1,300*	735	*(338)*	150	*(120)*
Mean Deviation from Target		-	*NA*	-	*1,300*	-	*(1,369)*	-	*(279)*

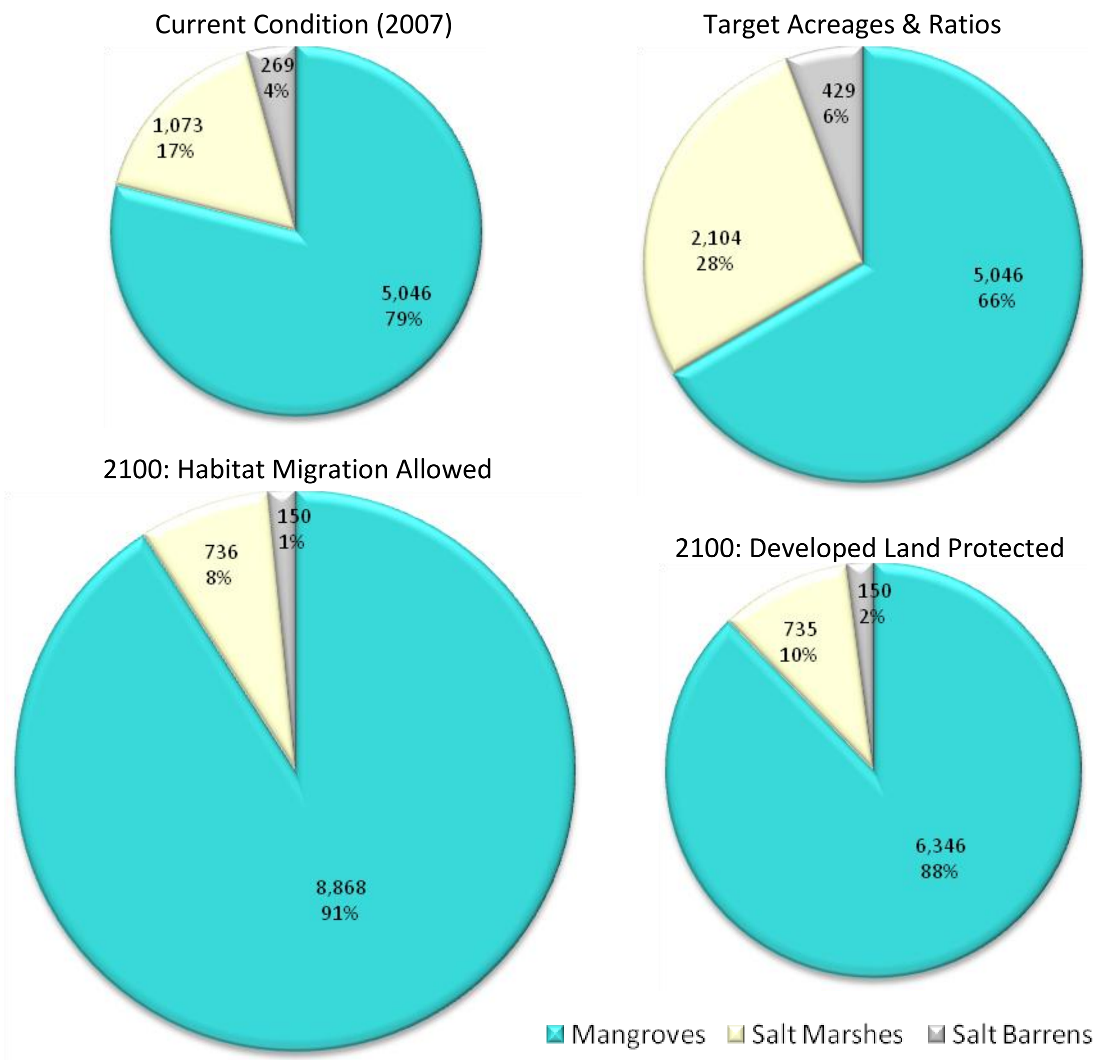

Figure 9: Pie charts depicting the critical coastal habitat acreages and percentages in Middle Tampa Bay currently (2007), ideally under target conditions, and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land). The 2100 plots use the mean result of all SLAMM runs, as depicted in Table 6. The size of each chart is proportional to the total acreages under each case.

Lower Tampa Bay

For the Lower Tampa Bay segment, coastal freshwater wetlands, salt marsh and salt barren habitats are all expected to decline with impending sea level rise regardless of the adaptation strategies employed in the region (Figure 10). Mangroves in Lower Tampa Bay are expected to increase, and the increases are predicted to modestly offset the losses predicted for the other three critical coastal habitats in Lower Tampa Bay (Figure 10).

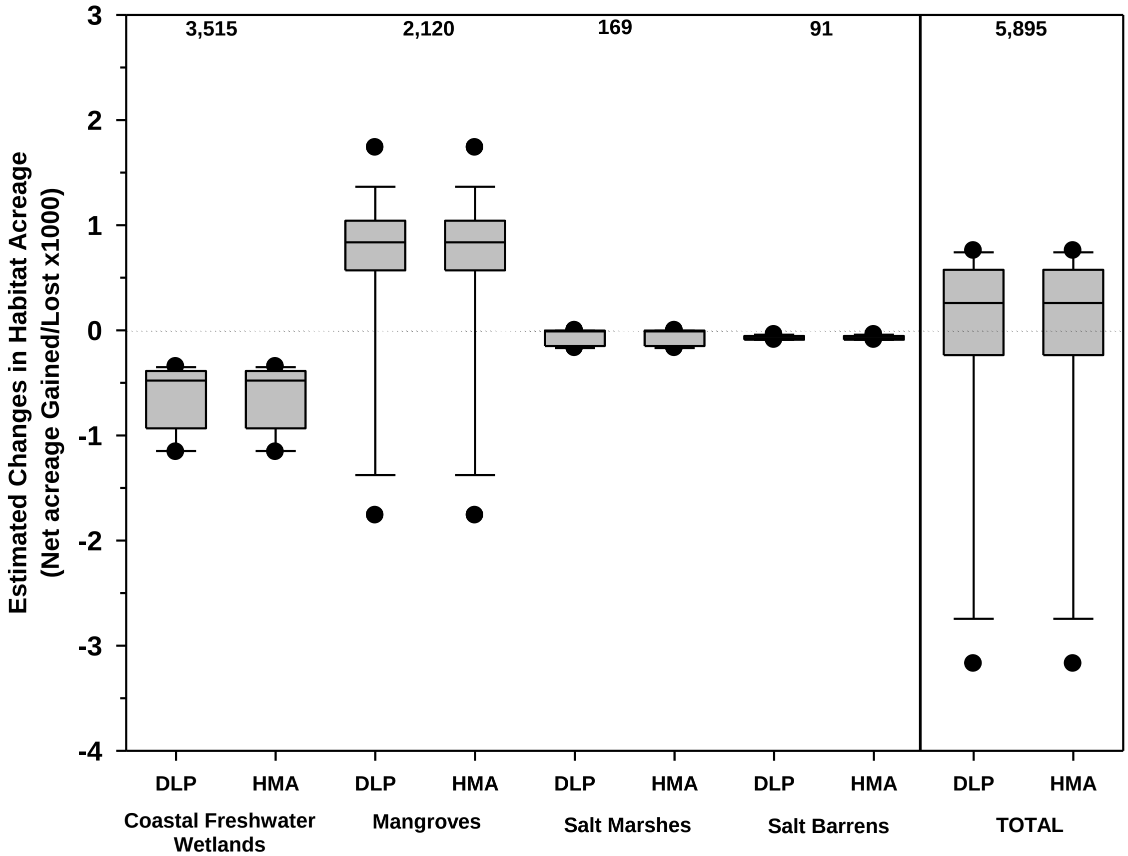

Figure 10. Box plots depicting the range of estimated changes in critical coastal habitat acreages based on SLAMM scenarios of 0.5-m, 1.0-m, 1.5-m, 2.0-m, mean A1B, mean A1F1, mean A1T, mean A2, mean B1, and mean B2 sea level rise by 2100 within the coastal Lower Tampa Bay watershed. A net increase in acreage is displayed with box plots above the dotted zero line and a net decrease is displayed vice-versa. Two adaptation strategies were considered in the SLAMM scenario runs (DLP = Currently Developed Land Protected and HMA = Coastal Habitat Migration Allowed to occur). Numbers arranged along the vertical border of the graph represent the current (2007) estimated acreage of each habitat.

Similar to the other bay segments, the estimated losses in salt marsh and salt barren habitats in Lower Tampa Bay are expected to make achieving the “restoring the balance” estimated targets for this bay segment difficult to achieve into the future (Table 7 and Figure 11). The Lower Tampa Bay segment is estimated to become a significantly mangrove-dominated system into the future regardless of the adaptation strategies employed within the region with proportional composition of mangroves reaching ~95% in this bay segment (Figure 11). In turn, salt marsh and salt barren habitats are expected to become proportionally less in this bay segment.

Table 7: Summary of critical coastal habitat acreages and targets as estimated under current conditions (2007) and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land) for Lower Tampa Bay.

		Coastal Freshwater Wetlands	Devia-tion	Mangroves	Devia-tion	Salt Marshes	Devia-tion	Salt Barrens	Devia-tion
Adapted Habitat Master Plan Target		**Not Defined**		**2,120**		**884**		**180**	
2007 Current Condition		**3,515**		**2,120**		**169**		**91**	
Adaptation Strategy	**SLAMM Scenario**								
Habitats Allowed to Migrate	0.5-m SLR by 2100	3,000	*(515)*	3,486	*1,366*	154	*(15)*	11	*(80)*
	1.0-m SLR by 2100	2,581	*(934)*	3,877	*1,757*	19	*(150)*	1	*(90)*
	1.5-m SLR by 2100	2,404	*(1,110)*	1,342	*(778)*	3	*(167)*	0	*(91)*
	2.0-m SLR by 2100	2,356	*(1,159)*	797	*(1,323)*	0	*(169)*	0	*(91)*
	Mean - A1B	3,105	*(410)*	3,177	*1,057*	165	*(4)*	32	*(58)*
	Mean - A1F1	3,003	*(512)*	3,480	*1,360*	155	*(15)*	11	*(80)*
	Mean - A1T	3,125	*(389)*	3,120	*999*	166	*(3)*	36	*(54)*
	Mean - A2	3,066	*(448)*	3,283	*1,162*	163	*(6)*	22	*(69)*
	Mean - B1	3,167	*(348)*	2,992	*872*	167	*(2)*	50	*(41)*
	Mean - B2	3,130	*(384)*	3,095	*974*	167	*(3)*	38	*(53)*
Mean of All Scenarios		2,894	*(621)*	2,865	*745*	116	*(53)*	20	*(71)*
Mean Deviation from Target		-	*NA*	-	*745*	-	*(768)*	-	*(160)*
Adaptation Strategy	**SLAMM Scenario**								
Currently Developed Dry Land Protected	0.5-m SLR by 2100	3,004	*(511)*	3,006	*886*	154	*(15)*	11	*(80)*
	1.0-m SLR by 2100	2,585	*(930)*	2,921	*801*	19	*(150)*	1	*(90)*
	1.5-m SLR by 2100	2,410	*(1,104)*	737	*(1,383)*	3	*(167)*	0	*(91)*
	2.0-m SLR by 2100	2,362	*(1,153)*	339	*(1,781)*	0	*(169)*	0	*(91)*
	Mean - A1B	3,108	*(407)*	2,805	*684*	165	*(4)*	32	*(58)*
	Mean - A1F1	3,006	*(509)*	3,006	*885*	155	*(15)*	11	*(80)*
	Mean - A1T	3,129	*(386)*	2,764	*643*	166	*(3)*	36	*(54)*
	Mean - A2	3,070	*(445)*	2,878	*757*	163	*(6)*	22	*(69)*
	Mean - B1	3,169	*(345)*	2,671	*551*	167	*(2)*	50	*(41)*
	Mean - B2	3,134	*(381)*	2,750	*630*	167	*(3)*	38	*(53)*
Mean of All Scenarios		2,898	*(617)*	2,388	*267*	116	*(53)*	20	*(71)*
Mean Deviation from Target		-	*NA*	-	*268*	-	*(768)*	-	*(160)*

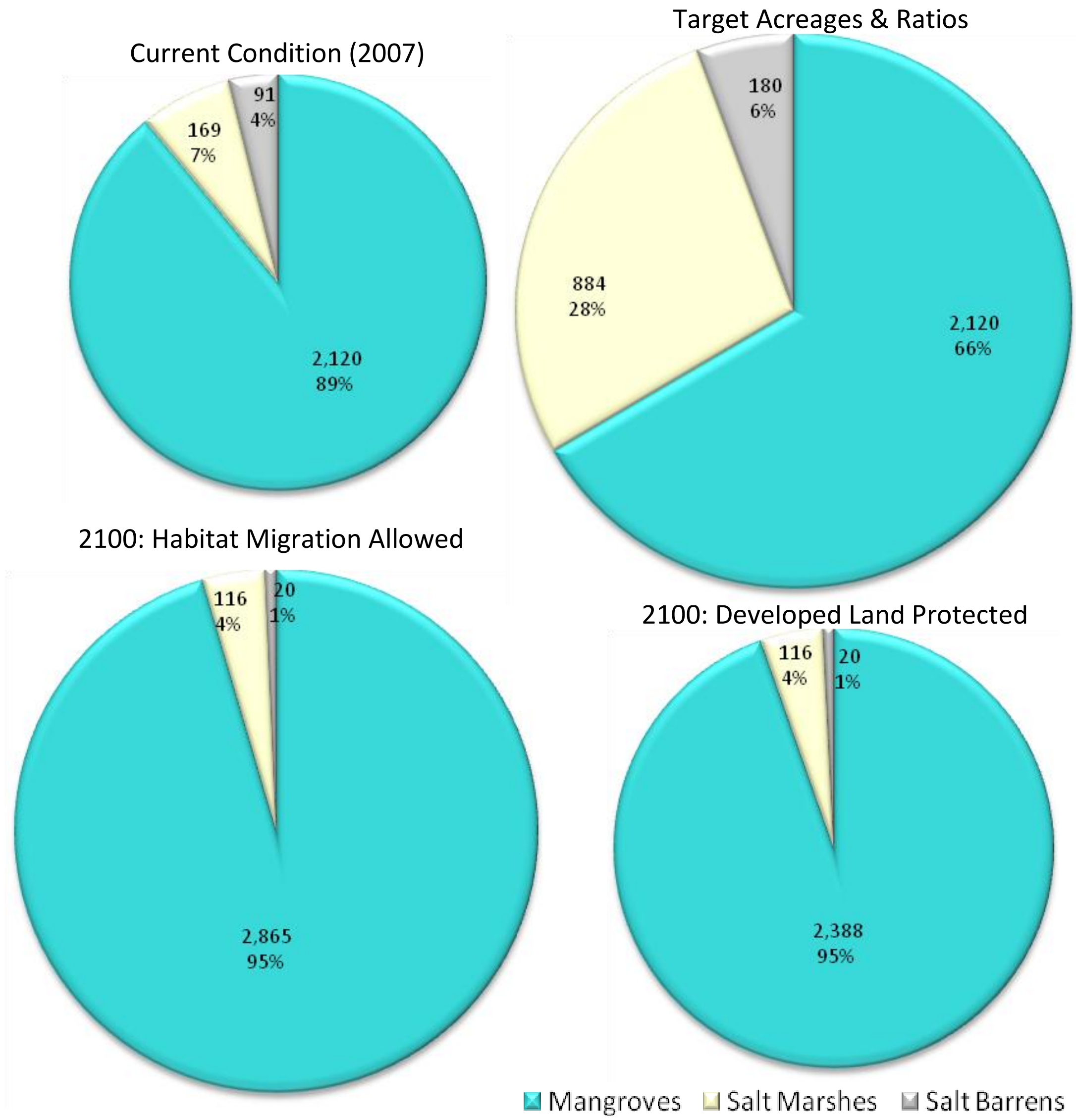

Figure 11: Pie charts depicting the critical coastal habitat acreages and percentages in Lower Tampa Bay currently (2007), ideally under target conditions, and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land). The 2100 plots use the mean result of all SLAMM runs, as depicted in Table 7. The size of each chart is proportional to the total acreages under each case.

Boca Ciega Bay

For the Boca Ciega Bay segment, coastal freshwater wetlands, salt marsh and salt barren habitats are all expected to decline with impending sea level rise regardless of the adaptation strategies employed in the region (Figure 12). Mangroves are also expected to decline if developed dry lands are protected into the future (Table 8). If this habitat is allowed to migrate inshore, then mangroves are predicted to increase and offset the losses predicted for the other three critical coastal habitats in Boca Ciega Bay (Table 8).

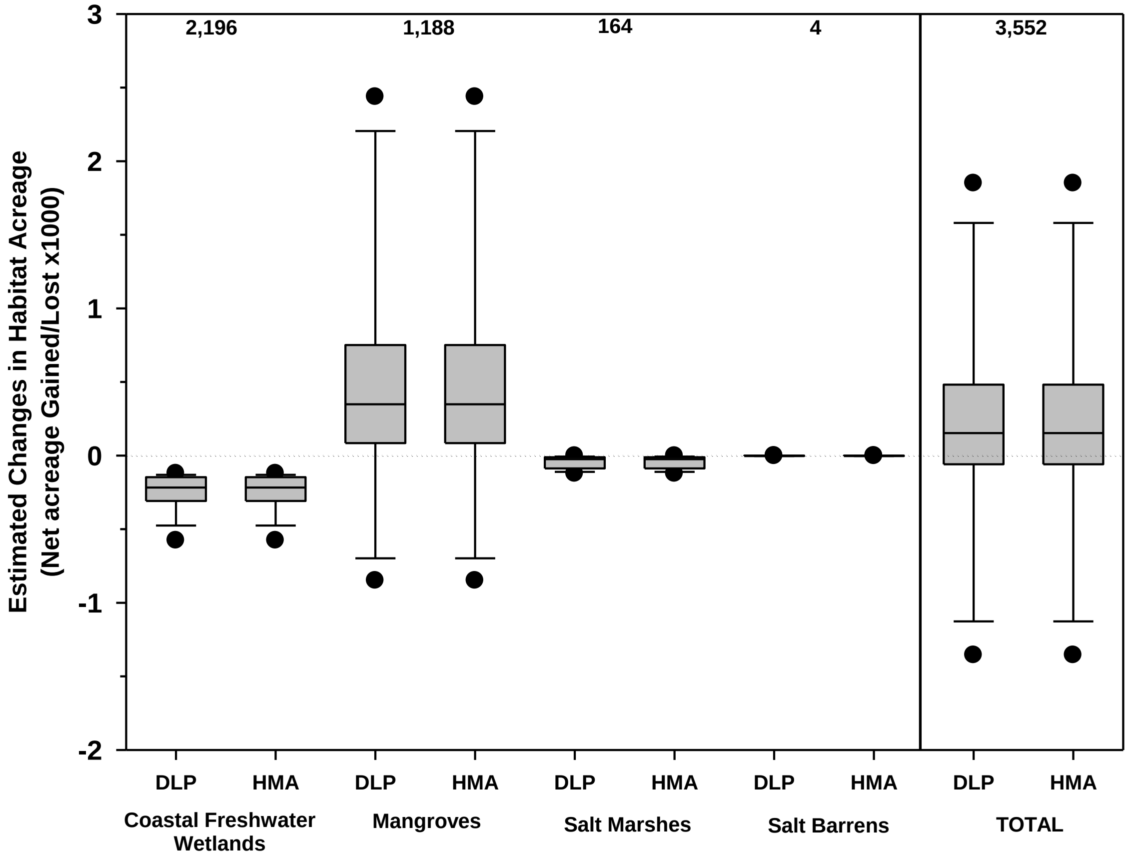

Figure 12. Box plots depicting the range of estimated changes in critical coastal habitat acreages based on SLAMM scenarios of 0.5-m, 1.0-m, 1.5-m, 2.0-m, mean A1B, mean A1F1, mean A1T, mean A2, mean B1, and mean B2 sea level rise by 2100 within the coastal Boca Ciega Bay watershed. A net increase in acreage is displayed with box plots above the dotted zero line and a net decrease is displayed vice-versa. Two adaptation strategies were considered in the SLAMM scenario runs (DLP = Currently Developed Land Protected and HMA = Coastal Habitat Migration Allowed to occur). Numbers arranged along the vertical border of the graph represent the current (2007) estimated acreage of each habitat.

Boca Ciega Bay is the only bay segment predicted to show a net decrease in all three estuarine habitats (i.e. mangrove, salt marsh, and salt barren habitats) under the "protecting developed dry land" adaptation strategy (Figure 13). Nevertheless, the segment is still predicted to become a mangrove-dominated system regardless of the adaptation strategy employed by the region into the future (Figure 13). Mangroves are estimated to make up 90-95% of the estuarine habitats into the future (Figure 13), and potentially, total habitat acreages could decline in this bay segment if the "protect developed dry land" adaptation strategy is employed.

Table 8: Summary of critical coastal habitat acreages and targets as estimated under current conditions (2007) and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land) for Boca Ciega Bay.

		Coastal Freshwater Wetlands	Deviation	Mangroves	Deviation	Salt Marshes	Deviation	Salt Barrens	Deviation
Adapted Habitat Master Plan Target		**Not Defined**		**1,188**		**495**		**101**	
2007 Current Condition		**2,196**		**1,188**		**164**		**4**	
Adaptation Strategy	**SLAMM Scenario**								
	0.5-m SLR by 2100	1,949	*(247)*	1,950	*763*	136	*(29)*	2	*(2)*
	1.0-m SLR by 2100	1,855	*(341)*	3,212	*2,024*	54	*(111)*	1	*(3)*
	1.5-m SLR by 2100	1,712	*(484)*	3,636	*2,448*	67	*(97)*	1	*(3)*
	2.0-m SLR by 2100	1,615	*(581)*	3,412	*2,225*	107	*(58)*	0	*(3)*
Habitats Allowed to Migrate	Mean - A1B	1,975	*(221)*	1,839	*651*	154	*(11)*	3	*(1)*
	Mean - A1F1	1,952	*(245)*	2,042	*855*	136	*(28)*	2	*(2)*
	Mean - A1T	1,979	*(217)*	1,804	*616*	157	*(8)*	3	*(1)*
	Mean - A2	1,968	*(228)*	1,904	*716*	149	*(16)*	2	*(1)*
	Mean - B1	1,996	*(200)*	1,744	*557*	163	*(1)*	3	*(0)*
	Mean - B2	1,984	*(212)*	1,791	*603*	158	*(7)*	3	*(1)*
Mean of All Scenarios		1,898	*(298)*	2,333	*1,146*	128	*(36)*	2	*(2)*
Mean Deviation from Target		-	*NA*	-	*1,145*	-	*(367)*	-	*(99)*
Adaptation Strategy	**SLAMM Scenario**								
	0.5-m SLR by 2100	2,042	*(154)*	1,326	*139*	131	*(33)*	2	*(2)*
	1.0-m SLR by 2100	1,979	*(217)*	1,229	*41*	41	*(123)*	1	*(3)*
	1.5-m SLR by 2100	1,867	*(329)*	407	*(780)*	58	*(106)*	1	*(3)*
	2.0-m SLR by 2100	1,800	*(397)*	335	*(853)*	54	*(110)*	0	*(3)*
Currently Developed Dry Land Protected	Mean - A1B	2,058	*(138)*	1,283	*95*	149	*(16)*	3	*(1)*
	Mean - A1F1	2,042	*(154)*	1,328	*140*	132	*(33)*	2	*(2)*
	Mean - A1T	2,061	*(135)*	1,275	*88*	151	*(13)*	3	*(1)*
	Mean - A2	2,052	*(144)*	1,299	*111*	144	*(21)*	2	*(1)*
	Mean - B1	2,075	*(121)*	1,263	*75*	157	*(8)*	3	*(0)*
	Mean - B2	2,066	*(130)*	1,271	*84*	152	*(12)*	3	*(1)*
Mean of All Scenarios		2,004	*(192)*	1,102	*(86)*	117	*(48)*	2	*(2)*
Mean Deviation from Target		-	*NA*	-	*(86)*	-	*(378)*	-	*(99)*

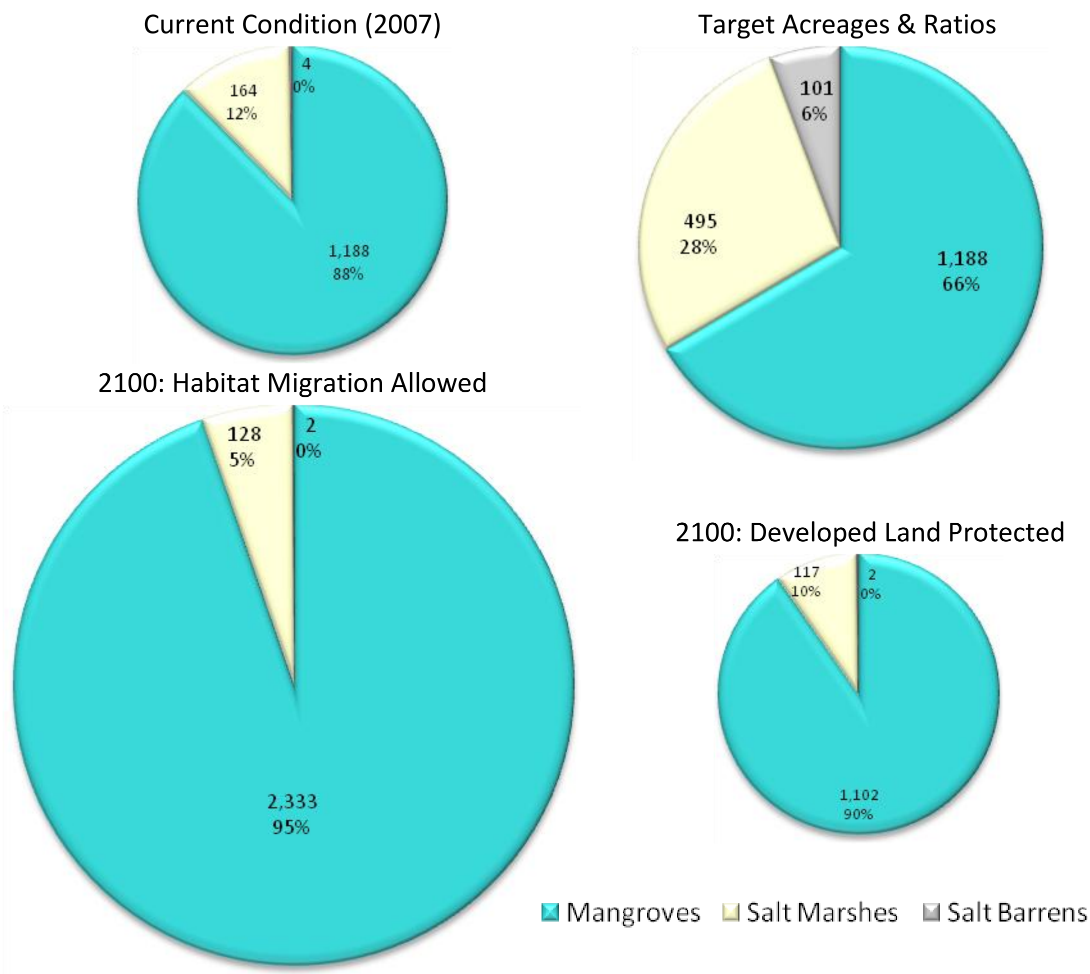

Figure 13: Pie charts depicting the critical coastal habitat acreages and percentages in Boca Ciega Bay currently (2007), ideally under target conditions, and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land). The 2100 plots use the mean result of all SLAMM runs, as depicted in Table 8. The size of each chart is proportional to the total acreages under each case.

Terra Ceia Bay

For the Terra Ceia Bay segment, increases in mangrove habitat are predicted to offset losses to coastal freshwater wetlands, salt marsh and salt barren habitats with impending sea level rise (Figure 14). As is the case for the majority of the bay segments examined, the Terra Ceia Bay segment is expected to become a mangrove-dominated system with approximately 98% of the estuarine habitats estimated to be mangrove in the future (Table 9 and Figure 15).

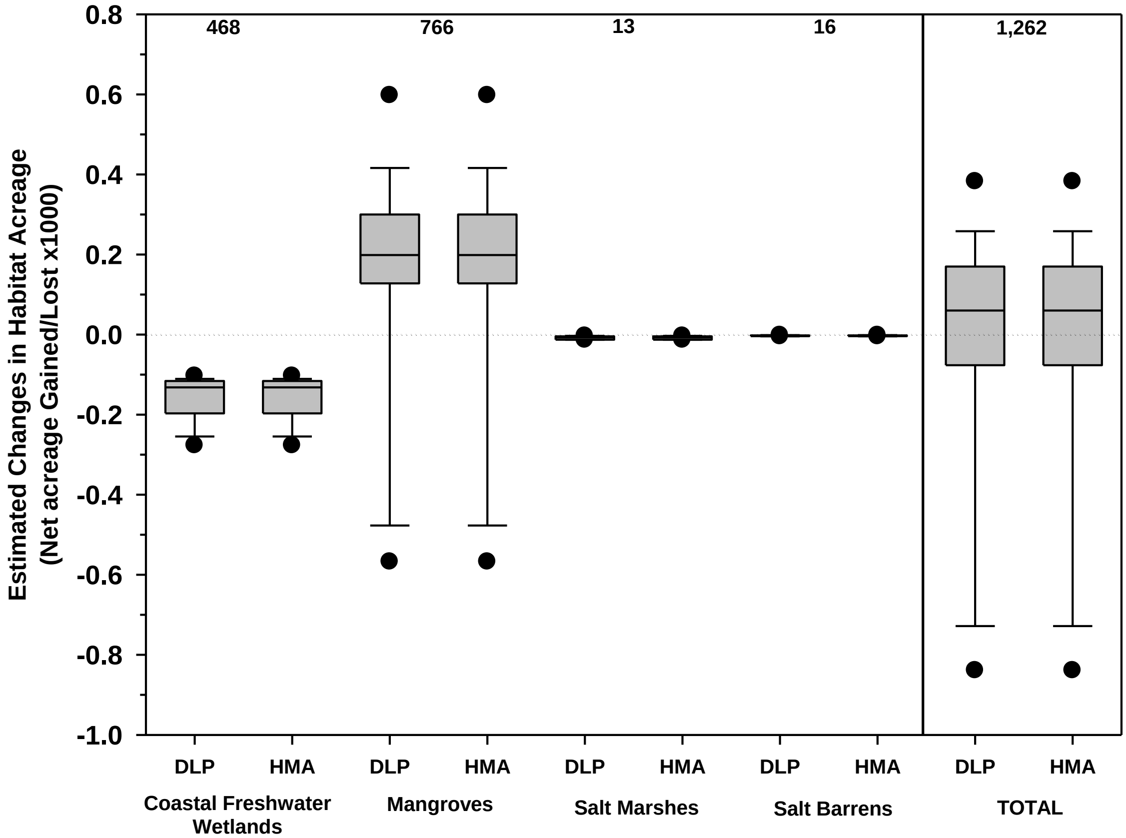

Figure 14. Box plots depicting the range of estimated changes in critical coastal habitat acreages based on SLAMM scenarios of 0.5-m, 1.0-m, 1.5-m, 2.0-m, mean A1B, mean A1F1, mean A1T, mean A2, mean B1, and mean B2 sea level rise by 2100 within the coastal Terra Ceia Bay watershed. A net increase in acreage is displayed with box plots above the dotted zero line and a net decrease is displayed vice-versa. Two adaptation strategies were considered in the SLAMM scenario runs (DLP = Currently Developed Land Protected and HMA = Coastal Habitat Migration Allowed to occur). Numbers arranged along the vertical border of the graph represent the current (2007) estimated acreage of each habitat.

The Terra Ceia Bay segment represents the smallest watershed area in terms of total coastal habitat acreage within its extent relative to the other bay segments of Tampa Bay. Modest estimated gains in mangrove habitat (18 – 299 acres) is expected to skew this bay segment's combined salt marsh and salt barren habitats to approximately 2% of the bay segment area into the future (Figure 15). If the adaptation strategy of "protecting currently developed dry lands" is employed in this bay segment, then it is expected that a cumulative net loss in total acreage for the four habitats considered in this study would occur (Table 9 and Figure 15).

Table 9: Summary of critical coastal habitat acreages and targets as estimated under current conditions (2007) and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land) for Terra Ceia Bay.

		Coastal Freshwater Wetlands	Devia-tion	Mangroves	Devia-tion	Salt Marshes	Devia-tion	Salt Barrens	Devia-tion
Adapted Habitat Master Plan Target		**Not Defined**		**766**		**319**		**65**	
2007 Current Condition		**468**		**766**		**13**		**16**	
Adaptation Strategy	**SLAMM Scenario**								
	0.5-m SLR by 2100	320	*(148)*	1,170	*404*	5	*(8)*	13	*(3)*
	1.0-m SLR by 2100	266	*(201)*	1,373	*607*	0	*(13)*	12	*(4)*
	1.5-m SLR by 2100	219	*(248)*	924	*159*	0	*(13)*	11	*(4)*
	2.0-m SLR by 2100	190	*(278)*	730	*(36)*	0	*(13)*	11	*(4)*
Habitats Allowed to Migrate	Mean - A1B	344	*(124)*	1,071	*306*	8	*(5)*	13	*(2)*
	Mean - A1F1	322	*(146)*	1,183	*417*	5	*(8)*	13	*(3)*
	Mean - A1T	348	*(120)*	1,048	*283*	9	*(4)*	14	*(2)*
	Mean - A2	338	*(129)*	1,112	*346*	7	*(6)*	13	*(3)*
	Mean - B1	357	*(111)*	996	*230*	10	*(3)*	15	*(1)*
	Mean - B2	349	*(118)*	1,040	*274*	9	*(4)*	14	*(2)*
Mean of All Scenarios		305	*(162)*	1,065	*299*	5	*(8)*	13	*(3)*
Mean Deviation from Target		-	*NA*	-	*299*	-	*(314)*	-	*(52)*
Adaptation Strategy	**SLAMM Scenario**								
	0.5-m SLR by 2100	332	*(136)*	981	*215*	5	*(8)*	13	*(3)*
	1.0-m SLR by 2100	285	*(183)*	849	*83*	0	*(13)*	12	*(4)*
	1.5-m SLR by 2100	239	*(229)*	240	*(526)*	0	*(13)*	11	*(4)*
	2.0-m SLR by 2100	212	*(255)*	196	*(569)*	0	*(13)*	11	*(4)*
Currently Developed Dry Land Protected	Mean - A1B	352	*(115)*	928	*162*	8	*(5)*	13	*(2)*
	Mean - A1F1	333	*(134)*	983	*218*	5	*(8)*	13	*(3)*
	Mean - A1T	356	*(112)*	916	*150*	9	*(4)*	14	*(2)*
	Mean - A2	347	*(120)*	948	*182*	7	*(7)*	13	*(3)*
	Mean - B1	365	*(103)*	888	*122*	10	*(3)*	15	*(1)*
	Mean - B2	357	*(111)*	912	*146*	9	*(4)*	14	*(2)*
Mean of All Scenarios		318	*(150)*	784	*18*	5	*(8)*	13	*(3)*
Mean Deviation from Target		-	*NA*	-	*18*	-	*(314)*	-	*(52)*

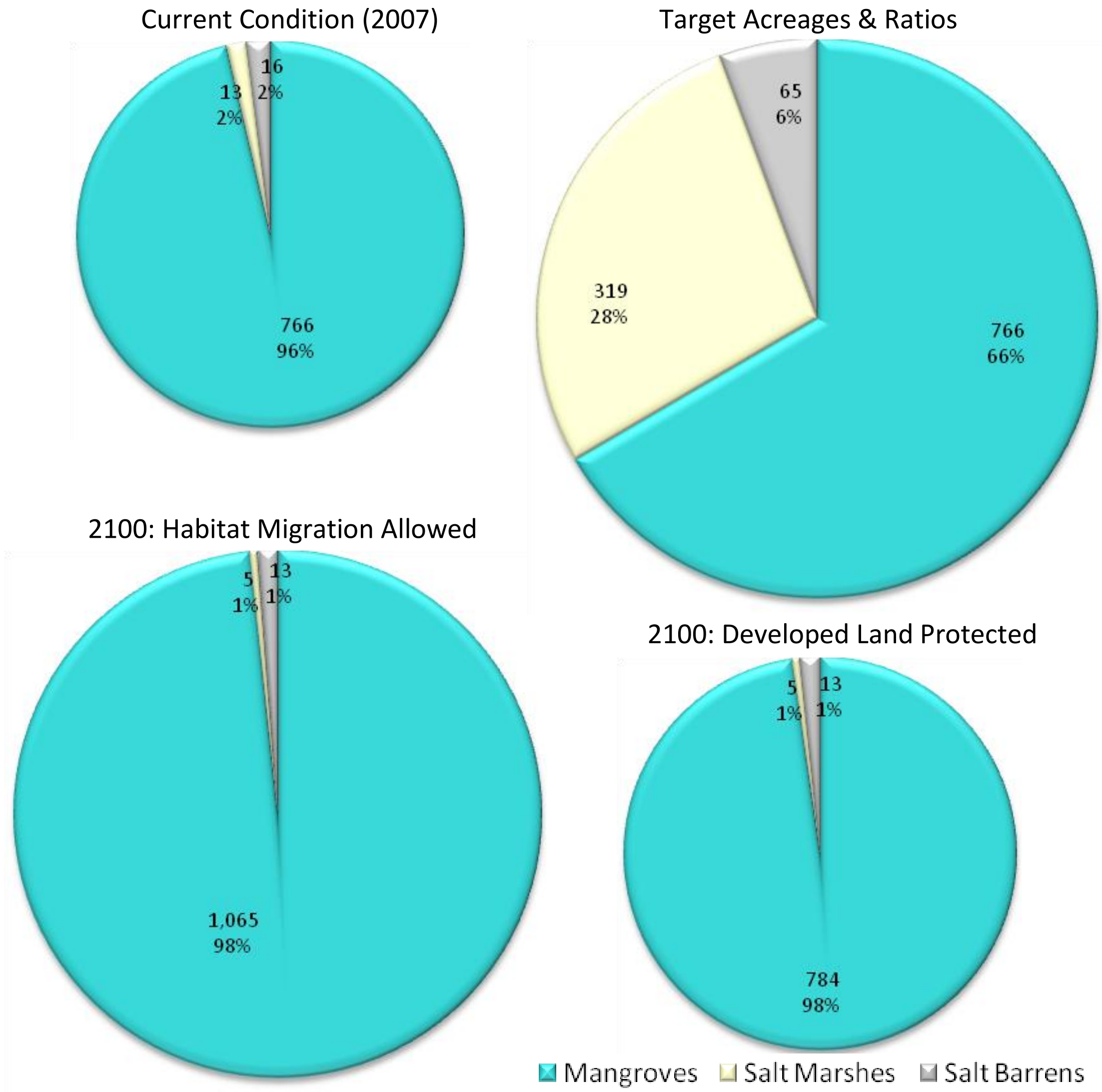

Figure 15: Pie charts depicting the critical coastal habitat acreages and percentages in Terra Ceia Bay currently (2007), ideally under target conditions, and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land). The 2100 plots use the mean result of all SLAMM runs, as depicted in Table 9. The size of each chart is proportional to the total acreages under each case.

Manatee River

The Manatee River represents the most distinct bay segment in Tampa Bay in terms of proportional areas of critical coastal habitats. Overall, substantial loss of coastal freshwater wetlands and salt marsh habitats may result in a total net loss of critical coastal habitats within this bay segment (Figure 16). Substantial estimated gains in mangrove habitats is not expected to provide enough offset to compensate for the losses of these two habitats regardless of the adaptation strategy employed within the region into the future (Figure 16).

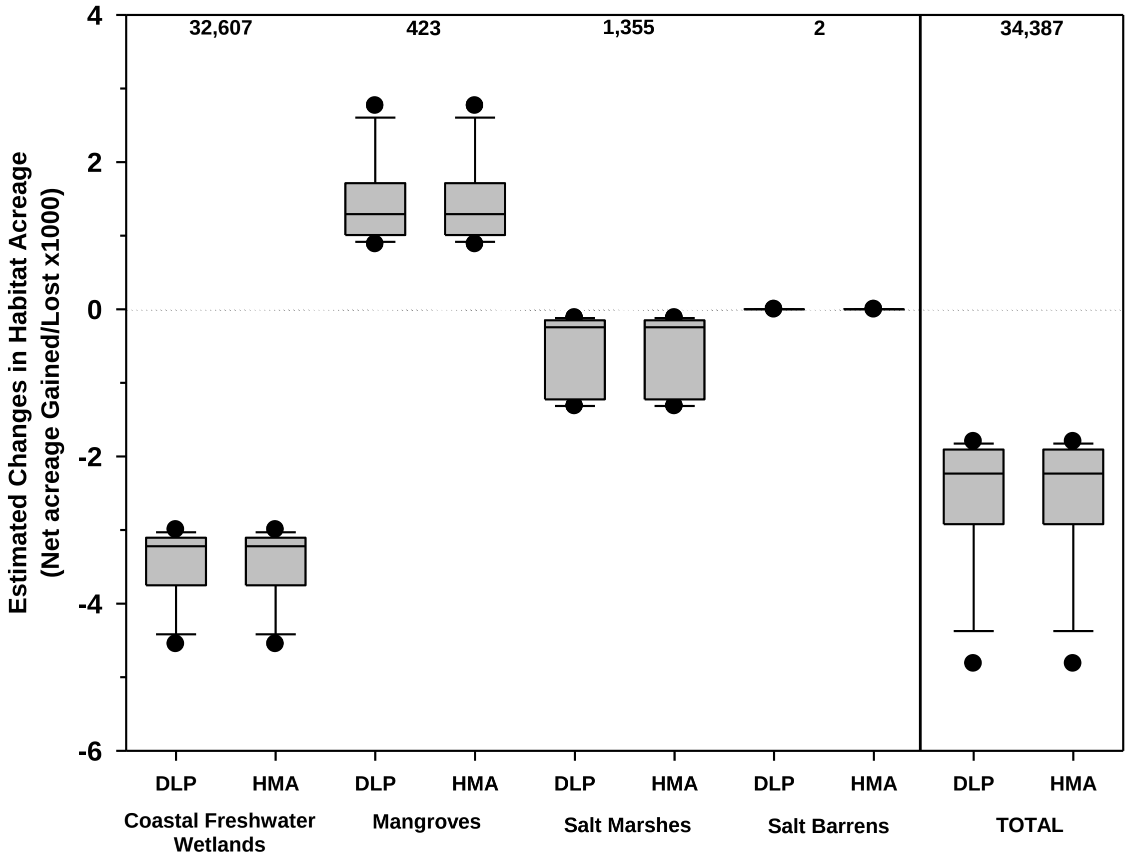

Figure 16. Box plots depicting the range of estimated changes in critical coastal habitat acreages based on SLAMM scenarios of 0.5-m, 1.0-m, 1.5-m, 2.0-m, mean A1B, mean A1F1, mean A1T, mean A2, mean B1, and mean B2 sea level rise by 2100 within the coastal Manatee River watershed. A net increase in acreage is displayed with box plots above the dotted zero line and a net decrease is displayed vice-versa. Two adaptation strategies were considered in the SLAMM scenario runs (DLP = Currently Developed Land Protected and HMA = Coastal Habitat Migration Allowed to occur). Numbers arranged along the vertical border of the graph represent the current (2007) estimated acreage of each habitat.

The estimated losses in salt marsh and salt barren habitats in the Manatee River are expected to make achieving the “restoring the balance” estimated targets for this bay segment very difficult to maintain and/or achieve into the future (Table 10 and Figure 17). The Manatee River segment is estimated to become a more mangrove-dominated system into the future regardless of the adaptation strategies employed within the region, even though under current conditions (and under ideal target conditions) it is primarily a salt marsh dominated system (Figure 17).

Additionally, the most significant loss of coastal freshwater wetlands (3,414 – 3,465 acres) and salt marsh habitats (519 - 520 acres) is expected for the Manatee River in comparison to the other bay segments of Tampa Bay (Table 6).

Table 10: Summary of critical coastal habitat acreages and targets as estimated under current conditions (2007) and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land) for Manatee River.

		Coastal Freshwater Wetlands	Devia-tion	Mangroves	Devia-tion	Salt Marshes	Devia-tion	Salt Barrens	Devia-tion
Adapted Habitat Master Plan Target		**Not Defined**		**423**		**1,355**		**36**	
2007 Current Condition		**32,607**		**423**		**1,355**		**2**	
Adaptation Strategy	**SLAMM Scenario**								
Habitats Allowed to Migrate	0.5-m SLR by 2100	29,323	*(3,284)*	2,170	*1,747*	1,070	*(284)*	1	*(1)*
	1.0-m SLR by 2100	28,841	*(3,766)*	3,195	*2,772*	131	*(1,224)*	0	*(2)*
	1.5-m SLR by 2100	28,433	*(4,174)*	2,784	*2,361*	38	*(1,316)*	0	*(2)*
	2.0-m SLR by 2100	28,051	*(4,556)*	3,055	*2,632*	55	*(1,300)*	0	*(2)*
	Mean - A1B	29,461	*(3,146)*	1,855	*1,433*	1,187	*(168)*	1	*(1)*
	Mean - A1F1	29,326	*(3,281)*	2,192	*1,769*	1,072	*(283)*	1	*(1)*
	Mean - A1T	29,492	*(3,115)*	1,784	*1,361*	1,204	*(151)*	1	*(1)*
	Mean - A2	29,406	*(3,201)*	1,976	*1,554*	1,150	*(205)*	1	*(1)*
	Mean - B1	29,580	*(3,027)*	1,615	*1,192*	1,239	*(115)*	2	*(0)*
	Mean - B2	29,504	*(3,102)*	1,761	*1,338*	1,209	*(145)*	2	*(1)*
Mean of All Scenarios		29,142	*(3,465)*	2,239	*1,816*	836	*(519)*	1	*(1)*
Mean Deviation from Target		-	*NA*	-	*1,816*	-	*(519)*	-	*(35)*
Adaptation Strategy	**SLAMM Scenario**								
Currently Developed Dry Land Protected	0.5-m SLR by 2100	29,363	*(3,243)*	1,664	*1,241*	1,069	*(285)*	1	*(1)*
	1.0-m SLR by 2100	28,902	*(3,705)*	2,037	*1,614*	129	*(1,225)*	0	*(2)*
	1.5-m SLR by 2100	28,514	*(4,093)*	1,346	*923*	37	*(1,318)*	0	*(2)*
	2.0-m SLR by 2100	28,163	*(4,444)*	1,338	*915*	53	*(1,302)*	0	*(2)*
	Mean - A1B	29,497	*(3,110)*	1,467	*1,044*	1,185	*(169)*	1	*(1)*
	Mean - A1F1	29,367	*(3,240)*	1,670	*1,247*	1,071	*(284)*	1	*(1)*
	Mean - A1T	29,528	*(3,079)*	1,420	*997*	1,203	*(152)*	1	*(1)*
	Mean - A2	29,445	*(3,162)*	1,543	*1,120*	1,148	*(206)*	1	*(1)*
	Mean - B1	29,613	*(2,994)*	1,305	*882*	1,238	*(117)*	2	*(0)*
	Mean - B2	29,539	*(3,068)*	1,406	*983*	1,208	*(147)*	2	*(1)*
Mean of All Scenarios		29,193	*(3,414)*	1,520	*1,097*	834	*(520)*	1	*(1)*
Mean Deviation from Target		-	*NA*	-	*1,097*	-	*(521)*	-	*(35)*

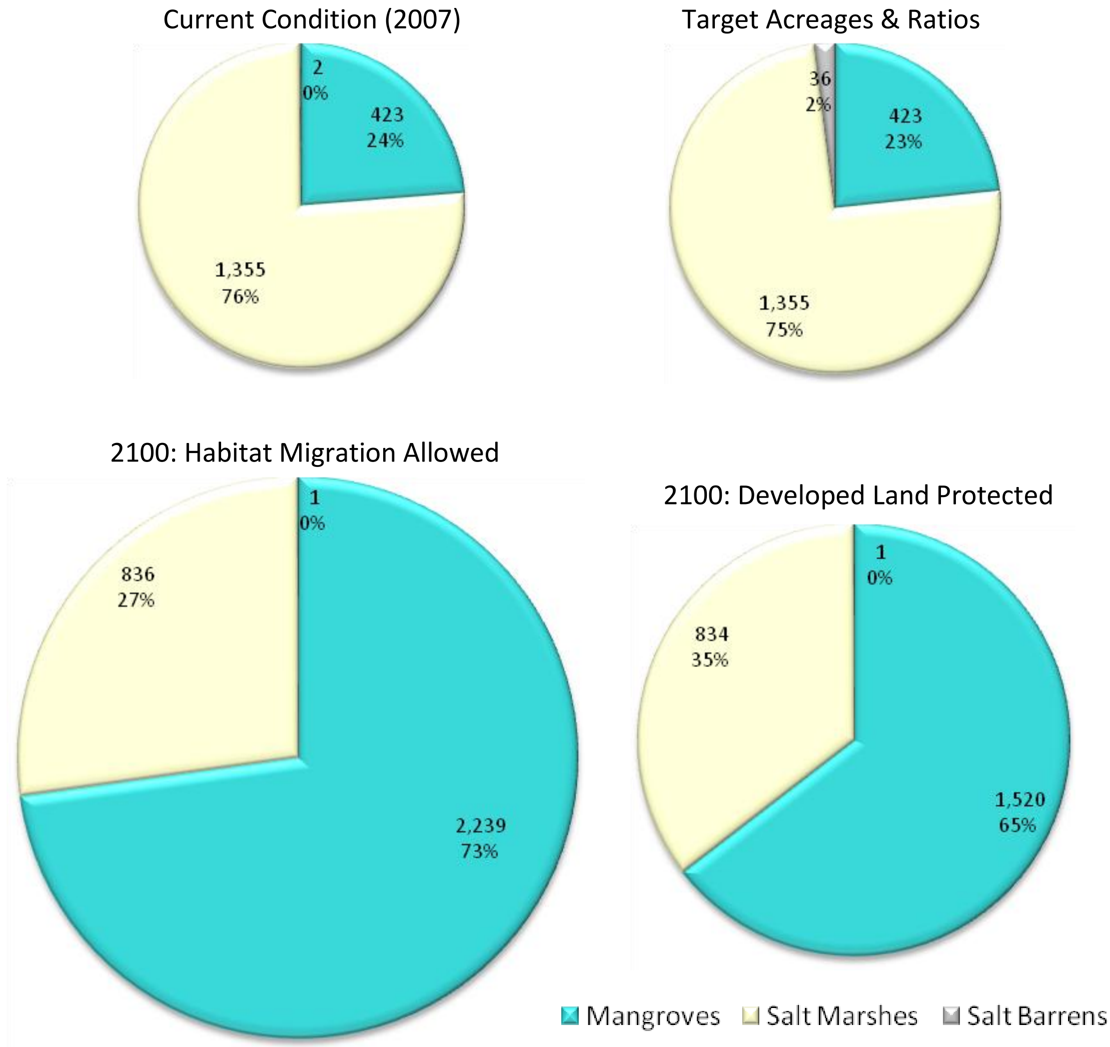

Figure 17: Pie charts depicting the critical coastal habitat acreages and percentages in Terra Ceia Bay currently (2007), ideally under target conditions, and projected into the future (2100) using SLAMM relative to two adaptation strategies (allowing habitats to migrate with sea level rise vs. protecting currently developed dry land). The 2100 plots use the mean result of all SLAMM runs, as depicted in Table 9. The size of each chart is proportional to the total acreages under each case.

MANAGEMENT RECOMMENDATIONS & CONSIDERATIONS

Significant changes in critical coastal habitat acreages and distributions have been estimated for the Tampa Bay watershed over the range of sea level rise scenarios investigated in this study. Two disparate adaptation strategies were considered and showed little potential effect on the modeled changes. Based on these results and as resource managers within the Tampa Bay region prepare for the impending effects of future climate change and sea level rise, it is important to consider that significant changes to the critical coastal habitats that support the rich diversity of biota within the Tampa Bay estuary is likely even if adaptation strategies are employed.

Increasingly, federal (e.g., US Climate Change Science Program, 2003; Titus, 2009), state (e.g., Mulkey, 2007; FOCC, 2009; Boicourt, K. and Z.P. Johnson, 2010.) and local (e.g., Beever et al., 2009; Robison, 2010) resource managers have recognized that global climate change will have significant and direct effects on coastal communities. The mosaic of estuarine habitats within the Tampa Bay region is a highly valued resource that provides ecological, aesthetic, socioeconomic and intrinsic benefits and vitality to the region. Local and regional efforts to sustain, restore and provide adaptation strategies for the continued benefit and enhancement of these resources is paramount for the Tampa Bay region. Given that the Tampa Bay region is currently one of the most densely populated coastal communities in the Gulf of Mexico (Figure 18) and that population within the region is expected to increase well into the future (Figure 19), efforts to incorporate adaptation strategies that promote habitat resiliency and sustainability into future land use planning practices is imperative.

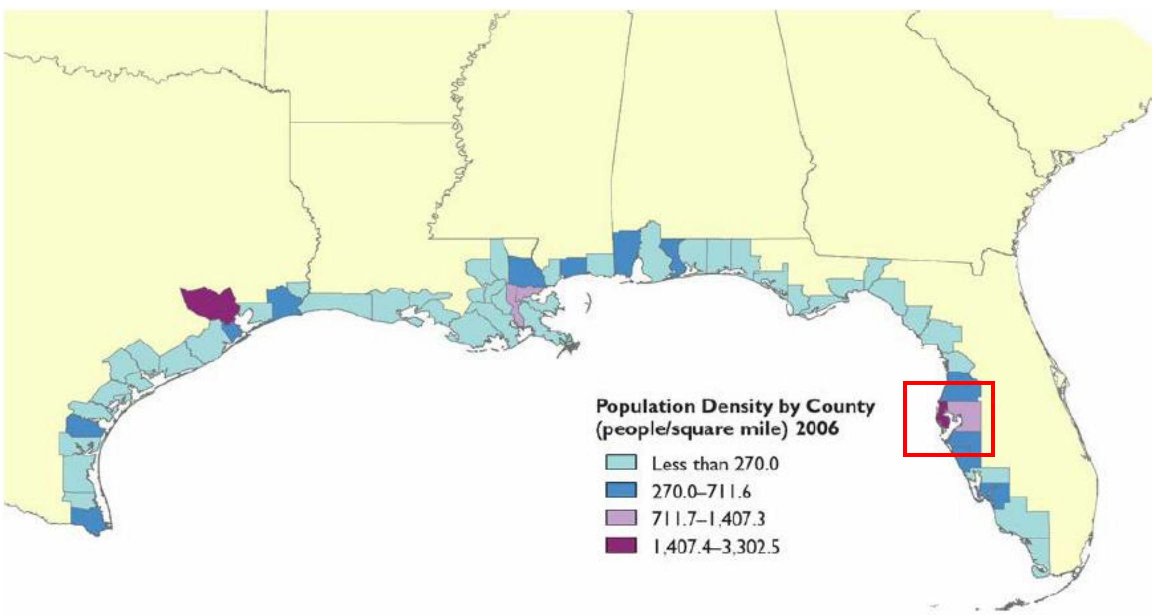

Figure 18: Gulf of Mexico coastal county population densities in 2006. The Tampa Bay region is highlighted in the red box. Adapted from: USEPA NCCR IV, 2012.

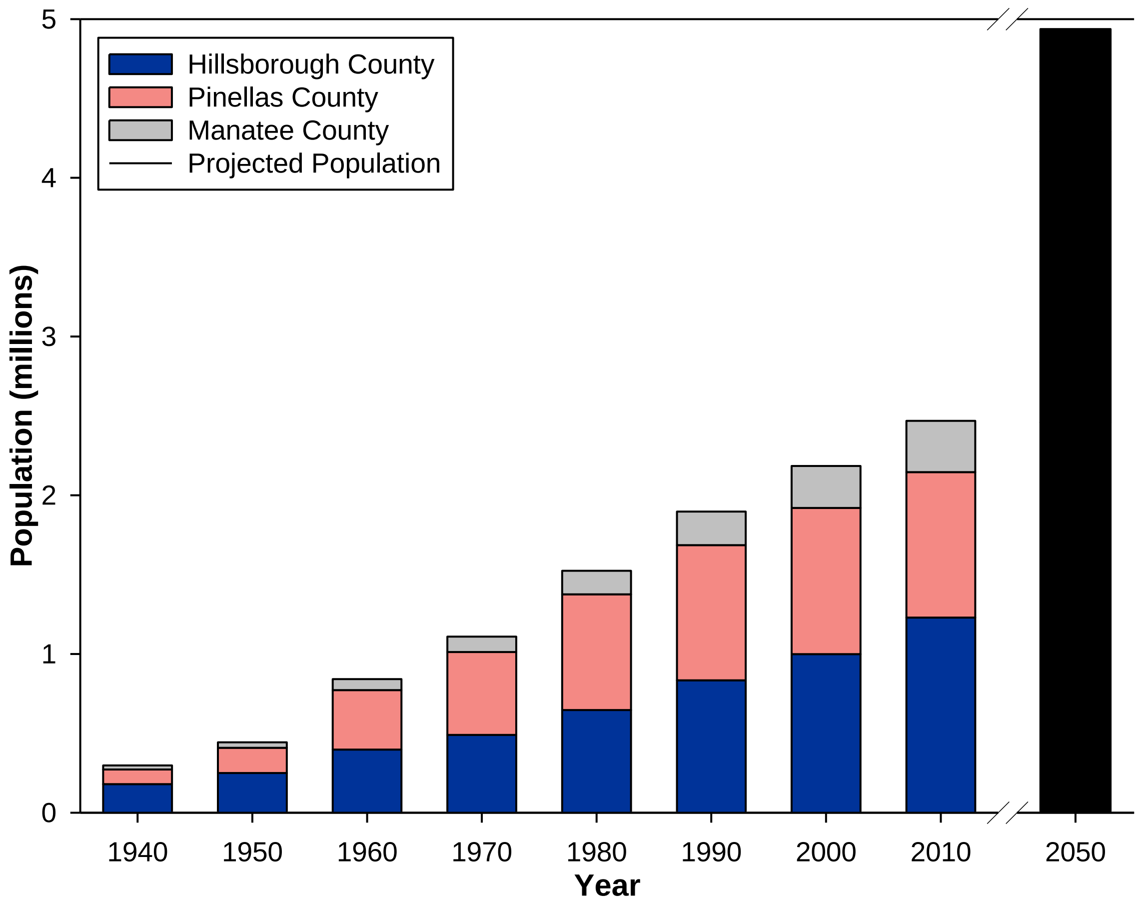

Figure 19: Population estimates for coastal counties of Tampa Bay, 1940-2010 and projected for 2050. Source: US Census Bureau; Tampa Bay Partnership.

To aid in this endeavor, the FOCC (2009) called for the development of integrated assessment tools to monitor the effects of climate change and sea level rise on Florida coasts into the future. Consequently, several tools have been developed by the NOAA on large regional scales within the Gulf of Mexico (e.g., see http://www.csc.noaa.gov/slr/viewer) that can be applied to land use planning and habitat restoration efforts within Tampa Bay. It is hoped that this report and the products developed under this project will build upon these efforts and will be incorporated into an On-Line Tampa Bay Sea Level Rise Visualization Tool for use by land use planners, natural resource managers, and habitat restoration partners [Web-Link Forthcoming].

Shifting Paradigms: Climate Change & Tampa Bay Coastal Habitat Composition

Tampa Bay is situated between temperate and subtropical climate conditions, and the suite of emergent tidal habitats represented within the estuary have been largely controlled by a balance of these climatic conditions. Mangrove habitat distribution and occurrence in Tampa Bay is controlled by periodic winter freezing events, and with the anticipated changes in climate forecasted for 2100, this climate controlling factor may have even more pronounced effects on emergent tidal wetland composition than sea level rise. Yates and Raabe (2011) have estimated that historically, the Tampa Bay estuary was comprised of more salt marsh habitats than what has been observed in contemporary periods (i.e. post-1950). They suggested that shifting dominance of mangrove habitats within Tampa Bay has been attributed to a "complex interplay of climate change, river discharge [i.e. freshwater delivery to the estuary], and urbanization impacts." As an example, Figure 20 depicts historic and current estimates of the composition of critical coastal habitats within Tampa Bay, and the anticipated effects of 1-m sea level rise on the composition of those habitats easily estimated by 2100. Mangroves come to dominate the tidal emergent habitat types within the estuary in 2100, and whether or not habitats are allowed to migrate as an adaptation strategy will have a significant impact on the total acreage of emergent tidal wetlands within the estuary into the future.

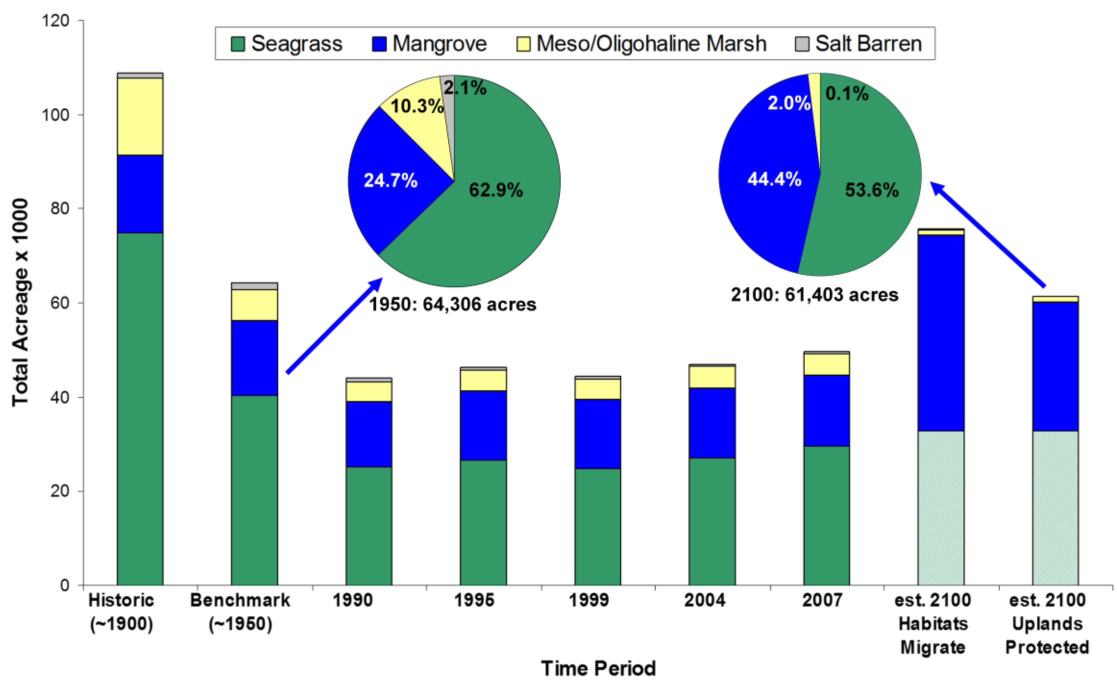

Figure 20: Estimated composition of critical coastal habitats in Tampa Bay and the anticipated changes in their composition due to climate change as estimated from the SLAMM under a 1-m sea level rise scenario. Note: 2100 projections for seagrass are not available from the model, so seagrass acreage estimates for the 2100 time period are from 2010.

With this in mind, it may be necessary to reconsider the paradigm of "Restoring the Balance" of critical coastal habitats in Tampa Bay. If the overwhelming progression and succession of emergent tidal habitats is towards a mangrove-dominated system in Tampa Bay, then large-scale restoration efforts that require significant fiscal resources to restore other emergent habitats (e.g., salt marsh or salt barrens) to help achieve unrealistic, future "Restoring the Balance" habitat acreage targets (see Table 1) may be called into question. Perhaps a greater restoration target for the region would be to create opportunity for mangrove habitat recruitment and growth in areas that otherwise would not foster emergent tidal wetlands into the future, whether it be related to anticipated changes to the climate or sea-level. For example, the restoration of salt marsh, salt barren, and even oligohaline marsh habitats should consider the long-term anticipated succession of mangroves as a functional indicator of success rather than simply looking at survivability of specific restored species at the time of restoration (e.g. salt marsh planting survivability).

In addition, as the results suggested from this study, fringing coastal freshwater wetlands may be an even more pressing habitat loss for the region into the future. And perhaps, a shift in effort to restore these systems as well as fringing transitional systems that may foster and benefit tidal emergent wetland recruitment and succession is warranted. Again, emphasis on prioritizing the restoration of oligohaline marsh habitats is warranted in this case, as the transitional zone of tidal and freshwater emergent wetlands will likely and significantly shift into the future due to changes in sea level within the Tampa Bay estuary.

Restoring Coastal Habitat Mosaics

The Southwest Florida Water Management District's Surface Water Improvement and Management Program (SWFWMD SWIM) has pioneered the restoration technique of restoring coastal habitat mosaics within Tampa Bay (Henningsen, 2005). Historically, early restoration projects within Tampa Bay consisted of small-scale, simple marsh plantings; however, the sophistication of coastal habitat restoration through the SWFWMD SWIM program and other TBEP partner restoration projects has evolved into a holistic ecosystem restoration ethos that, where possible, incorporates a rich diversity of subtidal, emergent wetland, and coastal upland restoration techniques into the site plan. An award winning example of this type of restoration technique is highlighted at the Fred and Ida Schultz Nature Preserve Restoration site (Figure 21). Here, a completely upland, spoil-created peninsula was restored into a braided tidal creek system with subtidal, marsh and coastal upland features.

Figure 21: **A.** Aerial image of the formally known as "Port Redwing" pre-restoration site looking east. **B.** Aerial image of the Fred and Ida Schultz Nature Preserve post-restoration site looking west. **C.** Overview conceptual plan for the Fred and Ida Schultz Nature Preserve restoration site.

Restoration efforts in the future should apply the lessons learned in Tampa Bay regarding the success of large-scale ecosystem restoration efforts that have incorporated habitat mosaics into their designs. Not only will these types of restoration efforts in the future provide more functional benefit to the estuary, but they also could proactively offer coastal habitat resiliency towards any future sea level rise impacts – especially when coastal upland features are integrated into the design and allow for the migration of tidal emergent wetlands into higher elevations.

Establishing Upland Coastal Habitat Refugia

Significant effort has been invested in the Tampa Bay watershed to prioritize coastal sites for either restoration or future acquisition and preservation (Lewis and Robison, 1996; Robison, 2010). Originally, Lewis and Robison (1996) identified and prioritized 28 coastal sites within the Tampa Bay watershed for these activities. Since that time, 19 sites have been completely or partially purchased, and of those, 8 have undergone restoration. Robison (2010) updated this priority list to now include 49 publicly-owned sites and 8 sites targeted for public-private partnership opportunities. The majority of these sites are located along Tampa Bay's coast and include large areas that are currently intertidal.

Given the projections developed under this project, the majority of these sites will most likely become subtidal habitats and may no longer support emergent tidal wetland habitats (see Appendix D). It is therefore imperative that land managers and planners, as well as restoration site practitioners, consider lands up-slope of these areas into the future for additional acquisition and restoration opportunities. With the limited land acquisition opportunities currently available within the Tampa Bay watershed – especially adjacent to the coast – it will be necessary to identify new potential public-private partnerships that could be fostered to add higher elevation restoration opportunities to the mix of priority sites. For critical coastal habitats with specific niche elevation requirements (e.g. salt barrens that are only seasonally tidally inundated), it may be necessary to identify low-lying inland areas that could become available as salt barren habitat in the future and set these areas aside as future habitat refugia sites. Along these same lines, long-term coastal land use planning could incorporate the ideas of rolling easements into the mix of planning tools to reserve/preserve lands along the coast in the future for coastal habitat migration and refugia (Titus, 2011).

Recommended Priority Management Action Updates

The following amendments and updates are recommended for inclusion in the Tampa Bay Estuary Program's Comprehensive Conservation and Management Plan for Tampa Bay. This list of updates should be considered a draft until fully vetted through the TBEP Technical Advisory Committee, the Tampa Bay Habitat Restoration Partnership, and the TBEP's Management and Policy Boards.

BH-XX Re-evaluate critical coastal habitat restoration targets and priorities to take into account the effects of climate change and sea level rise

- **STATUS:**
  New actions to be integrated into 2012 CCMP amendments.
- **BACKGROUND:**
  As stated above and in the context of this report.
- **STRTEGY 1:** Identify current acreage estimates for critical coastal habitats without targets (e.g., oysters, oligohaline marshes, coastal freshwater wetlands, etc.), update acreage estimates for those habitats with targets (e.g. salt

marsh, salt barrens and seagrass), and establish any new draft paradigm concepts / targets for next HMP update

Responsible Parties: Tampa Bay Habitat Restoration Partnership, TBEP, SWFWMD SWIM, Other TBEP partners
Schedule: Present – 2020 (incorporate into 2020 HMP Update)

STRATEGY 2: Develop a long-term monitoring program to assess the status, trends and ecological function of the mosaic of critical coastal habitats in Tampa Bay. The purpose of the program should be to: 1) detect any changes due to natural and indirect anthropogenic impacts, including sea level rise and climate change; and 2) improve the future management of these habitats.

Responsible Parties: Tampa Bay Habitat Restoration Partnership, TBEP, SWFWMD SWIM, Other TBEP partners
Schedule: Present – 2020 (incorporate into 2020 HMP Update)

STRATEGY 3: Identify and prioritize new site inventories that offer opportunities for coastal habitat protection, acquisition, ecosystem restoration, and habitat refugia in the face of sea level rise including the identification of any new mechanisms that may be required to better foster public-private partnerships to accomplish this action

Responsible Parties: Tampa Bay Habitat Restoration Partnership, TBEP, SWFWMD SWIM, Other TBEP partners
Schedule: Present – 2020 (incorporate into 2020 HMP Update)

STRATEGY 4: Initiate new research initiatives that investigate habitat restoration techniques that could be implemented to combat climate change and sea level rise impacts to improve coastal habitat resiliency (e.g. physical management of vulnerable habitats, hydrologic restoration of tidally-influenced confluences, beneficial use of dredged material to aid in wetland accretion, etc.).

Responsible Parties: Tampa Bay Habitat Restoration Partnership, TBEP, SWFWMD SWIM, Other TBEP partners
Schedule: Present – 2020 (incorporate into 2020 HMP Update)

STRATEGY 5: Better educate the public and Tampa Bay coastal communities on the anticipated impacts of sea level rise and encourage future home owner practices that provide for coastal habitat resiliency into the future (e.g. alternatively replacing dilapidated sea walls with living shorelines, creating shoreline vegetative buffers, etc.)

Responsible Parties: Tampa Bay Habitat Restoration Partnership, TBEP, FL Sea Grant, Other TBEP partners
Schedule: Present – 2020

STRATEGY 6: Work with the Tampa Bay planning community to identify needed land use code changes that incorporate coastal habitat resiliency requirements and utilize new web-based, sea level rise visualization tools into their planning activities

Responsible Parties: Tampa Bay Regional Planning Council, One Bay Partnership, ABM, Tampa Bay Habitat Restoration Partnership, TBEP
Schedule: Present – 2020

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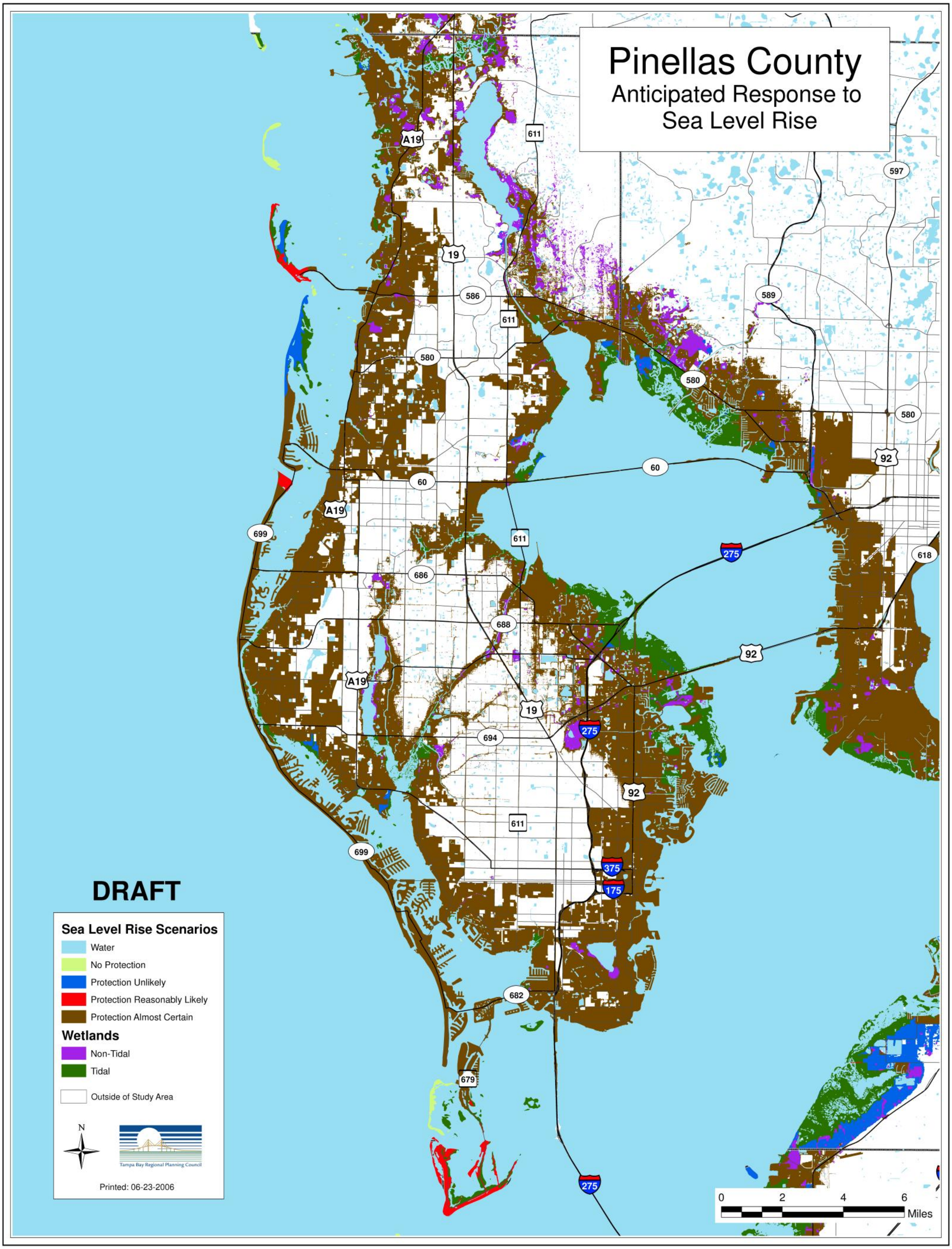
APPENDIX A:

Coastal Areas Likely Protected from Sea Level Rise into the Future as Estimated by the TBRPC (2006)



Pinellas County
Anticipated Response to
Sea Level Rise
DRAFT
Sea Level Rise Scenarios
Water
No Protection
Protection Unlikely
Protection Reasonably Likely
Protection Almost Certain
Wetlands
Non-Tidal
Tidal
Outside of Study Area
N
Tampa Bay Regional Planning Council
Printed: 06-23-2006
0
2
4
6
Miles
A19
611
597
19
586
589
611
580
580
580
60
60
92
A19
699
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688
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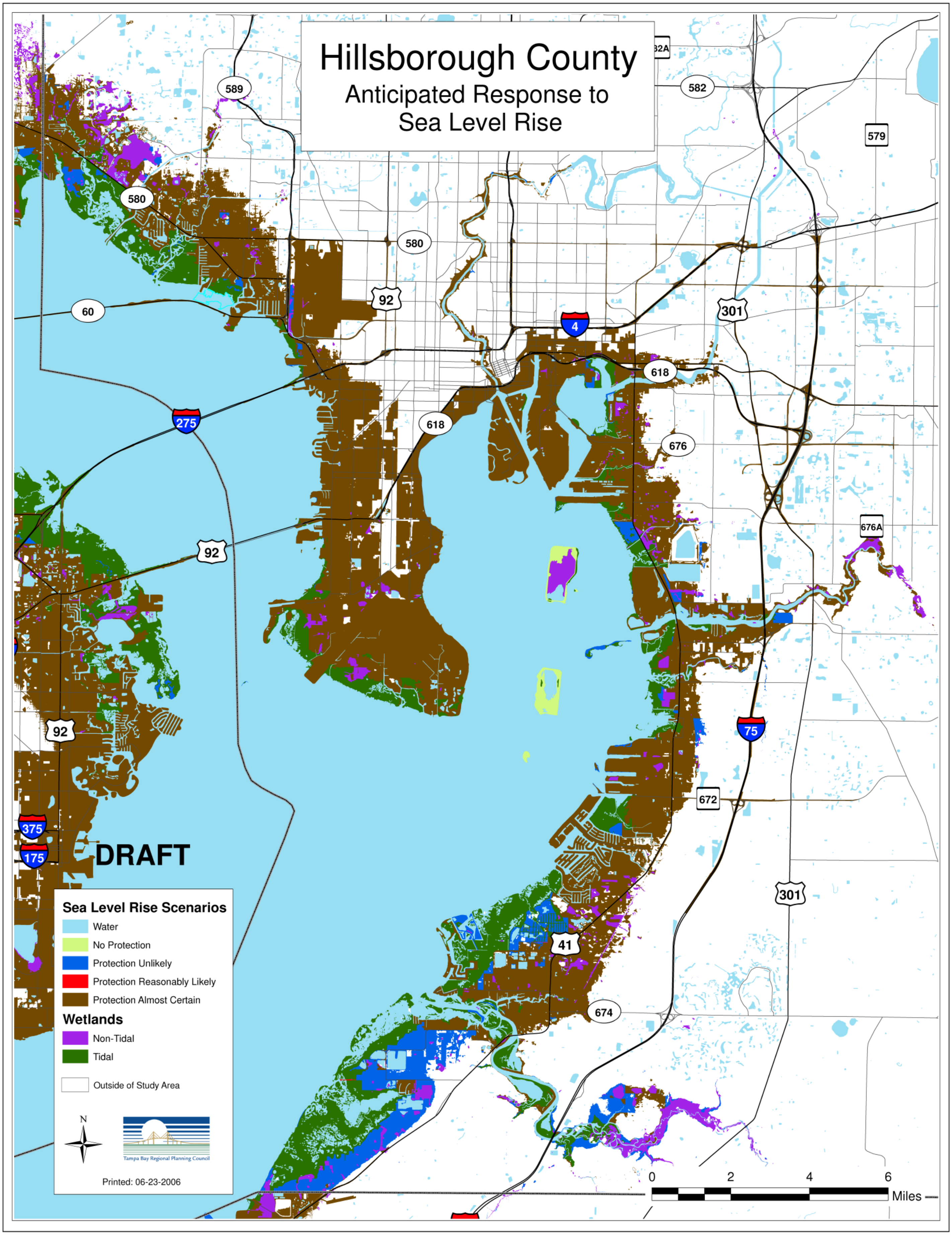
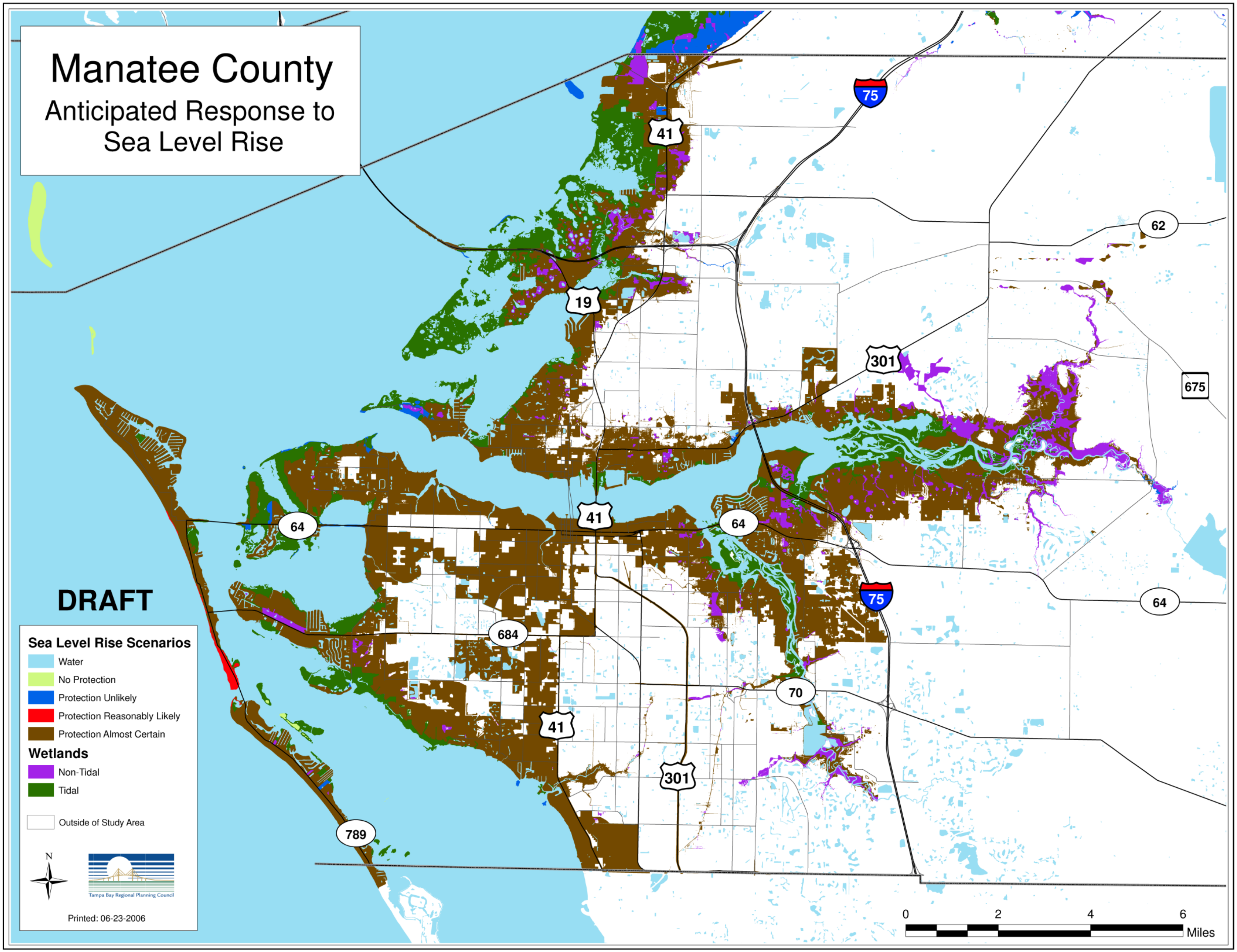
375
175
682
679
275



Hillsborough County
Anticipated Response to
Sea Level Rise
DRAFT
Sea Level Rise Scenarios
Water
No Protection
Protection Unlikely
Protection Reasonably Likely
Protection Almost Certain
Wetlands
Non-Tidal
Tidal
Outside of Study Area
N
Tampa Bay Regional Planning Council
Printed: 06-23-2006
0
2
4
6
Miles
589
582
579
580
580
60
92
4
301
618
275
618
676
676A
92
92
75
375
175
672
301
41
674



Manatee County
Anticipated Response to Sea Level Rise
DRAFT
Sea Level Rise Scenarios
Water
No Protection
Protection Unlikely
Protection Reasonably Likely
Protection Almost Certain
Wetlands
Non-Tidal
Tidal
Outside of Study Area
N
Tampa Bay Regional Planning Council
Printed: 06-23-2006
41
75
19
62
301
675
64
684
70
789
0
2
4
6
Miles

APPENDIX B:

Translation of Florida Land Use and Cover Classification System (FLUCCS) Codes to SLAMM Habitat Categories

FLUCCS CODE	FLUCCS Description	SLAMM CODE
1100	RESIDENTIAL LOW DENSITY < 2 DWELLING UNITS	1
1200	RESIDENTIAL MED DENSITY 2->5 DWELLING UNIT	1
1300	RESIDENTIAL HIGH DENSITY	1
1400	COMMERCIAL AND SERVICES	1
1500	INDUSTRIAL	1
1600	EXTRACTIVE	2
1650	RECLAIMED LAND	3
1700	INSTITUTIONAL	1
1800	RECREATIONAL	1, 2, 10, 12
1820	GOLF COURSES	1
1900	OPEN LAND	2
2100	CROPLAND AND PASTURELAND	2
2140	ROW CROPS	1
2200	TREE CROPS	1
2300	FEEDING OPERATIONS	2
2400	NURSERIES AND VINEYARDS	1
2500	SPECIALTY FARMS	1
2550	TROPICAL FISH FARMS	1
2600	OTHER OPEN LANDS <RURAL>	2
3100	HERBACEOUS	2
3200	SHRUB AND BRUSHLAND	2
3300	MIXED RANGELAND	2
4100	UPLAND CONIFEROUS FOREST	2
4110	PINE FLATWOODS	2
4120	LONGLEAF PINE - XERIC OAK	2
4200	UPLAND HARDWOOD FORESTS - PART 1	2
4340	HARDWOOD CONIFER MIXED	2
4400	TREE PLANTATIONS	2
5100	STREAMS AND WATERWAYS	11, 15, 16, 17, 18
5200	LAKES	15
5300	RESERVOIRS	15, 18
5400	BAYS AND ESTUARIES	11, 15, 16, 17, 18
5720	GULF OF MEXICO	13, 19
6100	WETLAND HARDWOOD FORESTS	3, 7
6110	BAY SWAMPS	3
6120	MANGROVE SWAMPS	9
6150	STREAM AND LAKE SWAMPS (BOTTOMLAND)	3, 6, 7, 23
6200	WETLAND CONIFEROUS FORESTS	3, 23
6210	CYPRESS	4
6300	WETLAND FORESTED MIXED	3
6400	VEGETATED NON-FORESTED WETLANDS	3
6410	FRESHWATER MARSHES	5
6420	SALTWATER MARSHES	7, 8
6430	WET PRAIRIES	3, 4, 5, 7, 20
6440	EMERGENT AQUATIC VEGETATION	5
6510	TIDAL FLATS / SUBMERGED SHALLOW PLATFORM	11
6520	SHORELINES	22
6530	INTERMITTENT PONDS	15

FLUCCS CODE	FLUCCS Description	SLAMM CODE
6600	SALT FLATS	20
7100	BEACHES OTHER THAN SWIMMING BEACHES	10, 12
7200	SAND OTHER THAN BEACHES	10
7400	DISTURBED LAND	2
8100	TRANSPORTATION	1
8200	COMMUNICATIONS	1
8300	UTILITIES	1
9113	PATCHY SEAGRASS	11
9116	CONTINUOUS SEAGRASS	11
9121	ALGAE BEDS	11

APPENDIX C:

Climate Change Storylines Described in the Special Report on Emissions Scenarios (SRES; IPCC 2007b)

A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil-intensive (A1FI), non-fossil energy sources (A1T) or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1. The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

APPENDIX D:

Maps Depicting Changes in Critical Coastal Habitat Distribution Relative to Various Sea Level Rise Scenarios as Estimated by the SLAMM in Each of the Major Bay Segments of Tampa Bay

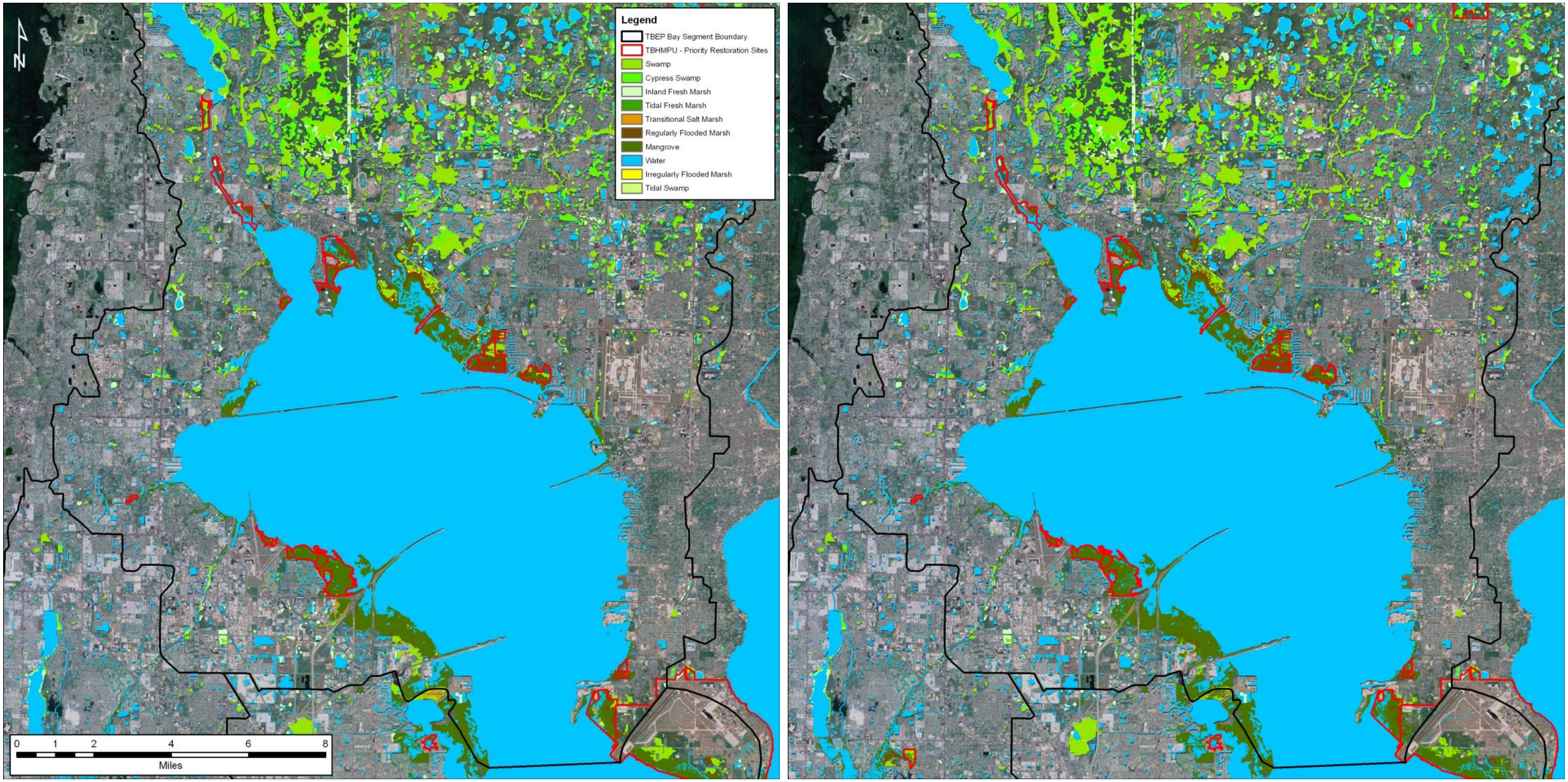


Figure OTB-1: Comparison of current (2007, left) coastal habitat conditions in Old Tampa Bay relative to a 0.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

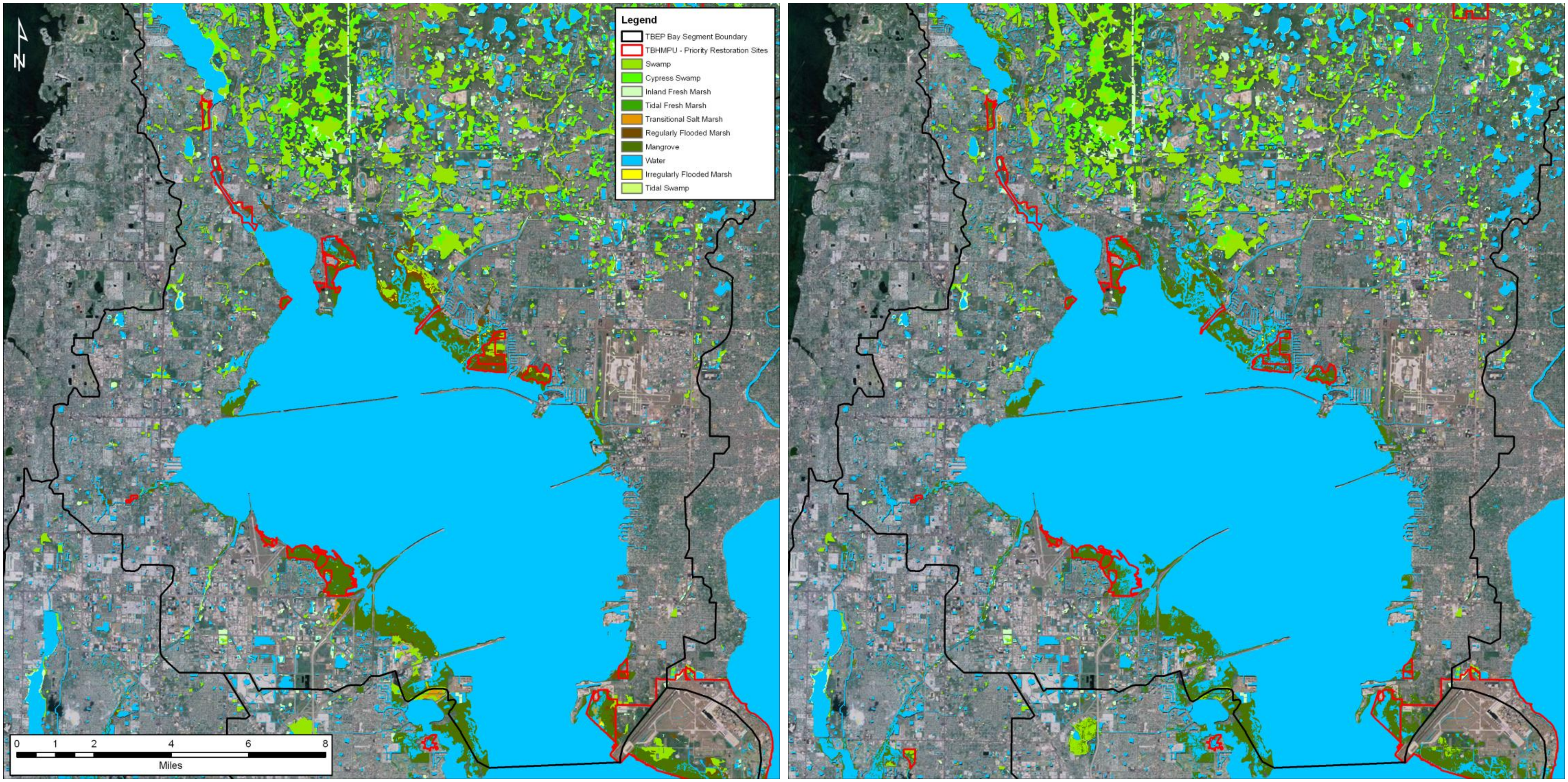


Figure OTB-2: Comparison of current (2007, left) coastal habitat conditions in Old Tampa Bay relative to a 1.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

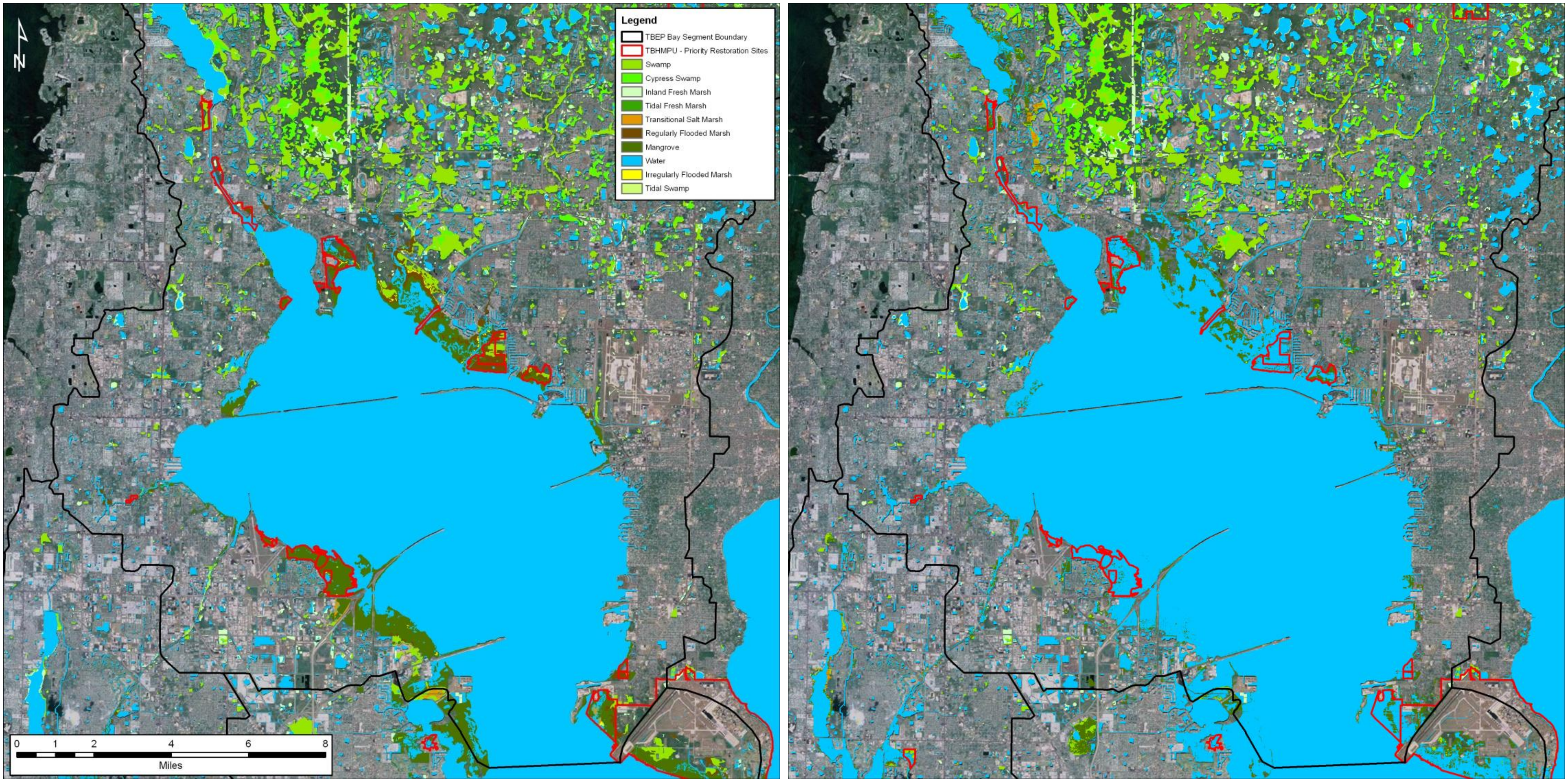


Figure OTB-3: Comparison of current (2007, left) coastal habitat conditions in Old Tampa Bay relative to a 1.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

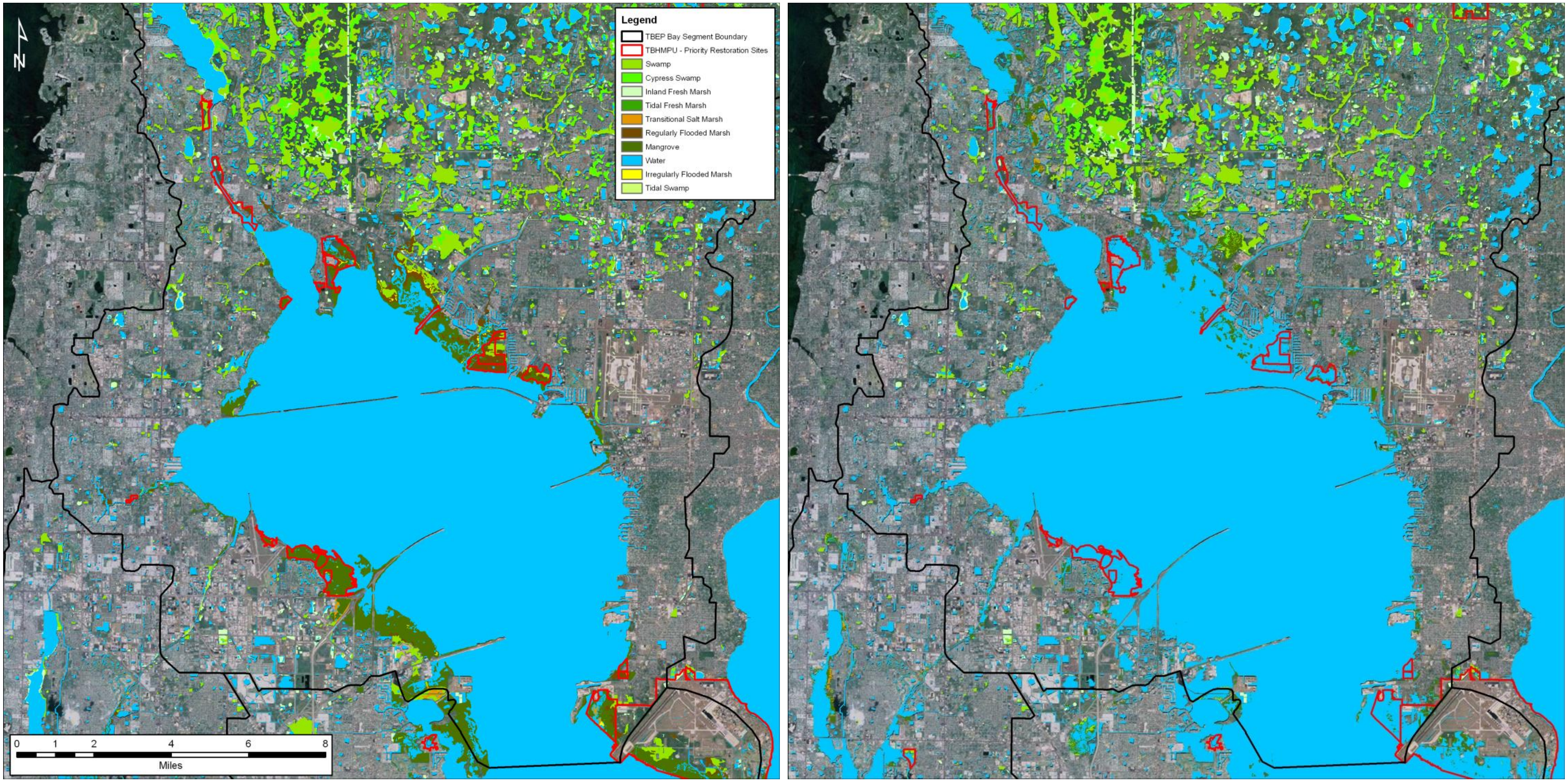


Figure OTB-4: Comparison of current (2007, left) coastal habitat conditions in Old Tampa Bay relative to a 2.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

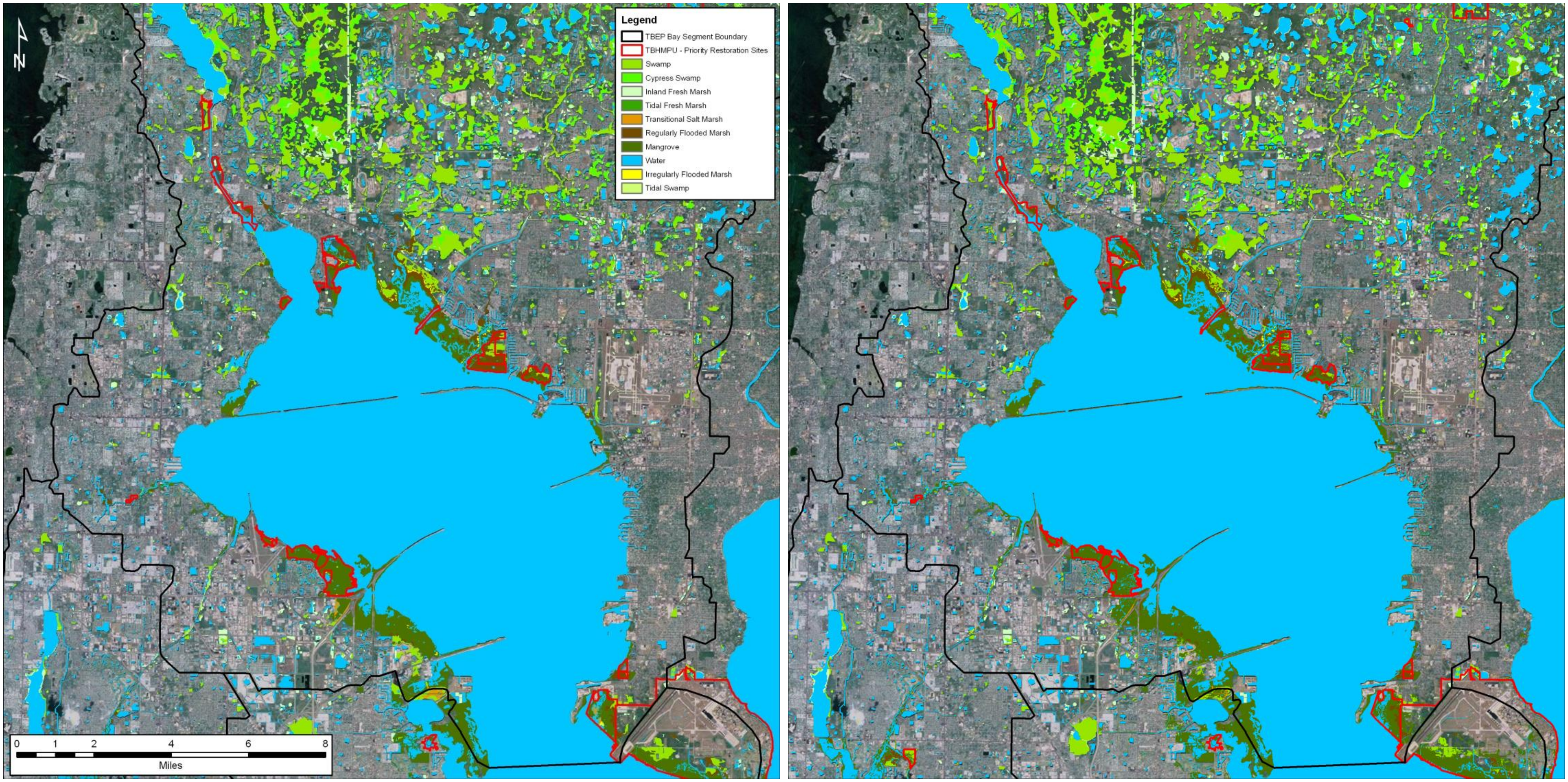


Figure OTB-5: Comparison of current (2007, left) coastal habitat conditions in Old Tampa Bay relative to a 0.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

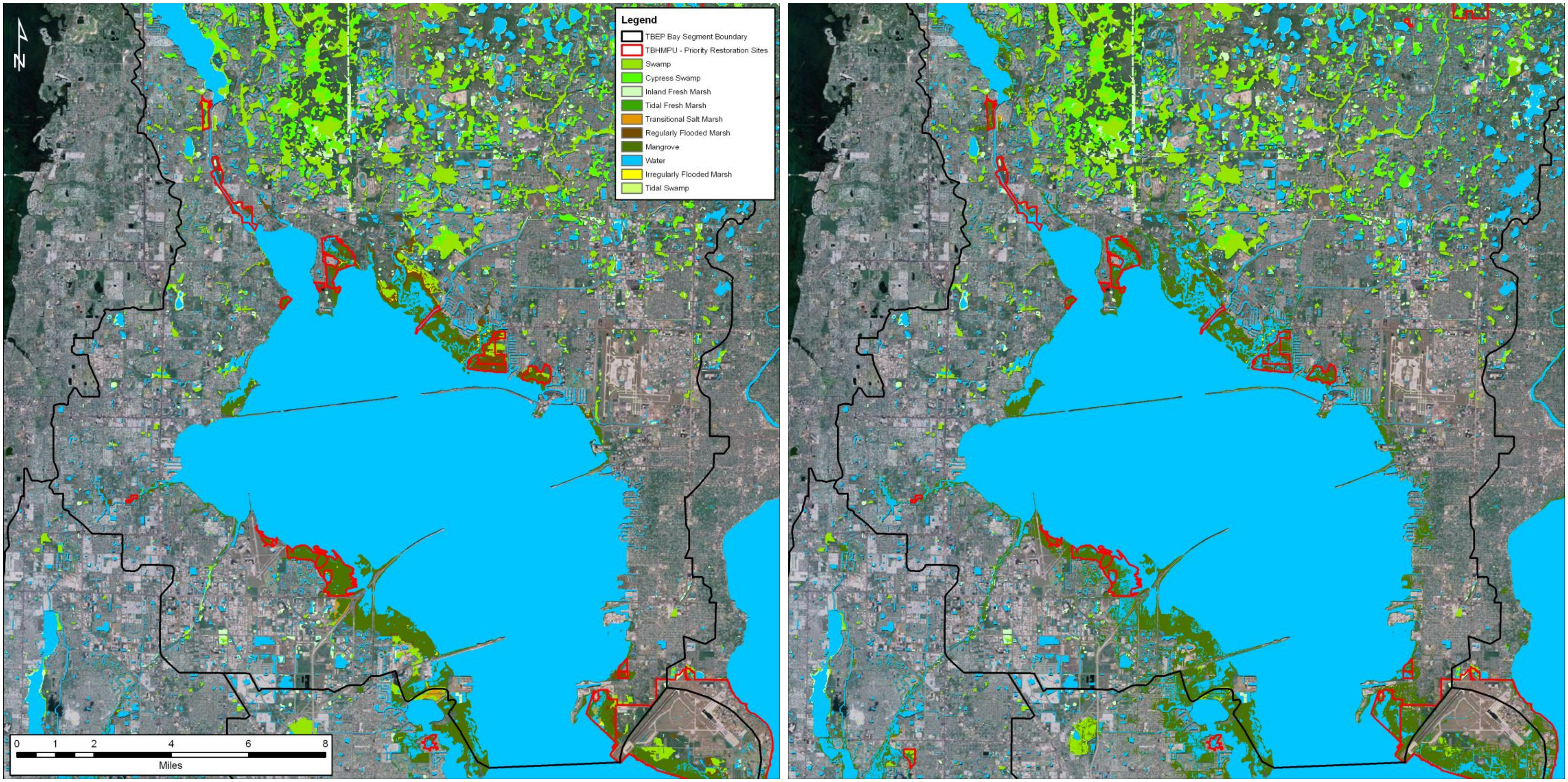


Figure OTB-6: Comparison of current (2007, left) coastal habitat conditions in Old Tampa Bay relative to a 1.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

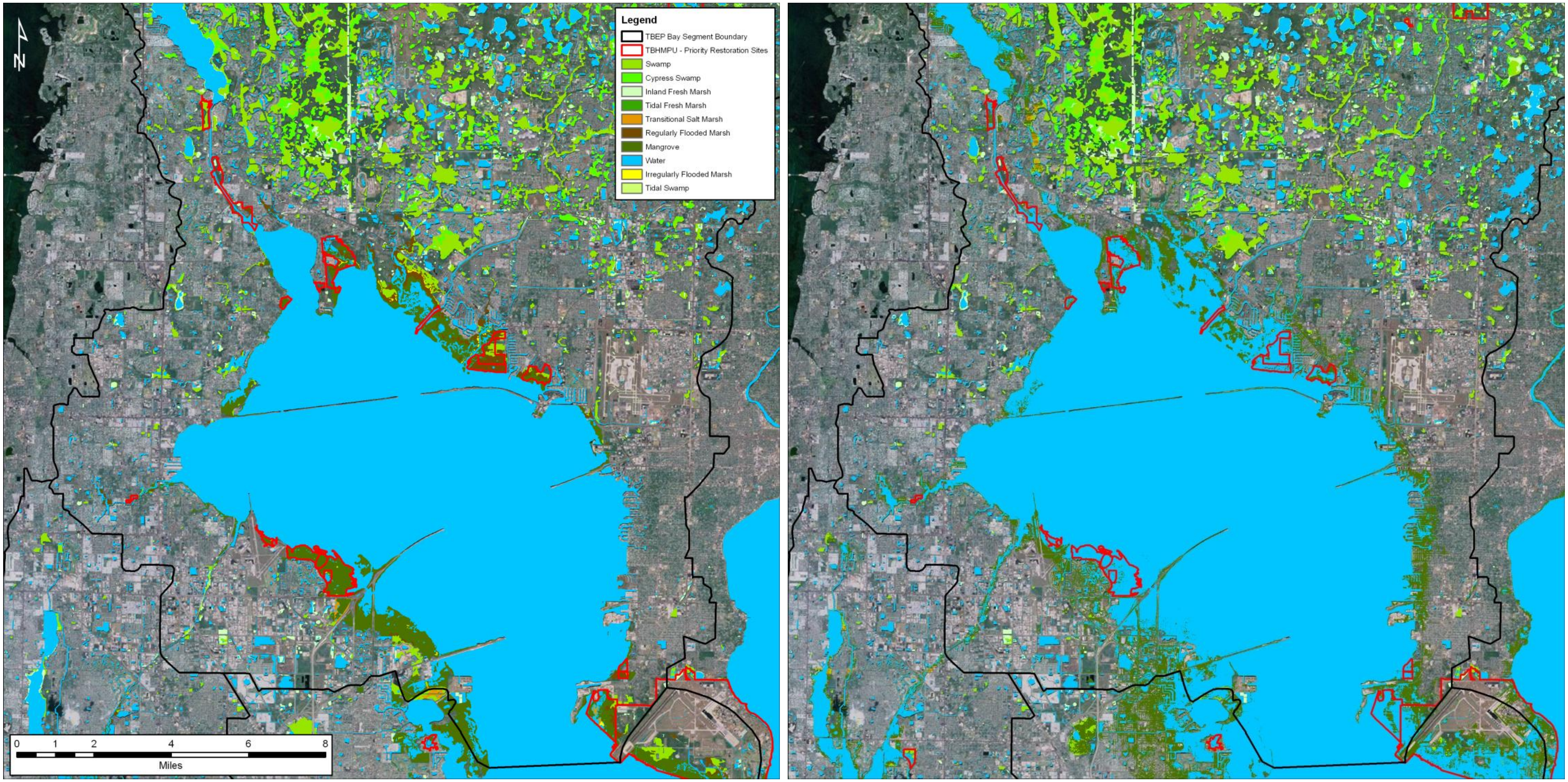


Figure OTB-7: Comparison of current (2007, left) coastal habitat conditions in Old Tampa Bay relative to a 1.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

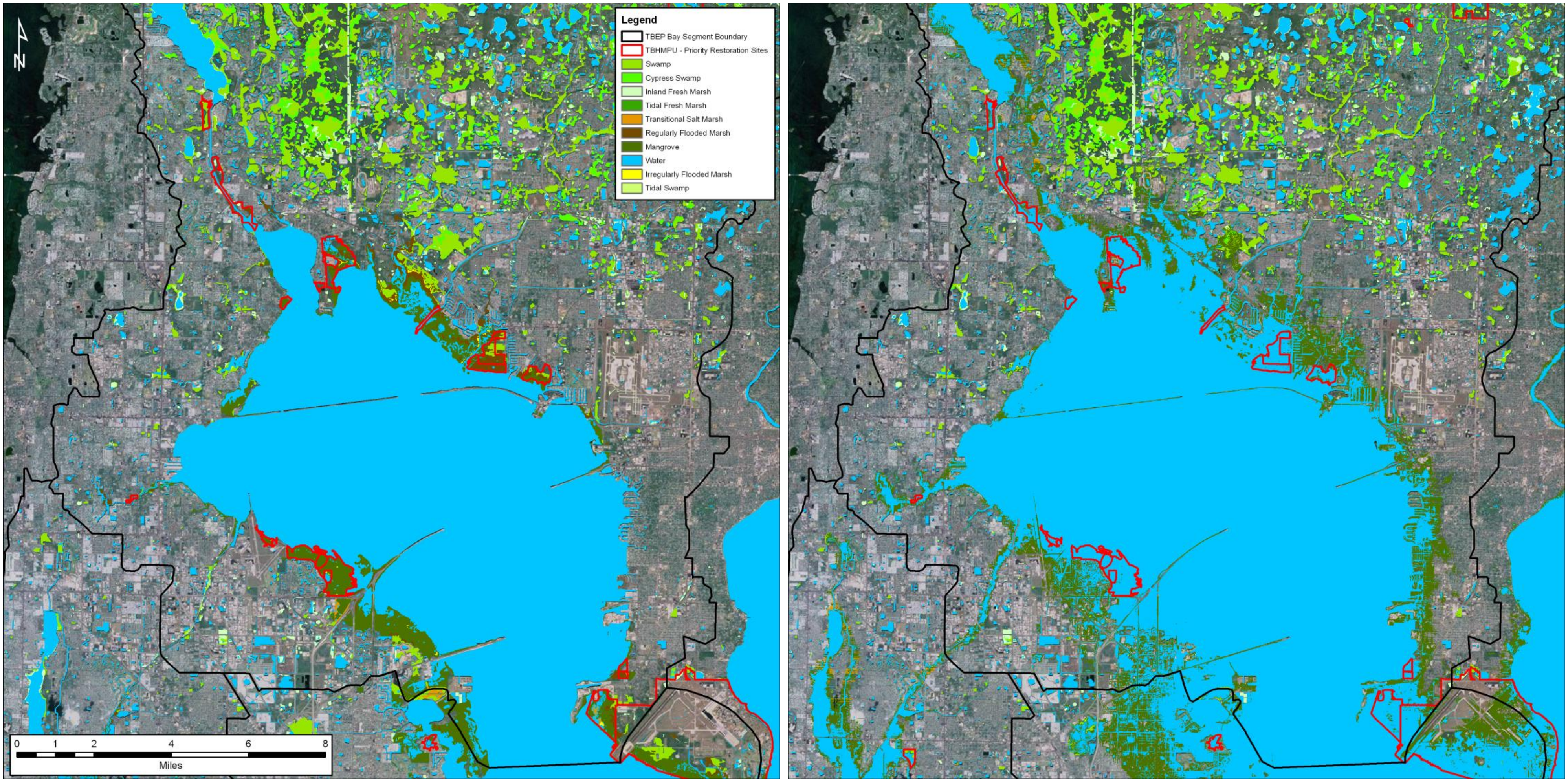


Figure OTB-8: Comparison of current (2007, left) coastal habitat conditions in Old Tampa Bay relative to a 2.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

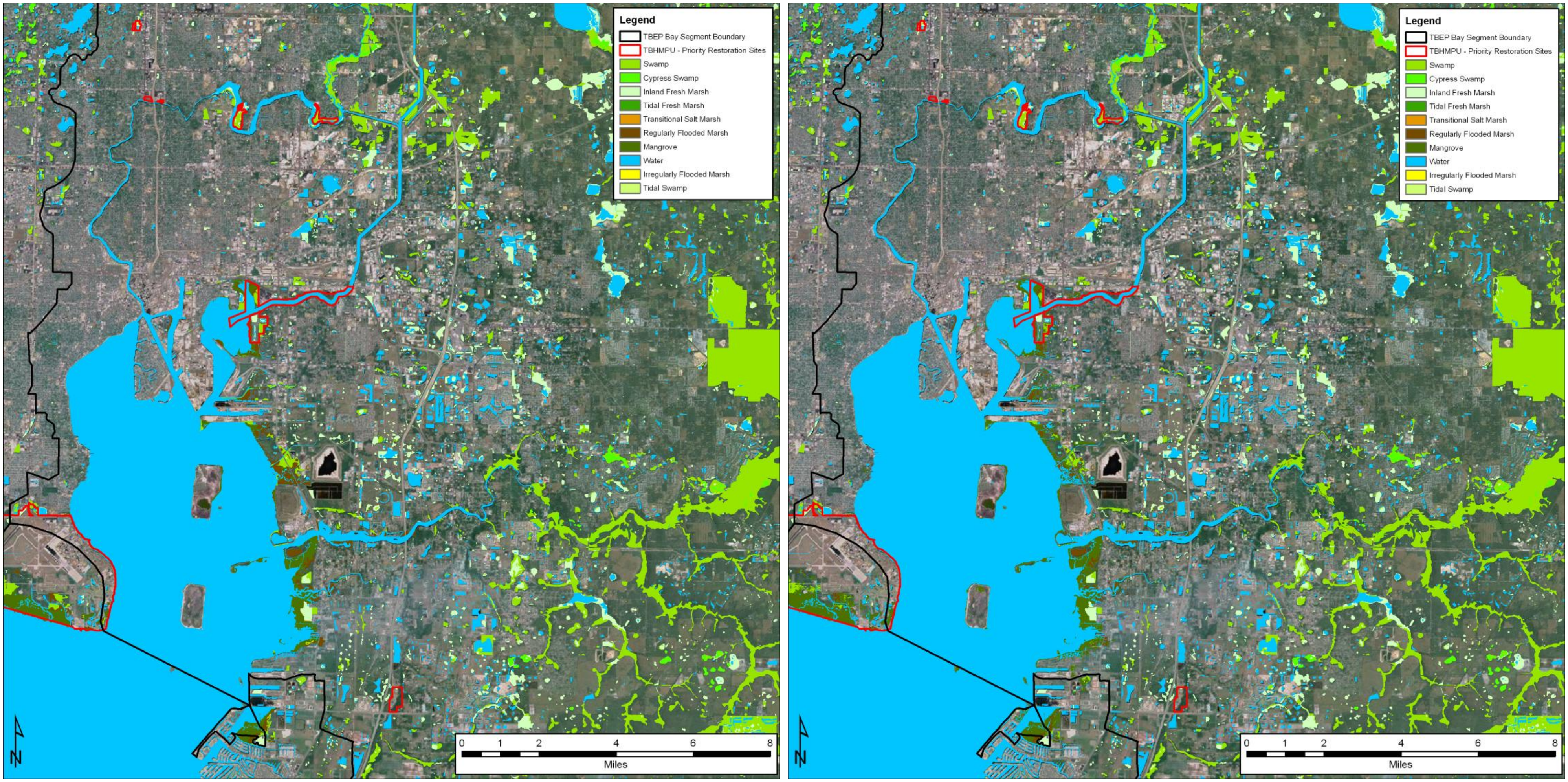


Figure HB-1: Comparison of current (2007, left) coastal habitat conditions in Hillsborough Bay relative to a 0.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

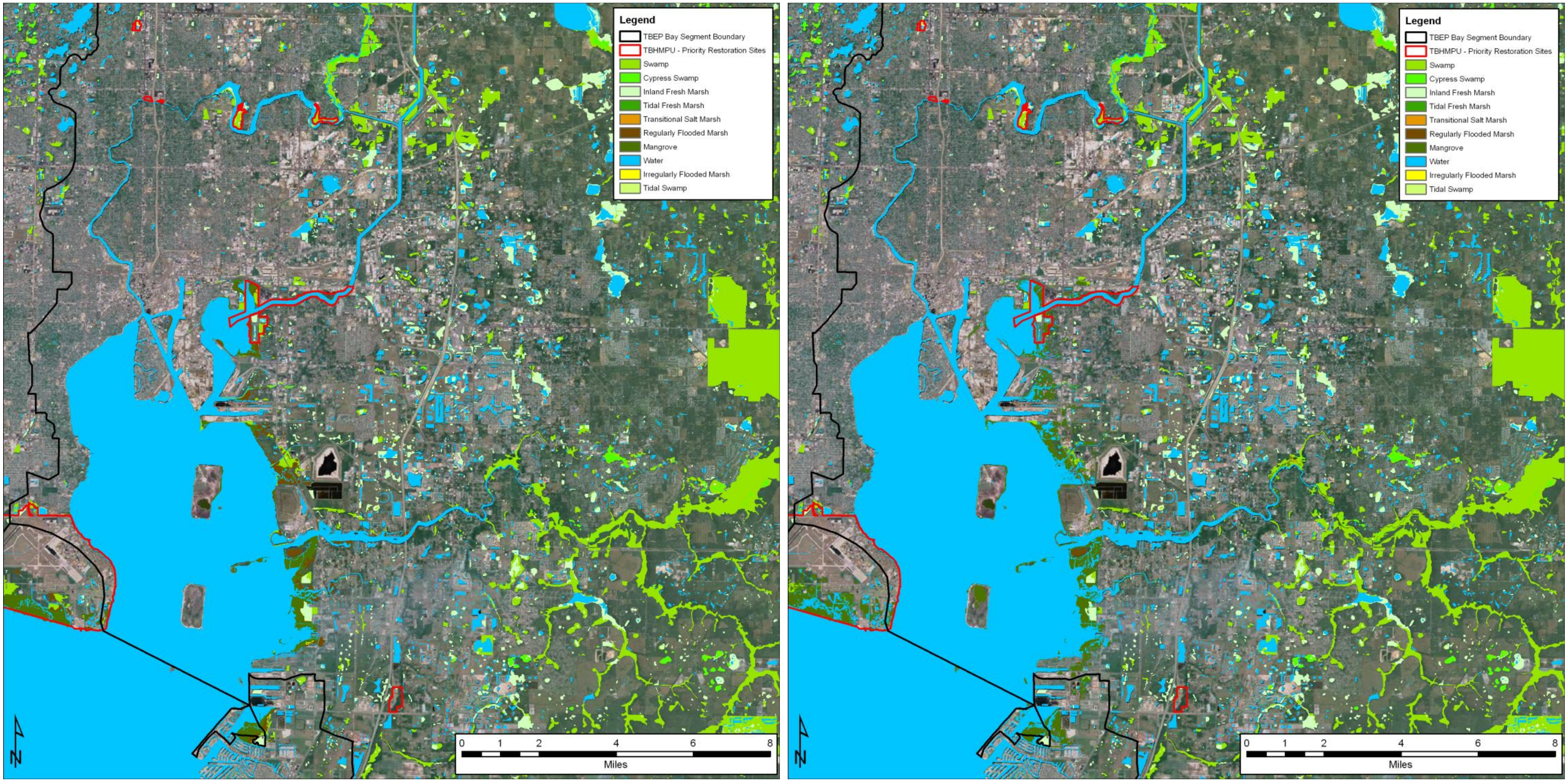


Figure HB-2: Comparison of current (2007, left) coastal habitat conditions in Hillsborough Bay relative to a 1.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

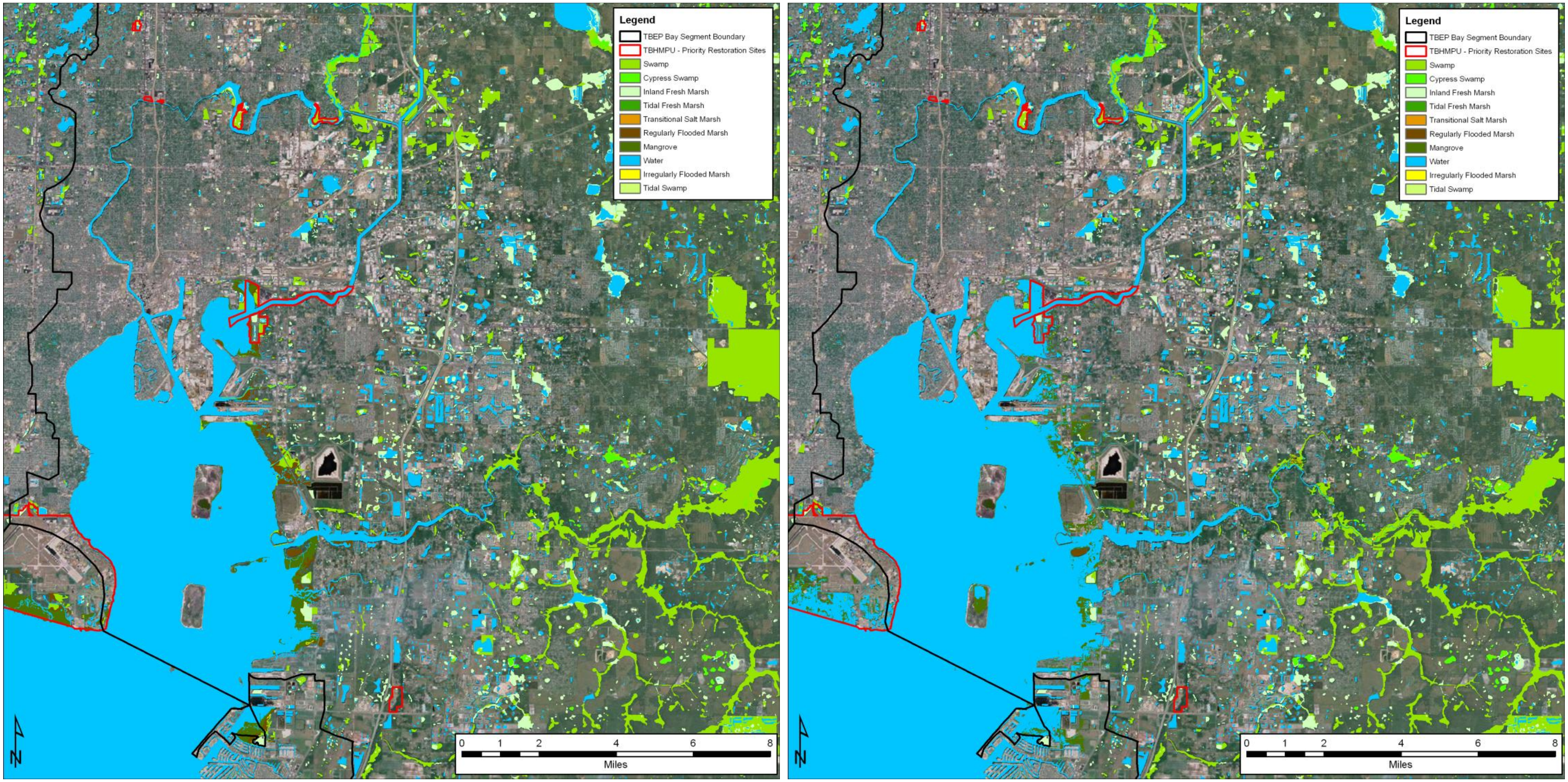


Figure HB-3: Comparison of current (2007, left) coastal habitat conditions in Hillsborough Bay relative to a 1.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

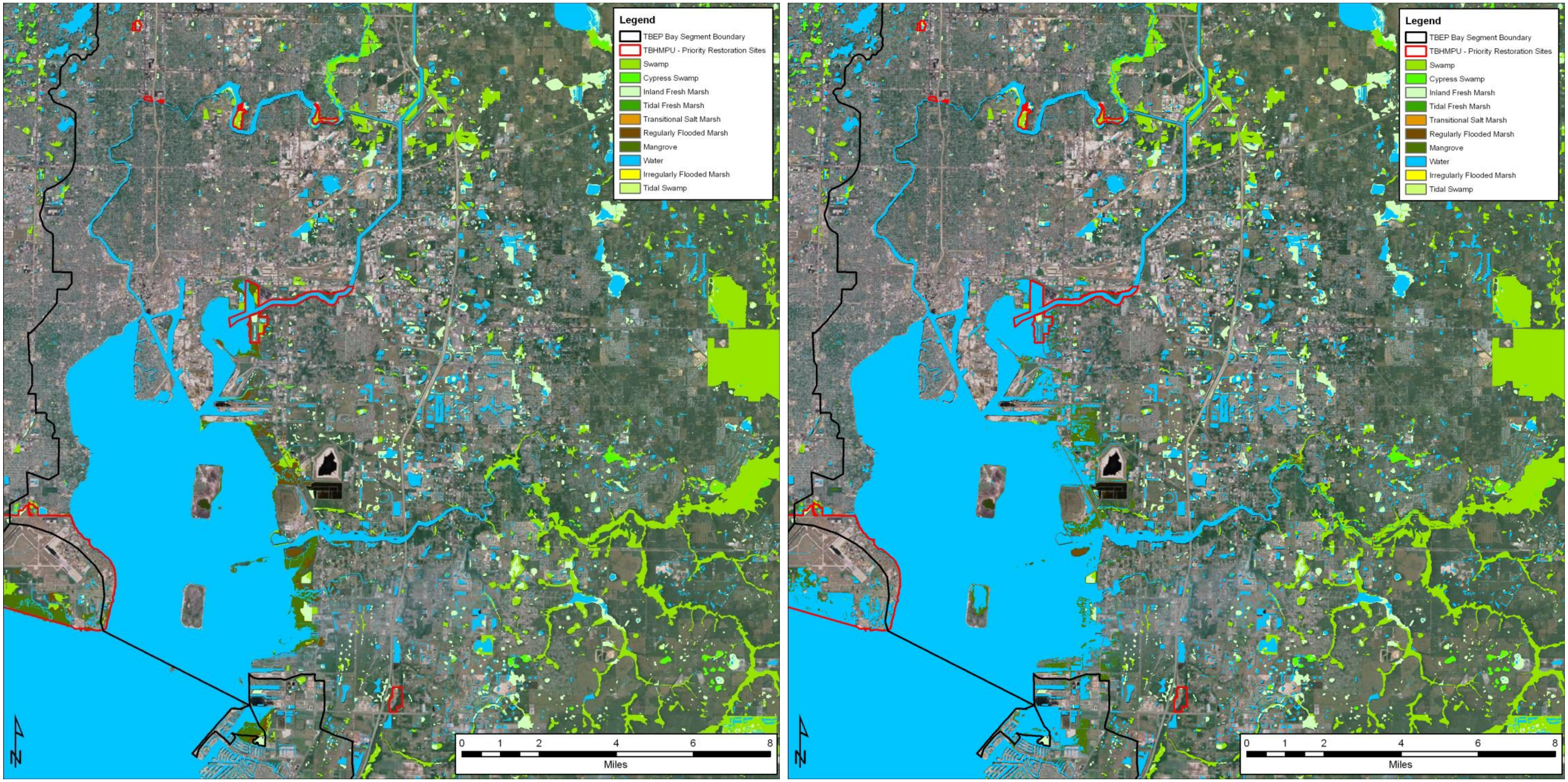


Figure HB-4: Comparison of current (2007, left) coastal habitat conditions in Hillsborough Bay relative to a 2.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

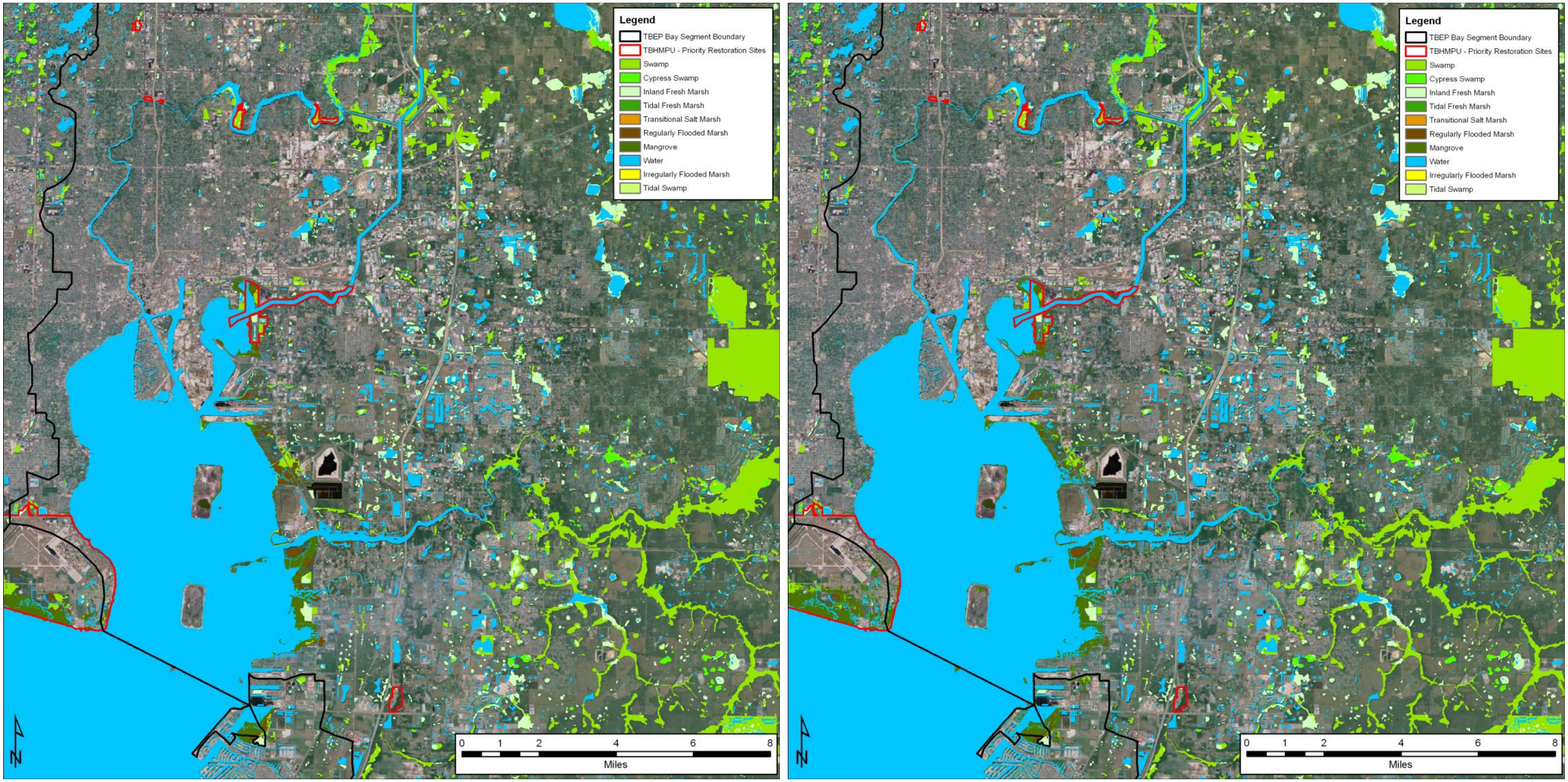


Figure HB-5: Comparison of current (2007, left) coastal habitat conditions in Hillsborough Bay relative to a 0.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

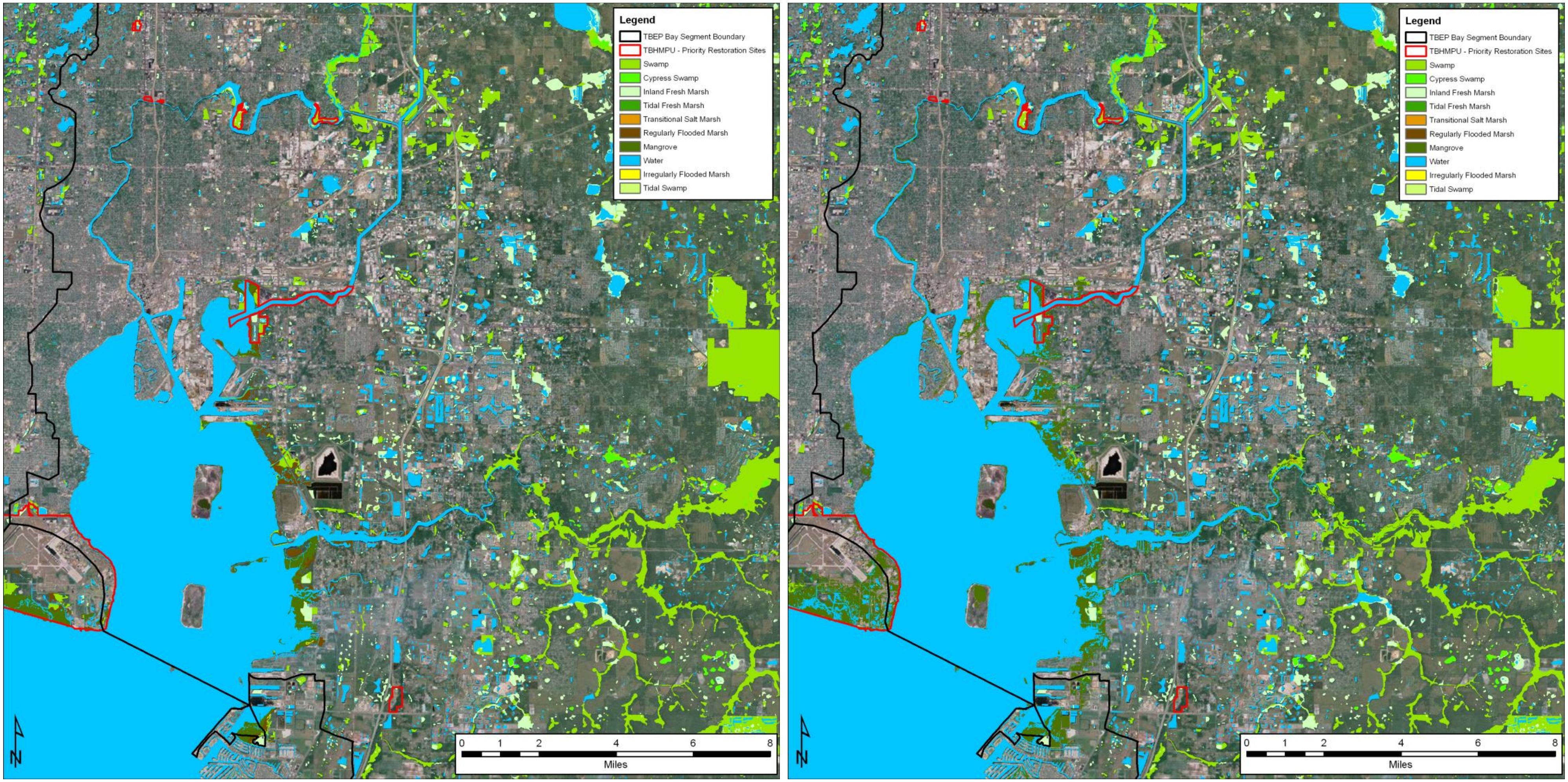


Figure HB-6: Comparison of current (2007, left) coastal habitat conditions in Hillsborough Bay relative to a 1.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

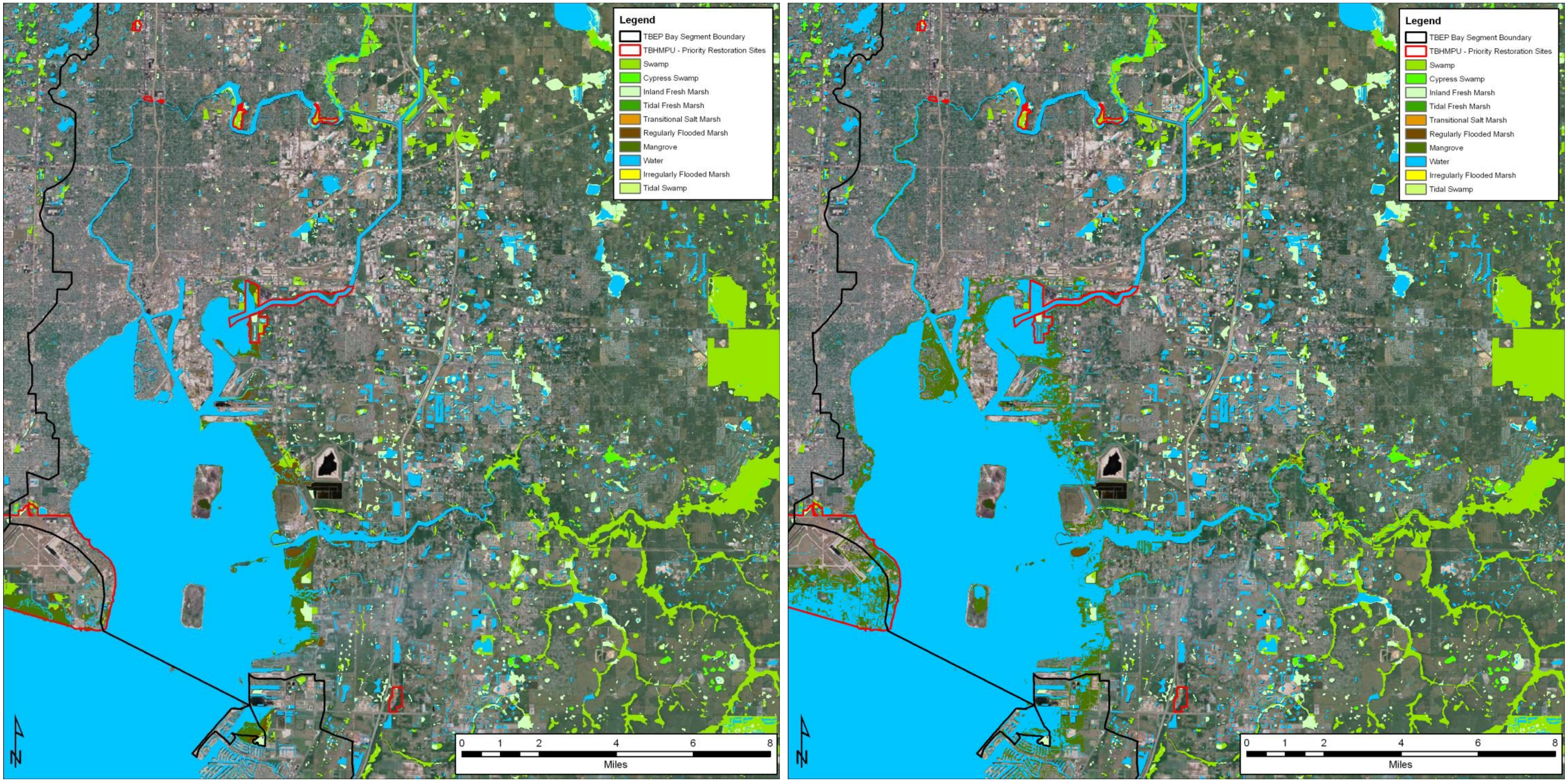


Figure HB-7: Comparison of current (2007, left) coastal habitat conditions in Hillsborough Bay relative to a 1.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

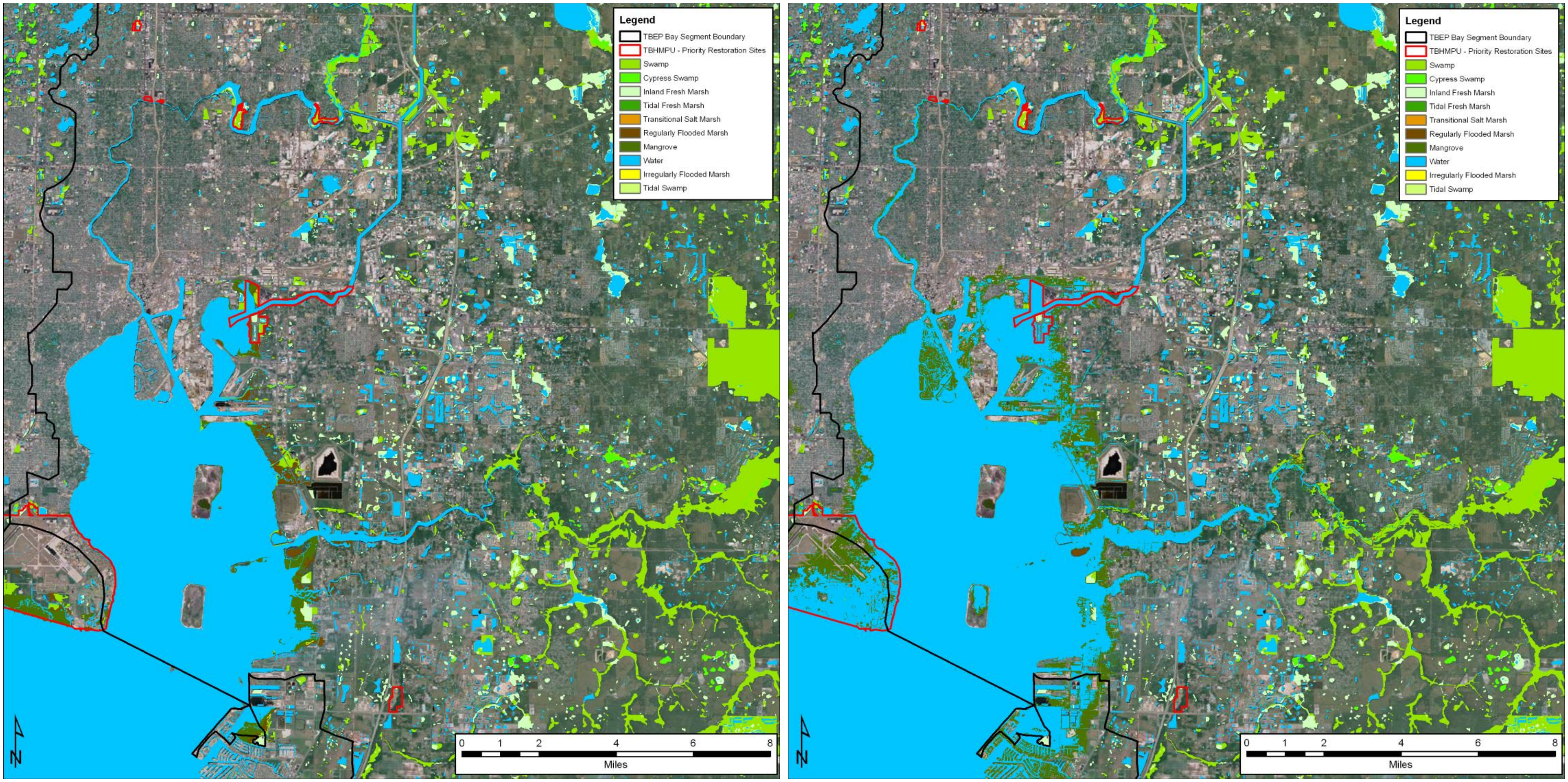


Figure HB-8: Comparison of current (2007, left) coastal habitat conditions in Hillsborough Bay relative to a 2.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

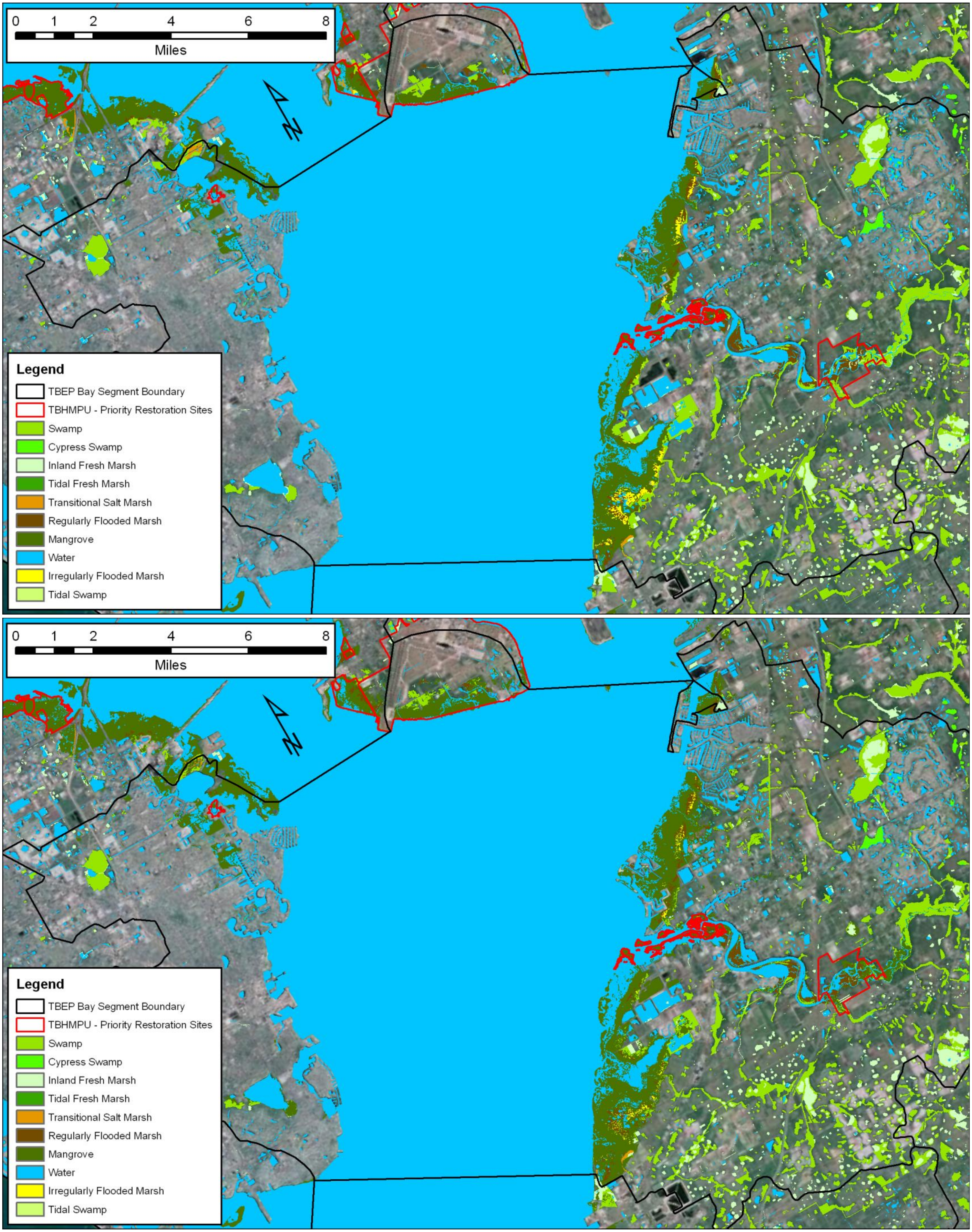


Figure MTB-1: Comparison of current (2007, left) coastal habitat conditions in Middle Tampa Bay relative to a 0.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

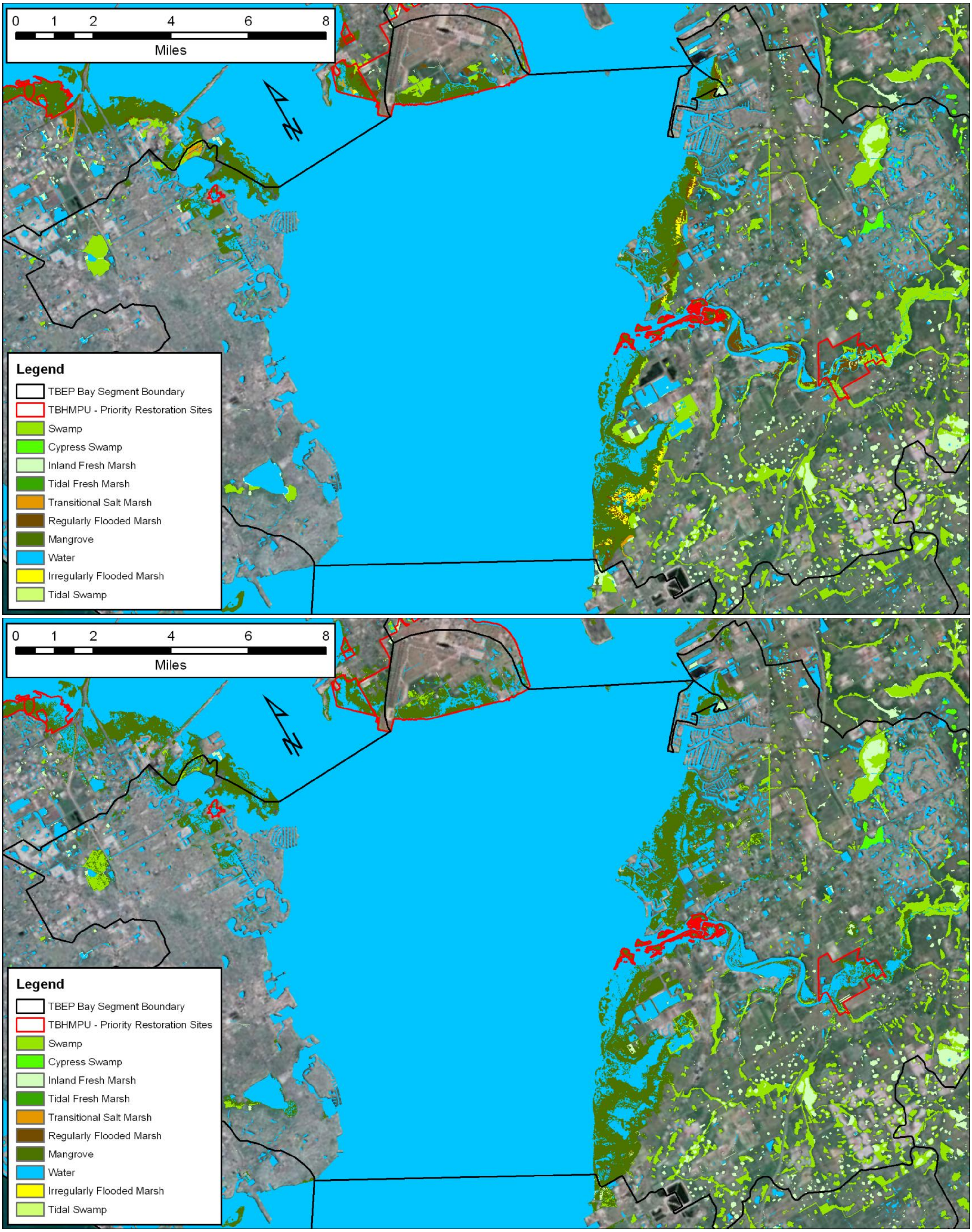


Figure MTB-2: Comparison of current (2007, left) coastal habitat conditions in Middle Tampa Bay relative to a 1.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

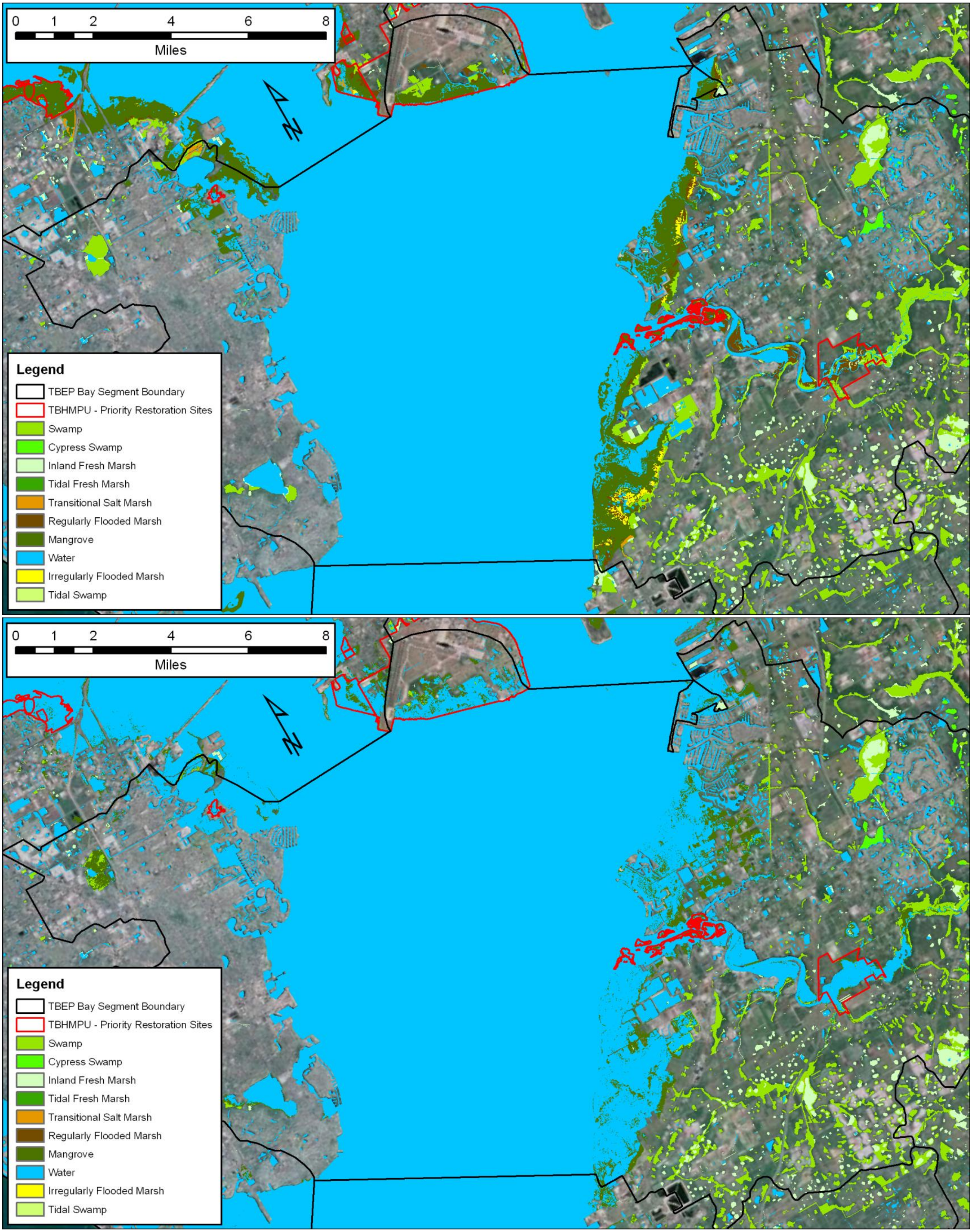


Figure MTB-3: Comparison of current (2007, left) coastal habitat conditions in Middle Tampa Bay relative to a 1.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

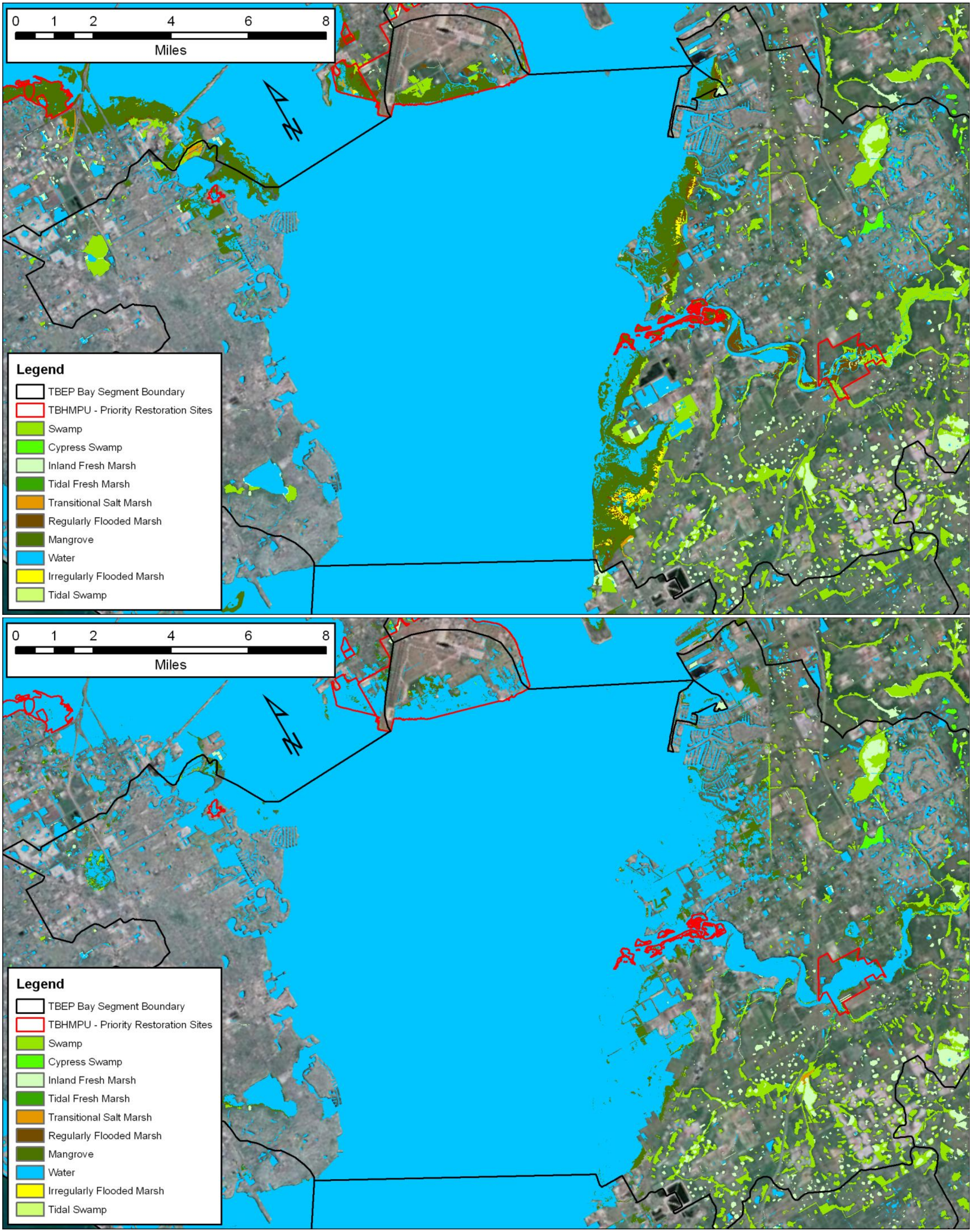


Figure MTB-4: Comparison of current (2007, left) coastal habitat conditions in Middle Tampa Bay relative to a 2.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

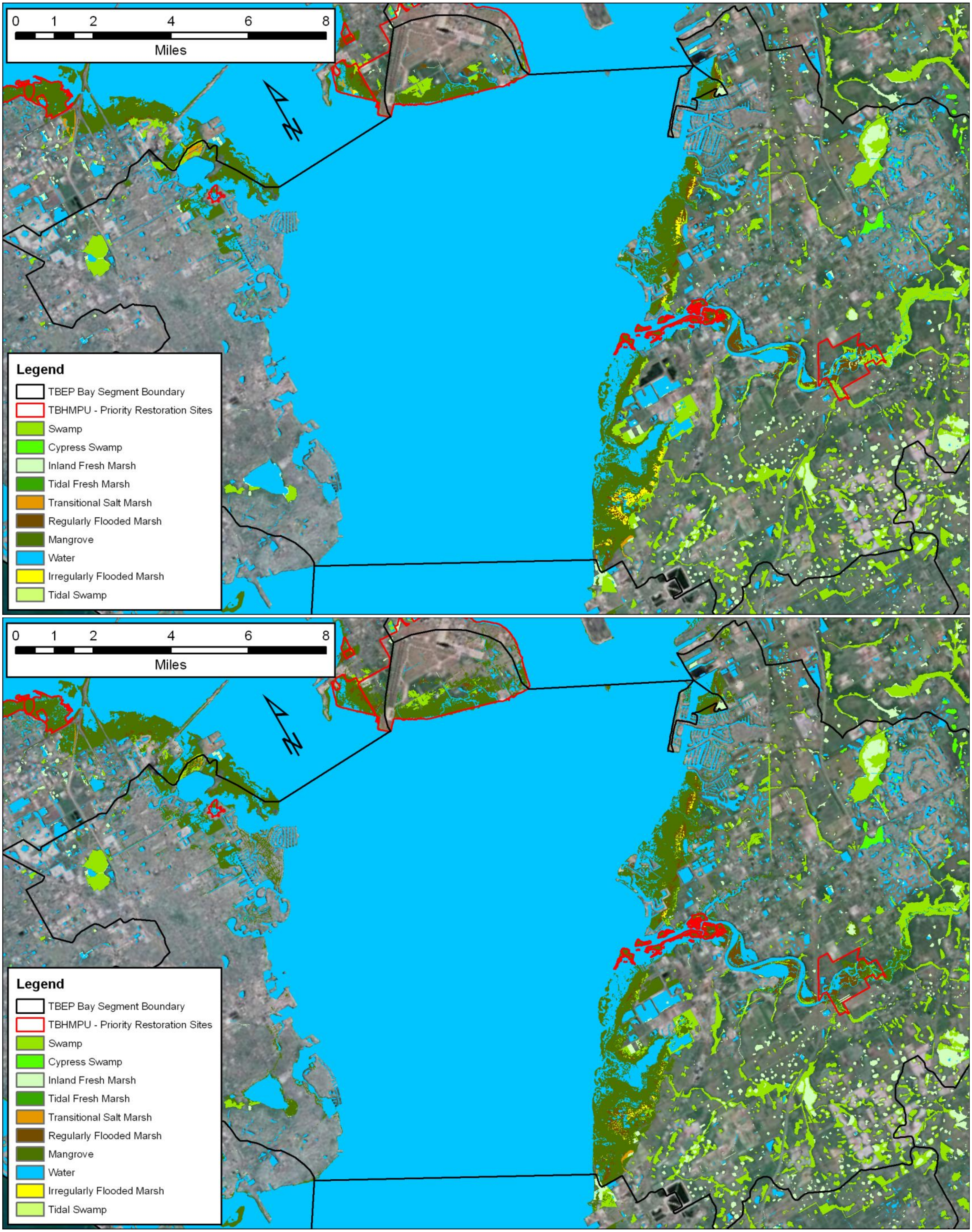
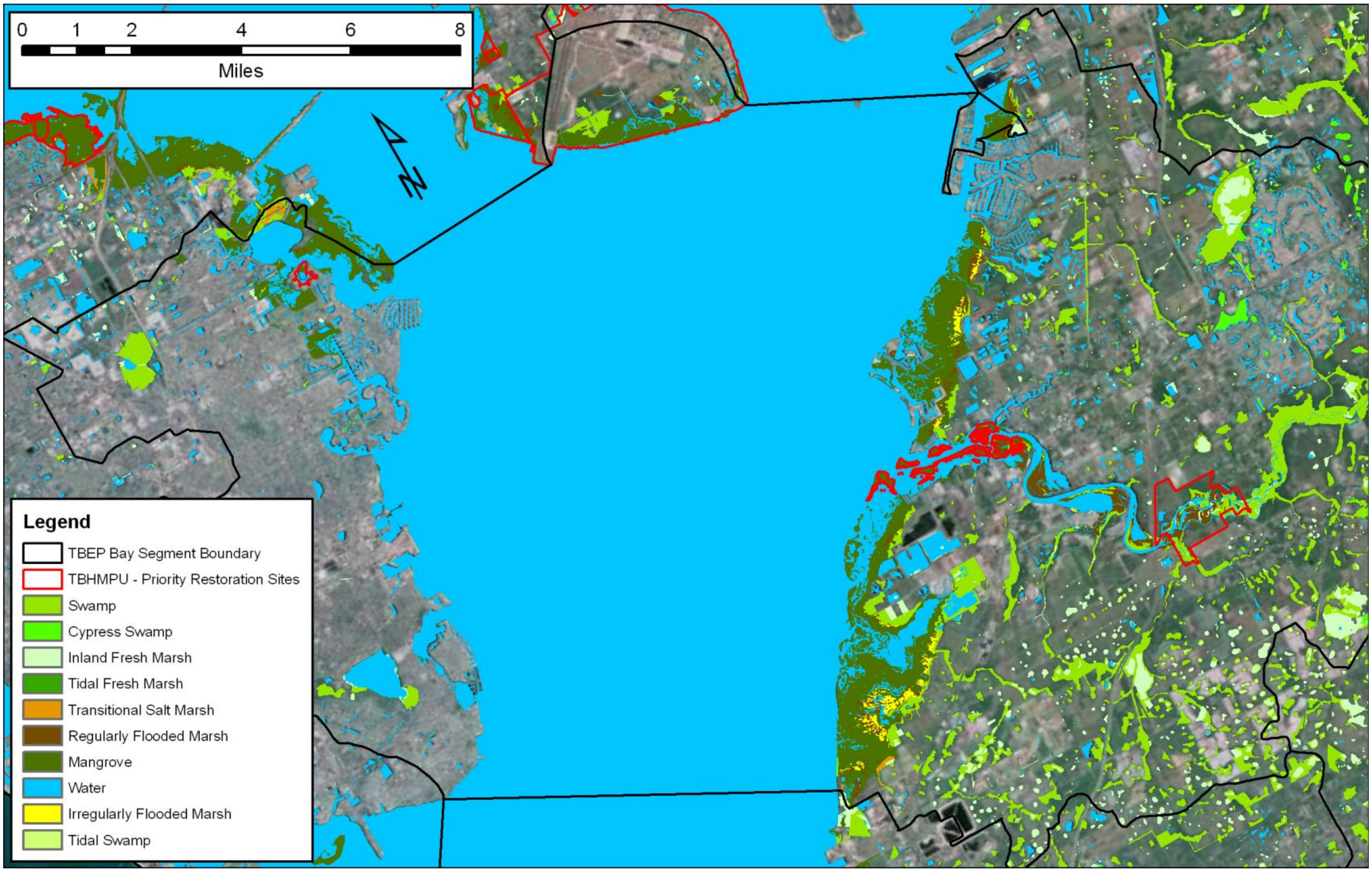


Figure MTB-5: Comparison of current (2007, left) coastal habitat conditions in Middle Tampa Bay relative to a 0.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).



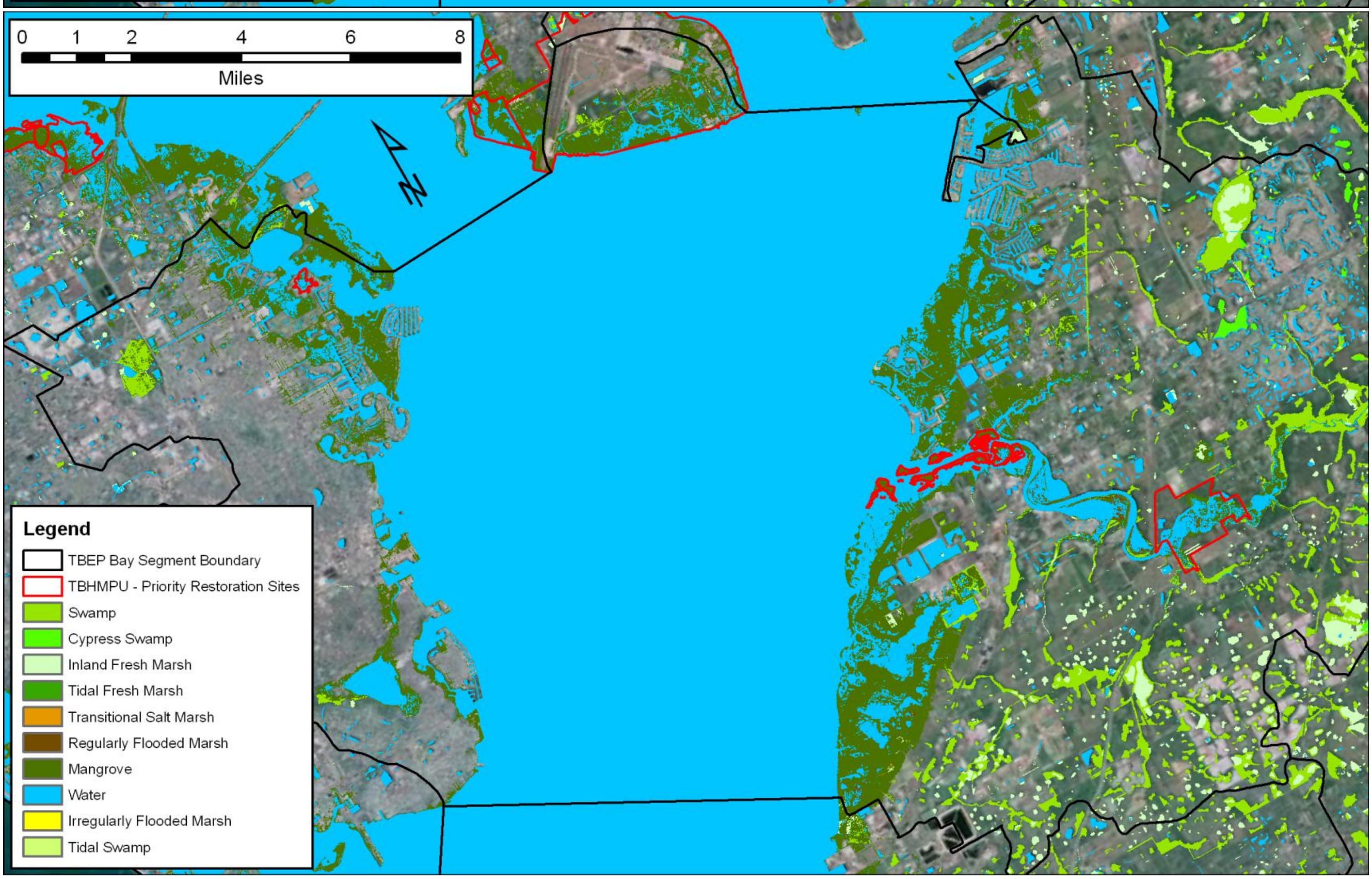
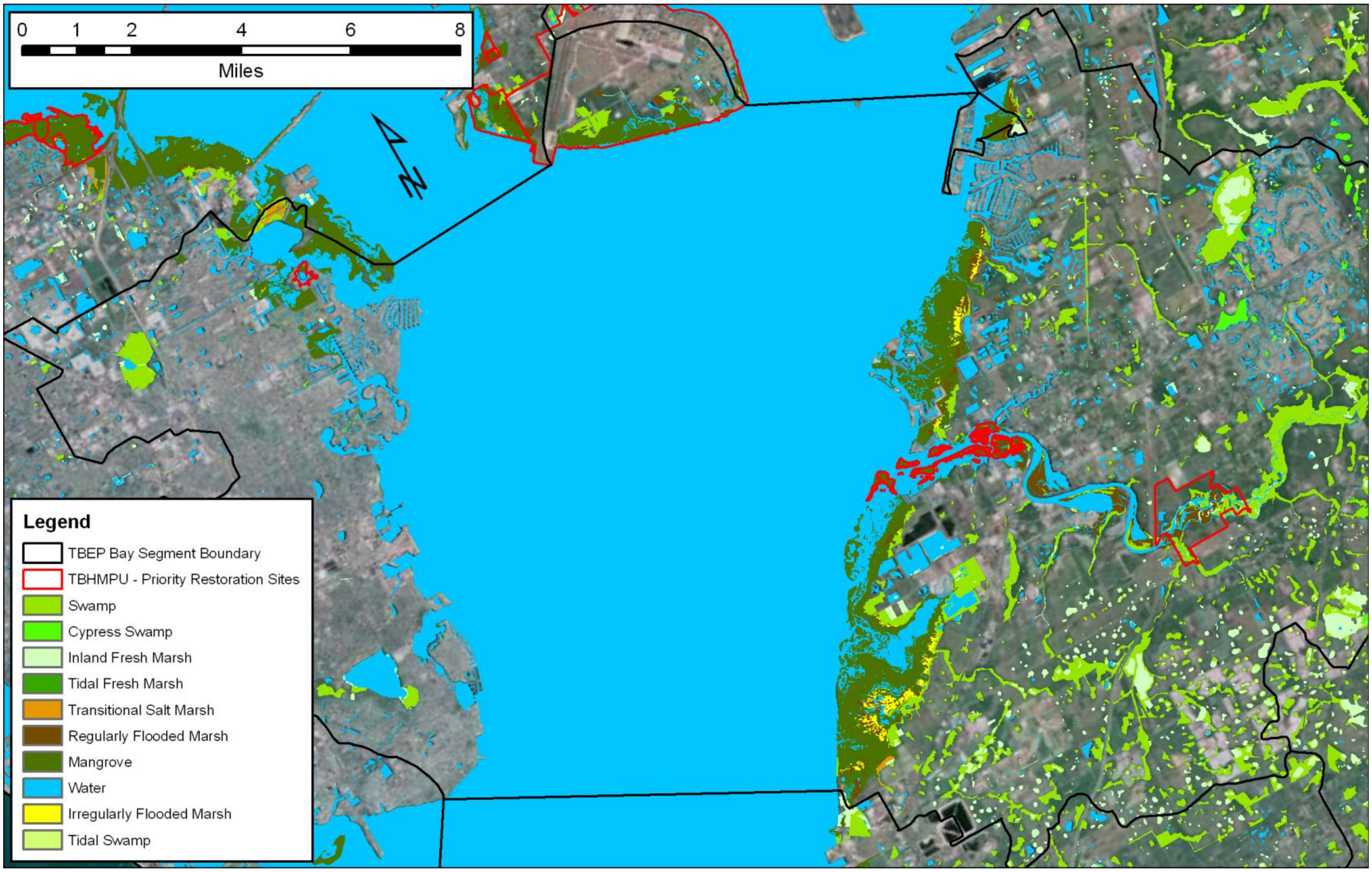


Figure MTB-6: Comparison of current (2007, left) coastal habitat conditions in Middle Tampa Bay relative to a 1.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).



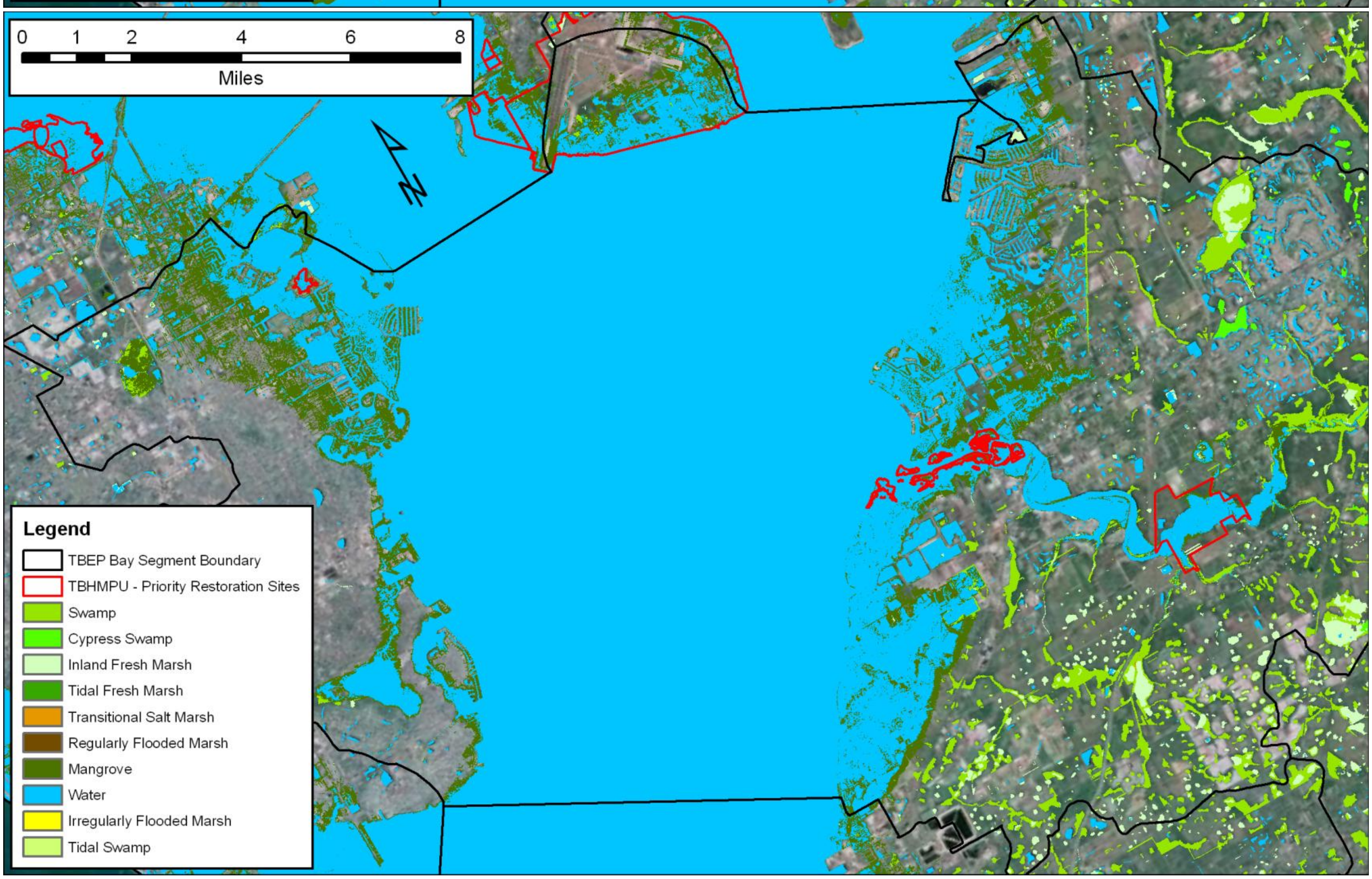
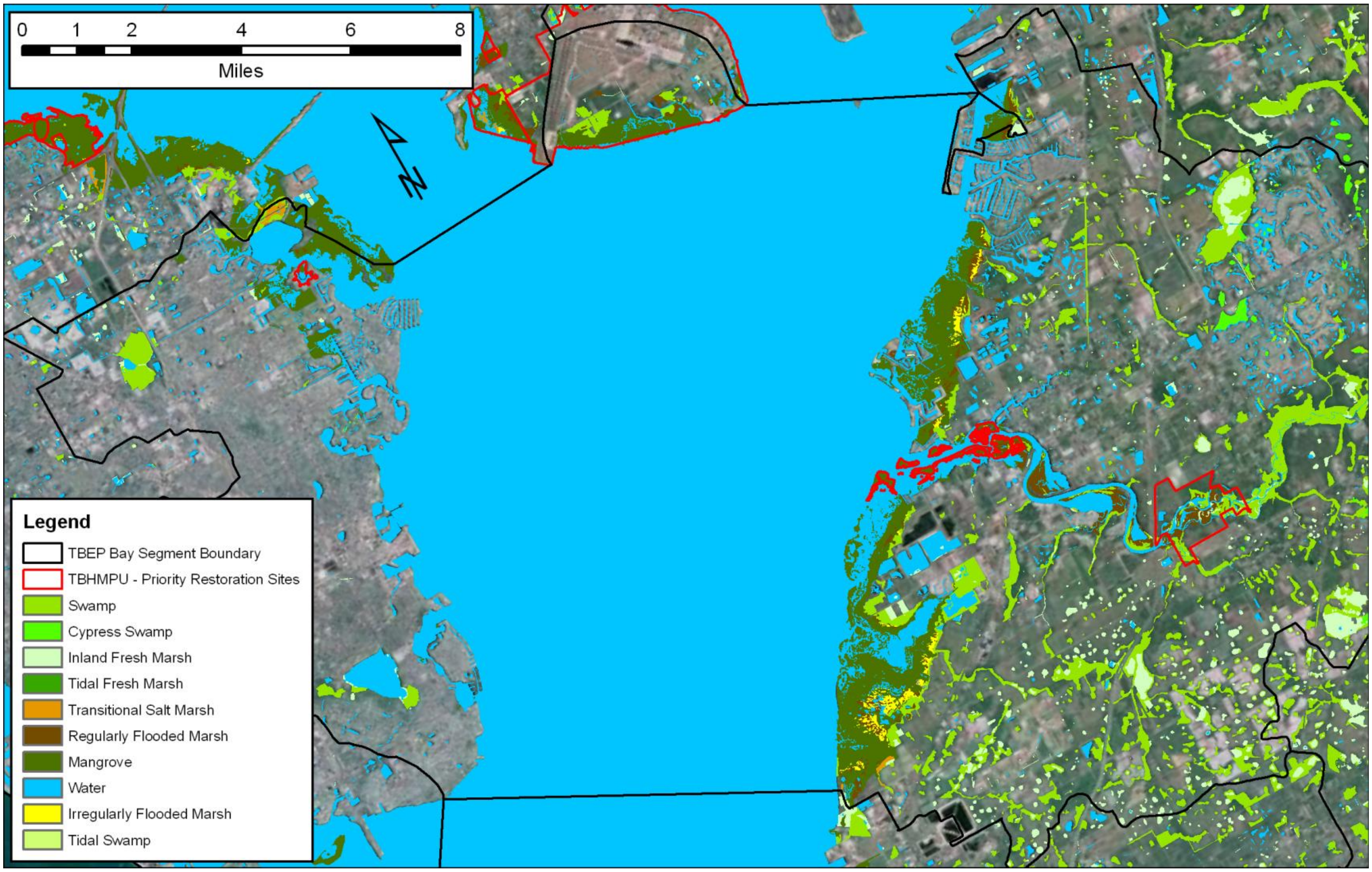


Figure MTB-7: Comparison of current (2007, left) coastal habitat conditions in Middle Tampa Bay relative to a 1.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).



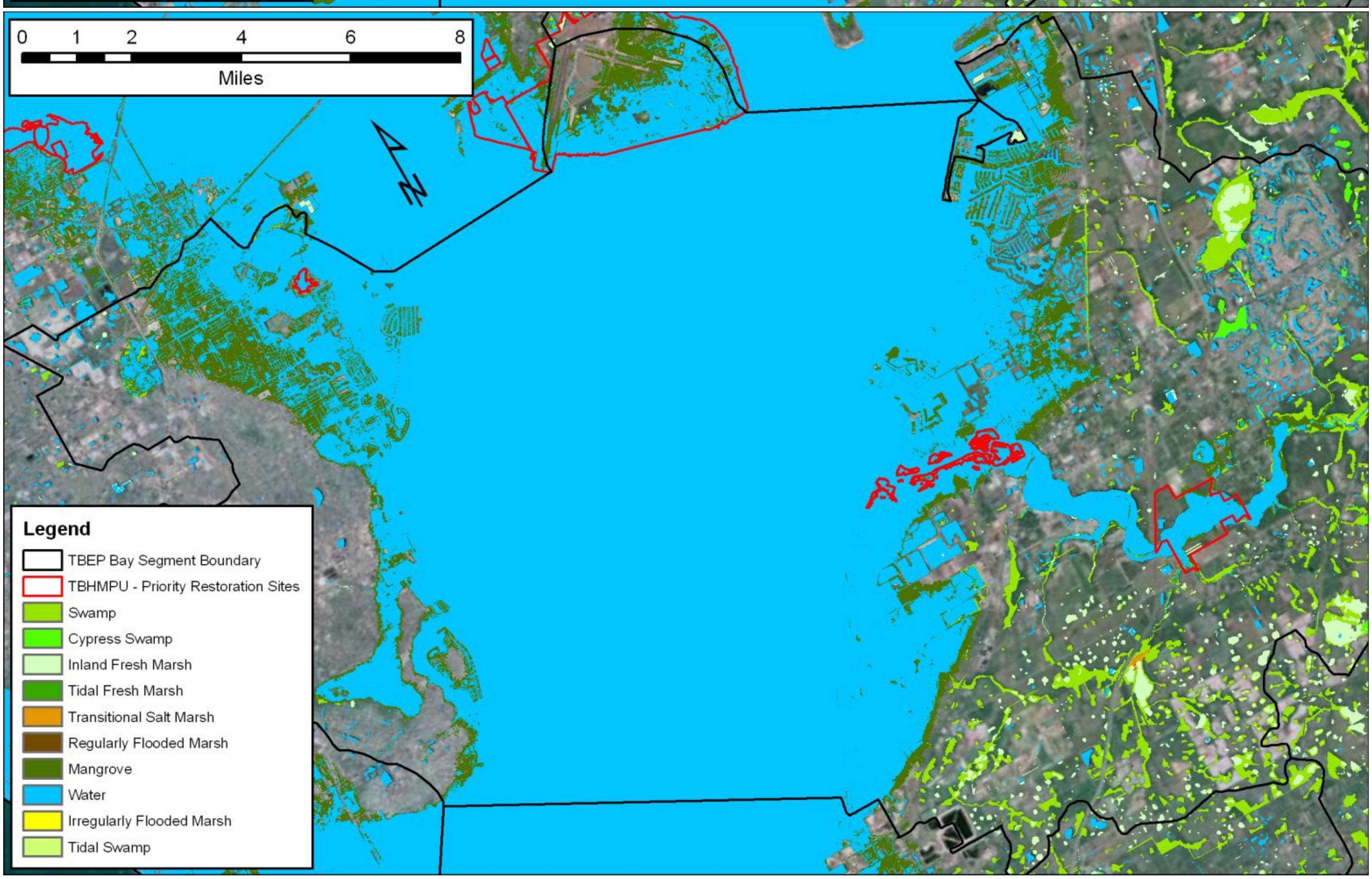


Figure MTB-8: Comparison of current (2007, left) coastal habitat conditions in Middle Tampa Bay relative to a 2.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

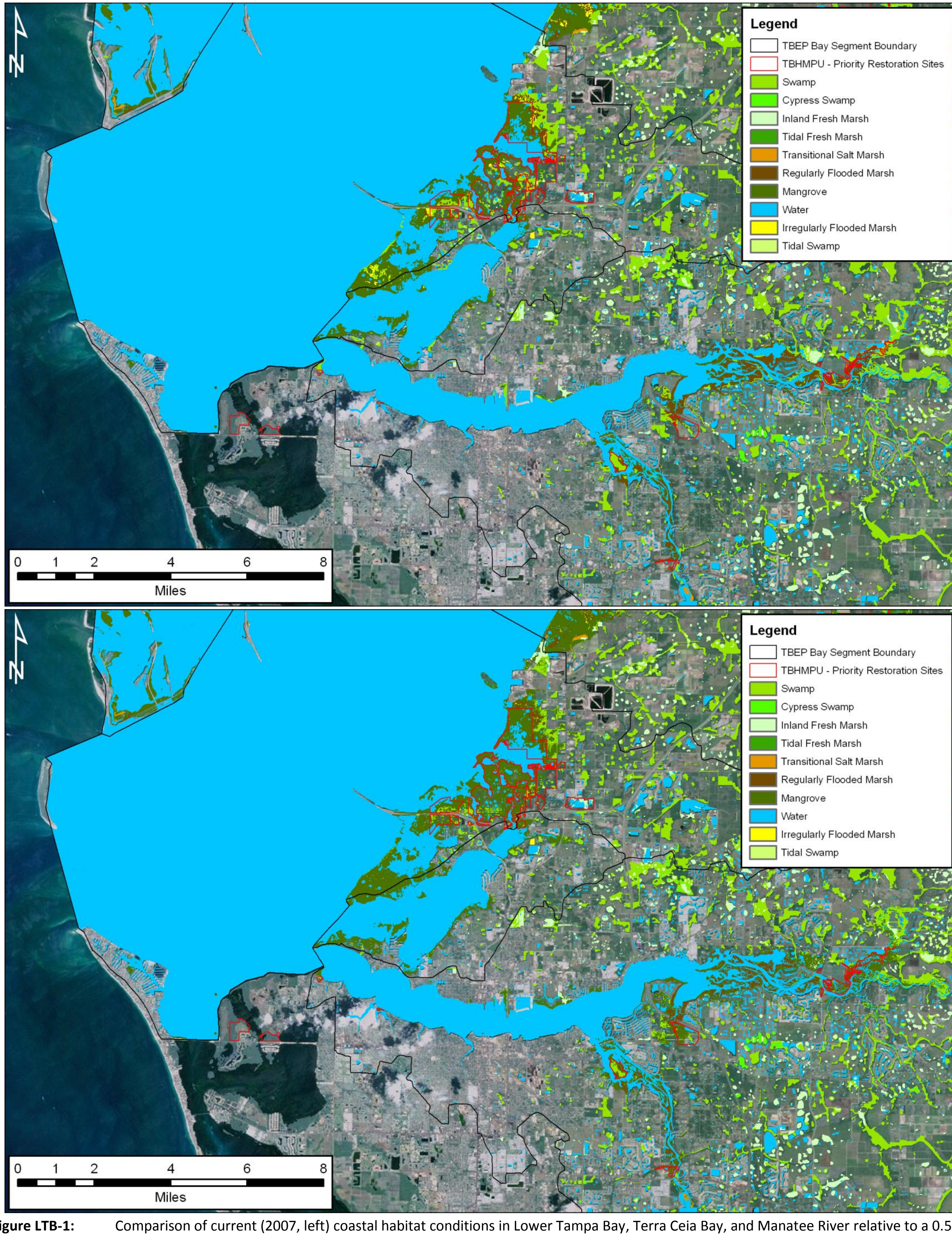


Figure LTB-1: Comparison of current (2007, left) coastal habitat conditions in Lower Tampa Bay, Terra Ceia Bay, and Manatee River relative to a 0.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

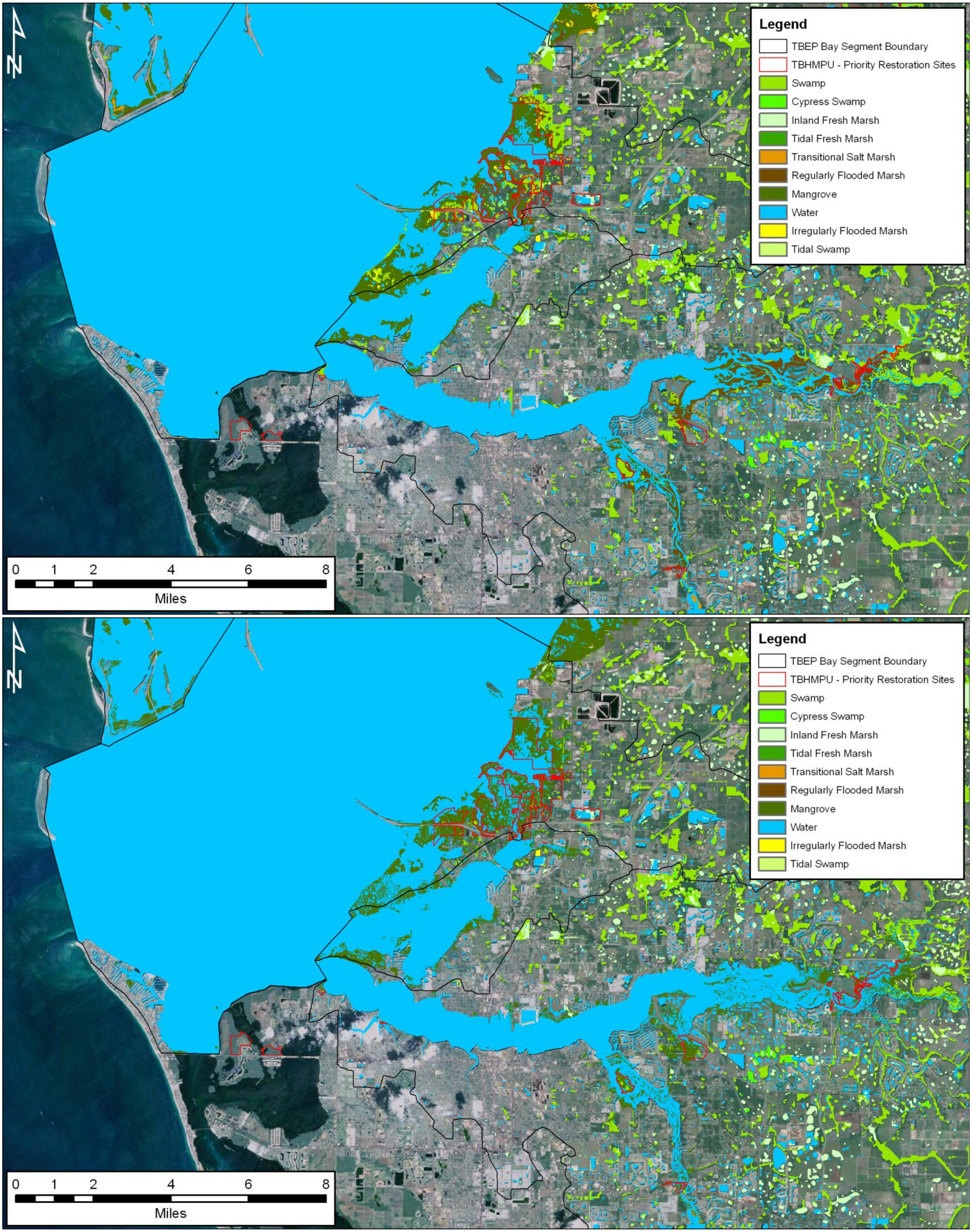


Figure LTB-2: Comparison of current (2007, left) coastal habitat conditions in Lower Tampa Bay, Terra Ceia Bay, and Manatee River relative to a 1.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

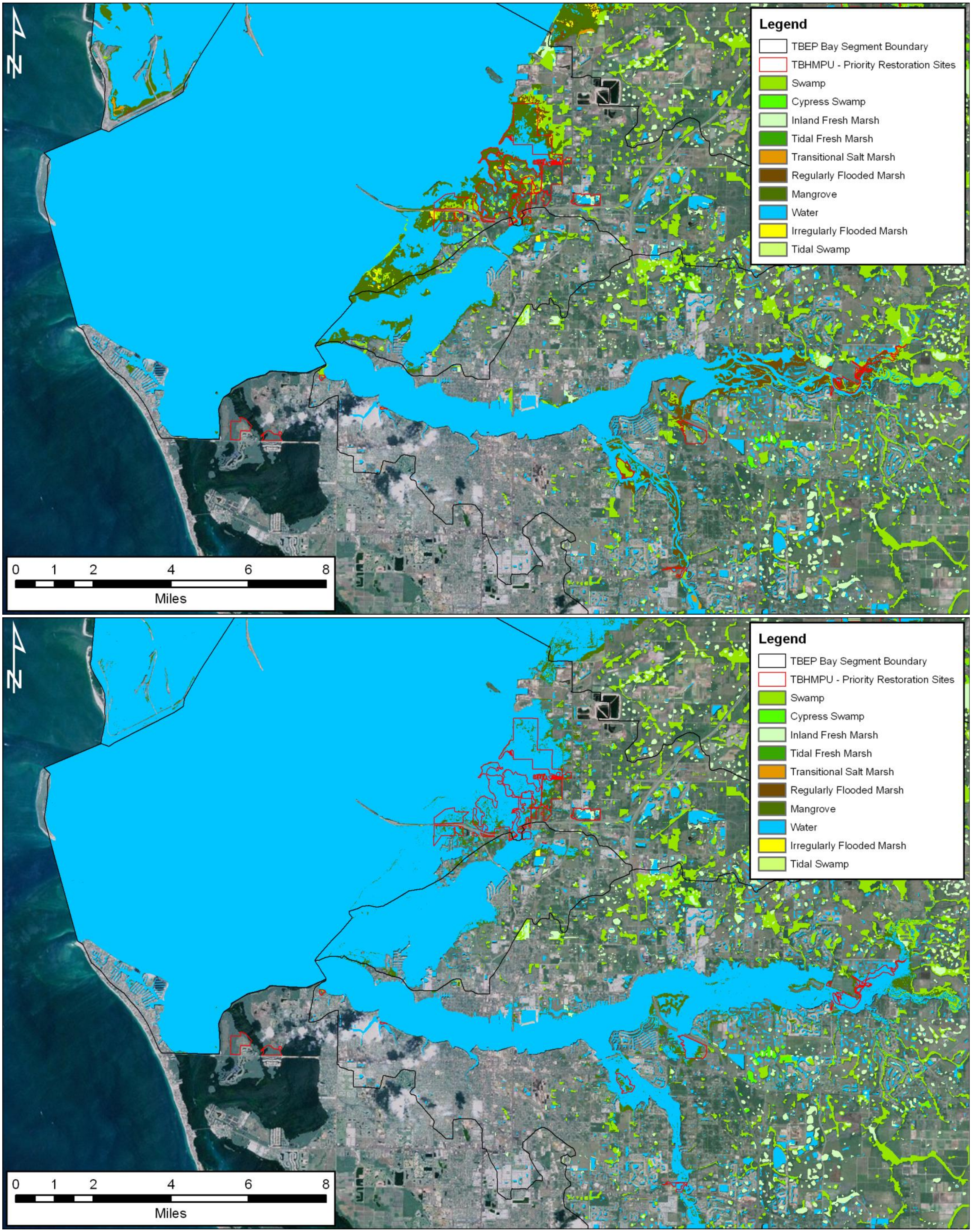


Figure LTB-3: Comparison of current (2007, left) coastal habitat conditions in Lower Tampa Bay, Terra Ceia Bay, and Manatee River relative to a 1.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

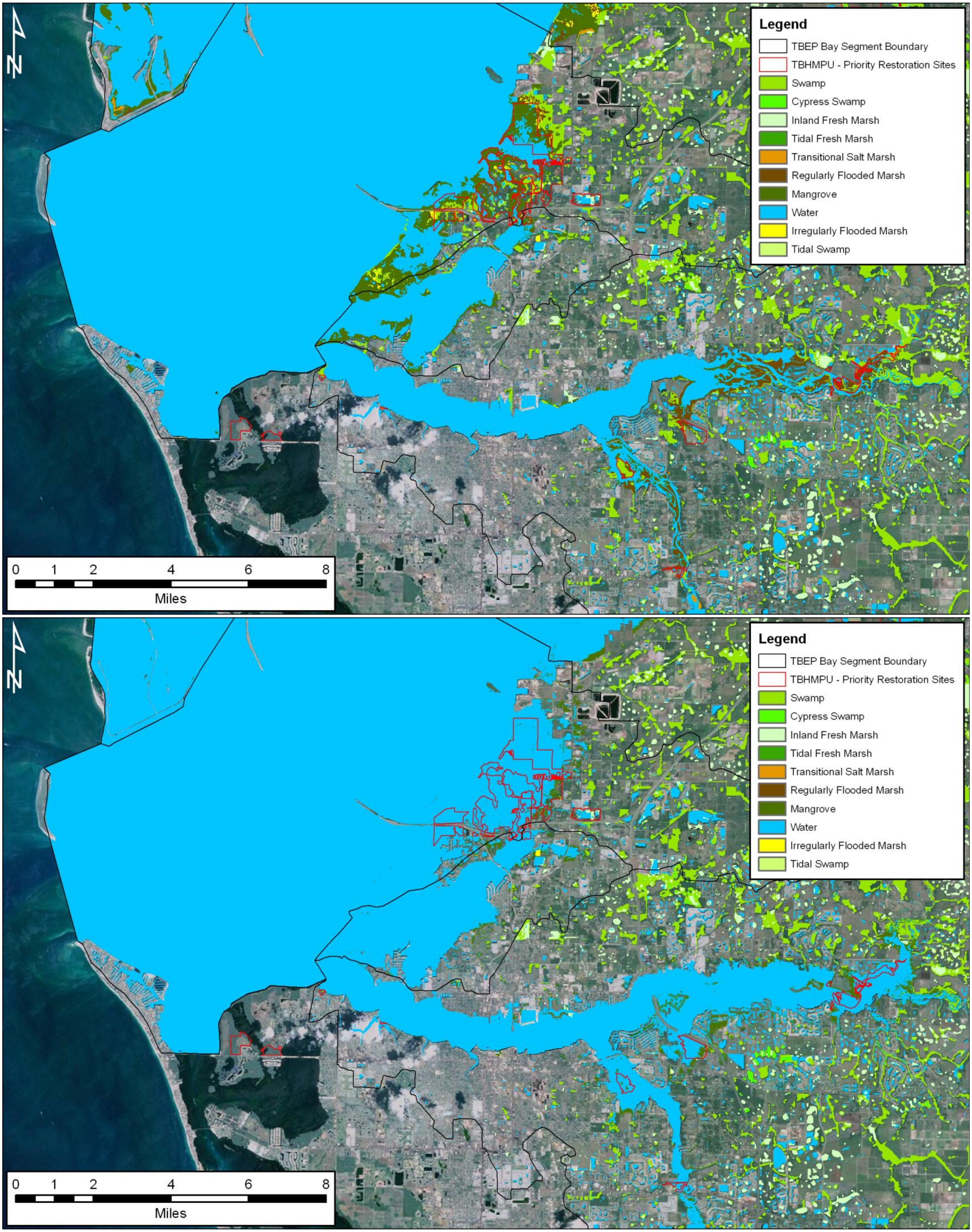


Figure LTB-4: Comparison of current (2007, left) coastal habitat conditions in Lower Tampa Bay, Terra Ceia Bay, and Manatee River relative to a 2.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

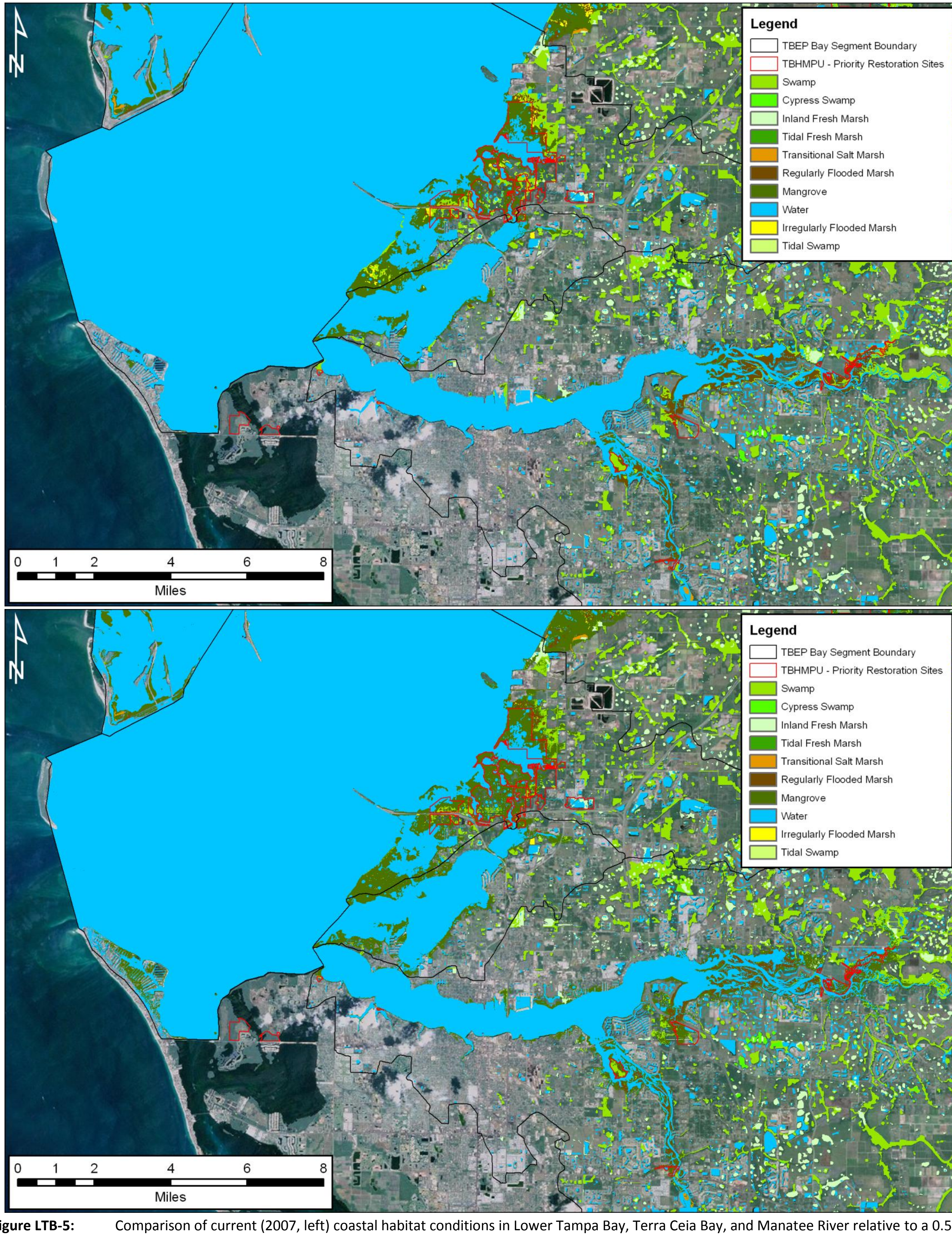


Figure LTB-5: Comparison of current (2007, left) coastal habitat conditions in Lower Tampa Bay, Terra Ceia Bay, and Manatee River relative to a 0.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

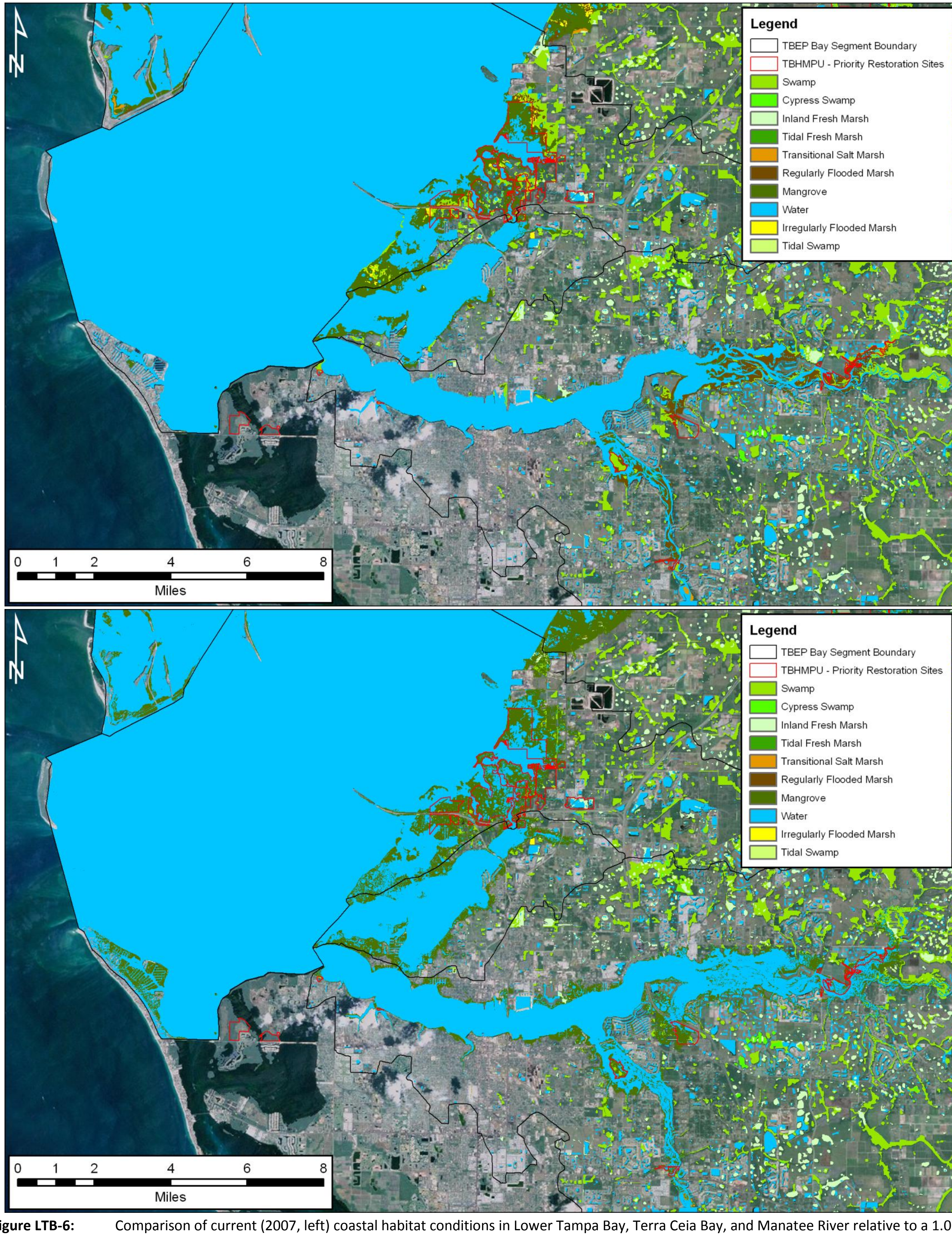
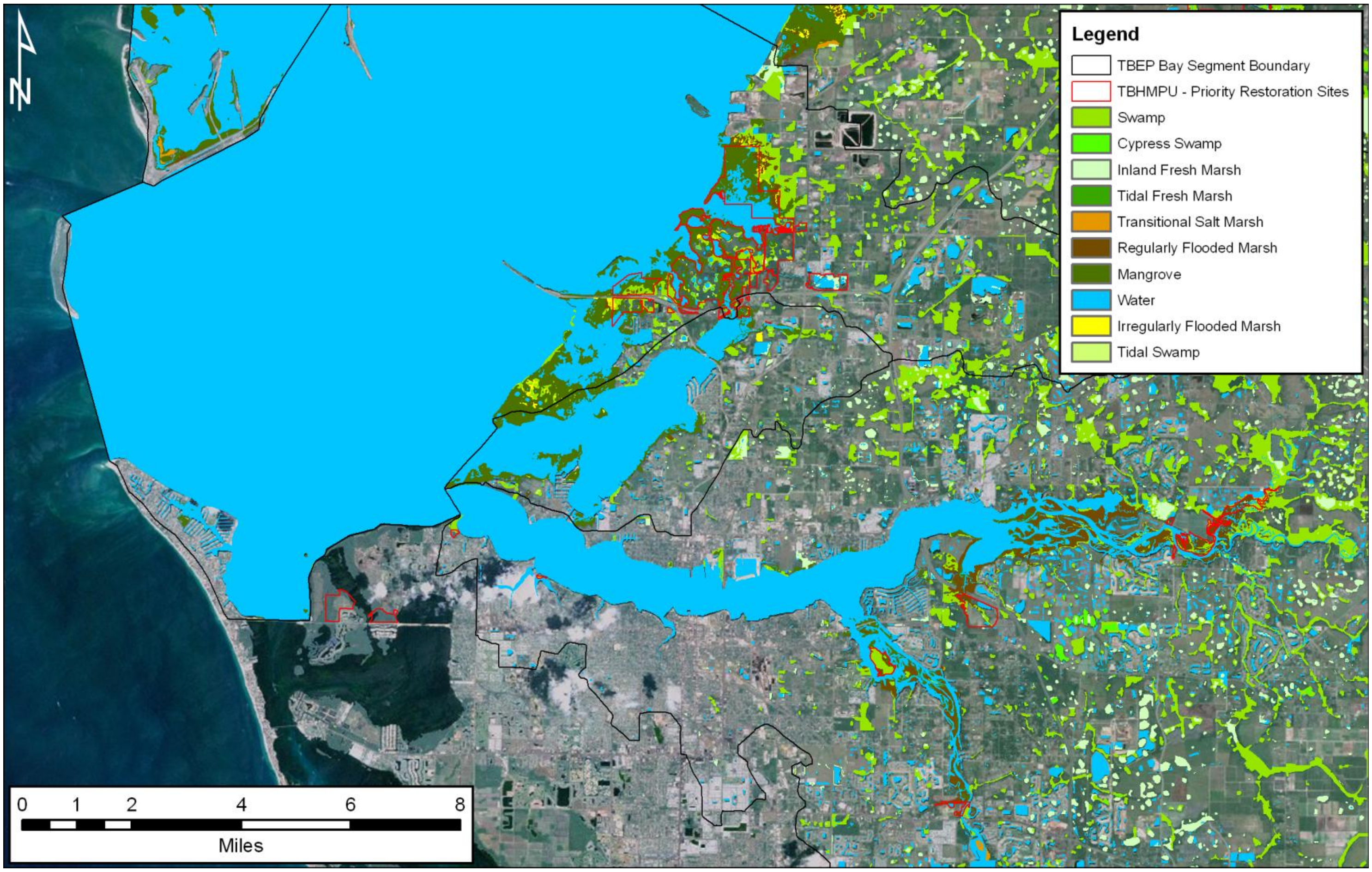


Figure LTB-6: Comparison of current (2007, left) coastal habitat conditions in Lower Tampa Bay, Terra Ceia Bay, and Manatee River relative to a 1.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).



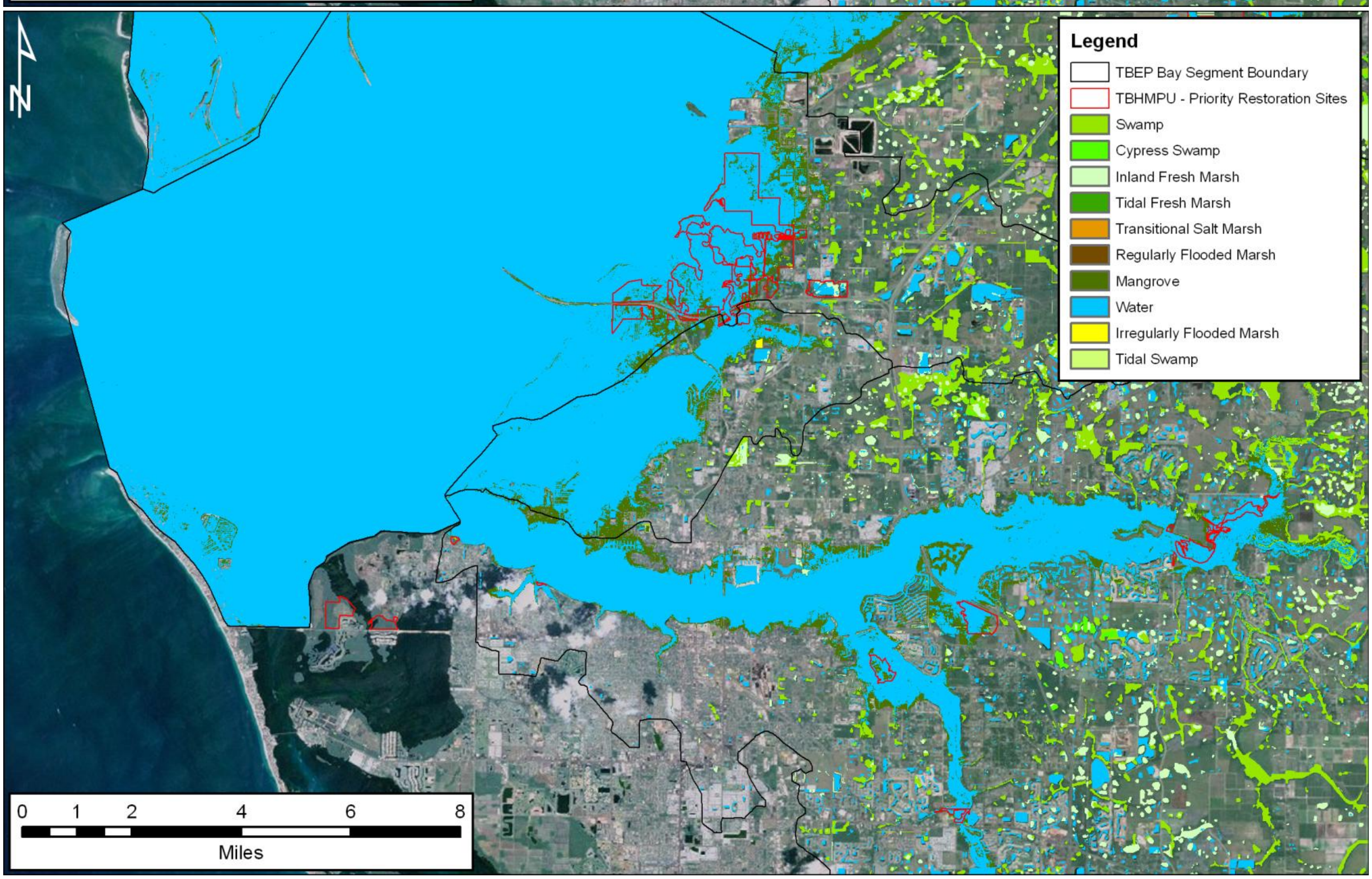


Figure LTB-7: Comparison of current (2007, left) coastal habitat conditions in Lower Tampa Bay, Terra Ceia Bay, and Manatee River relative to a 1.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

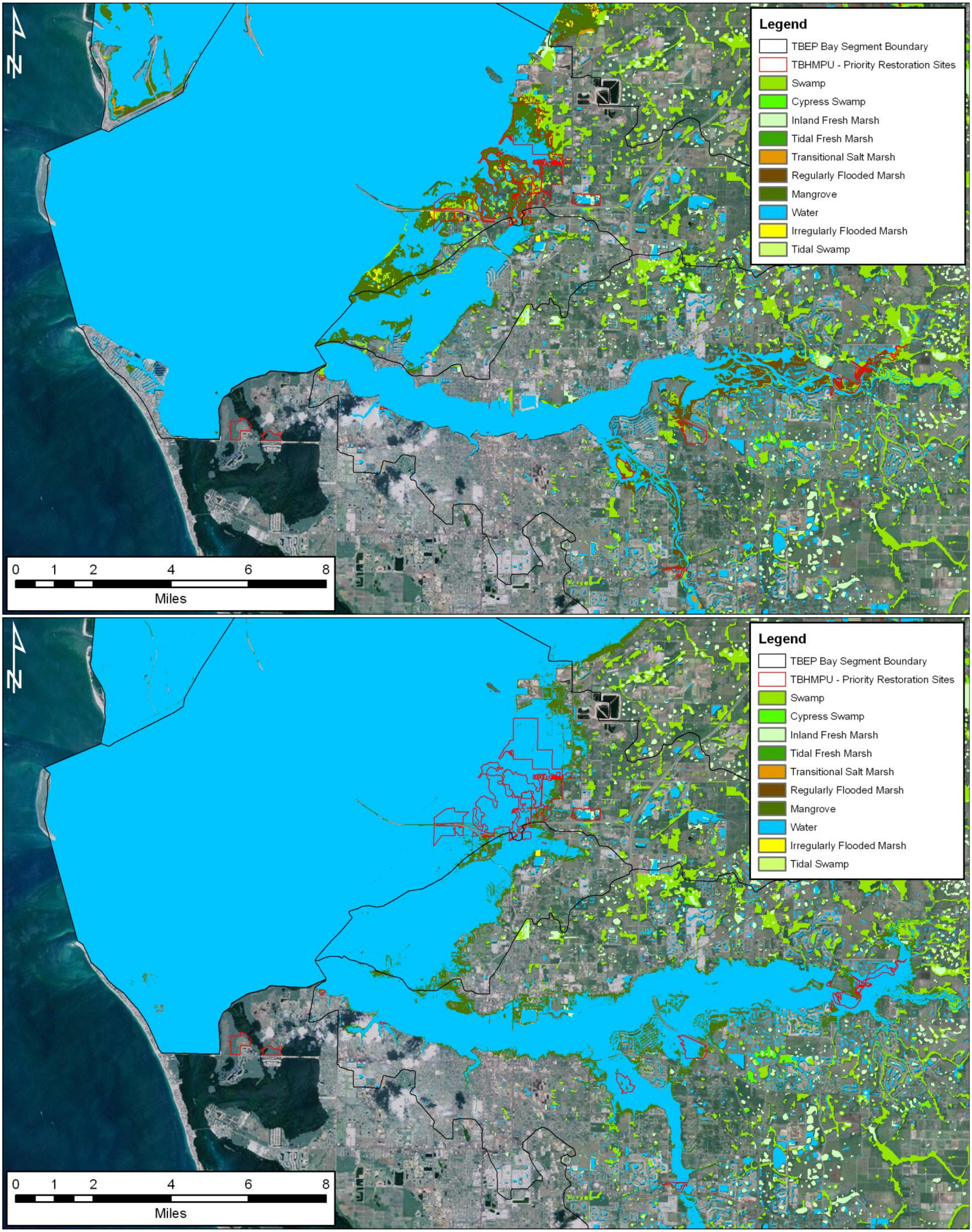


Figure LTB-8: Comparison of current (2007, left) coastal habitat conditions in Lower Tampa Bay, Terra Ceia Bay, and Manatee River relative to a 2.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

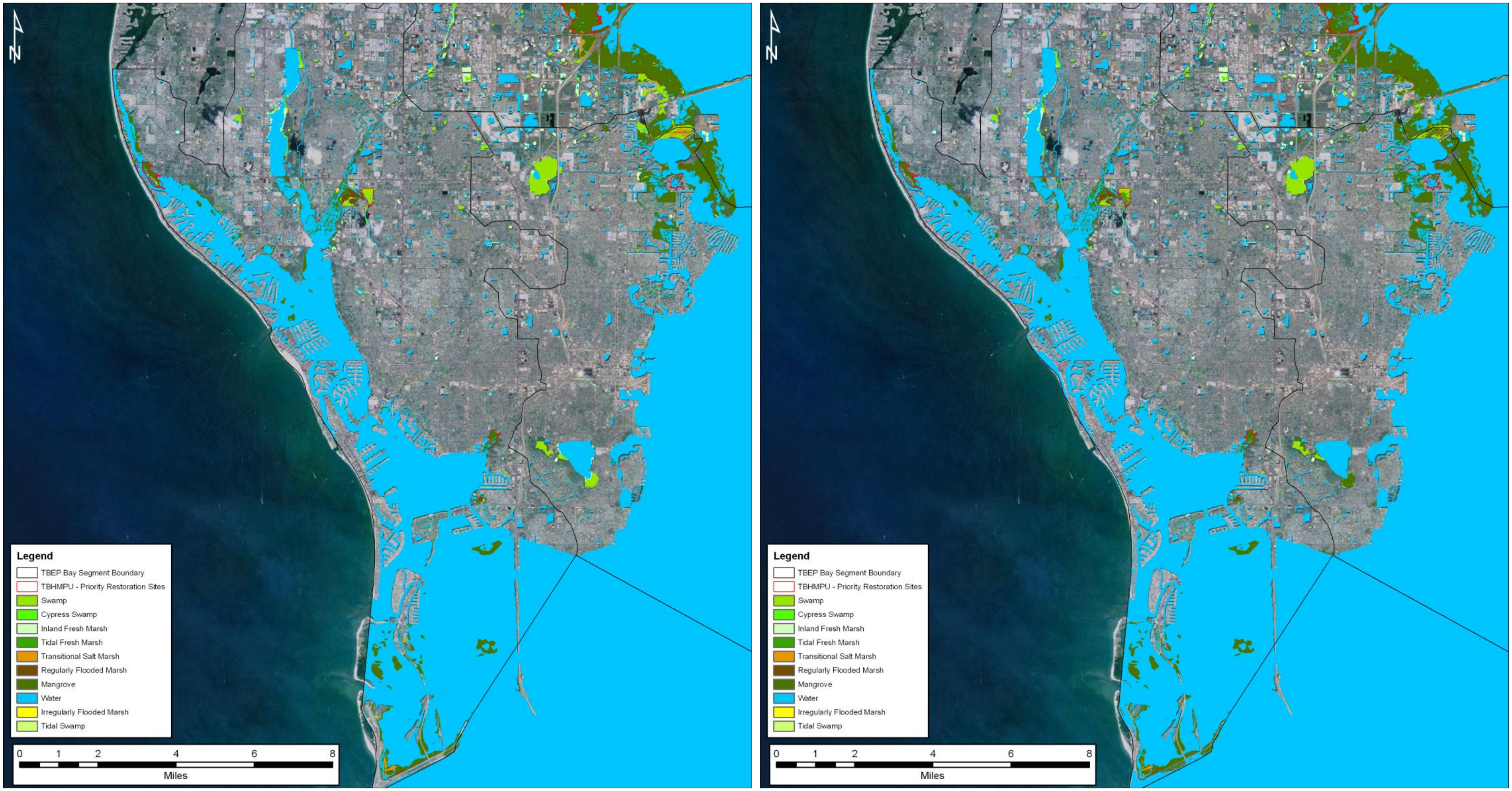


Figure BCB-1: Comparison of current (2007, left) coastal habitat conditions in Boca Ciega Bay relative to a 0.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

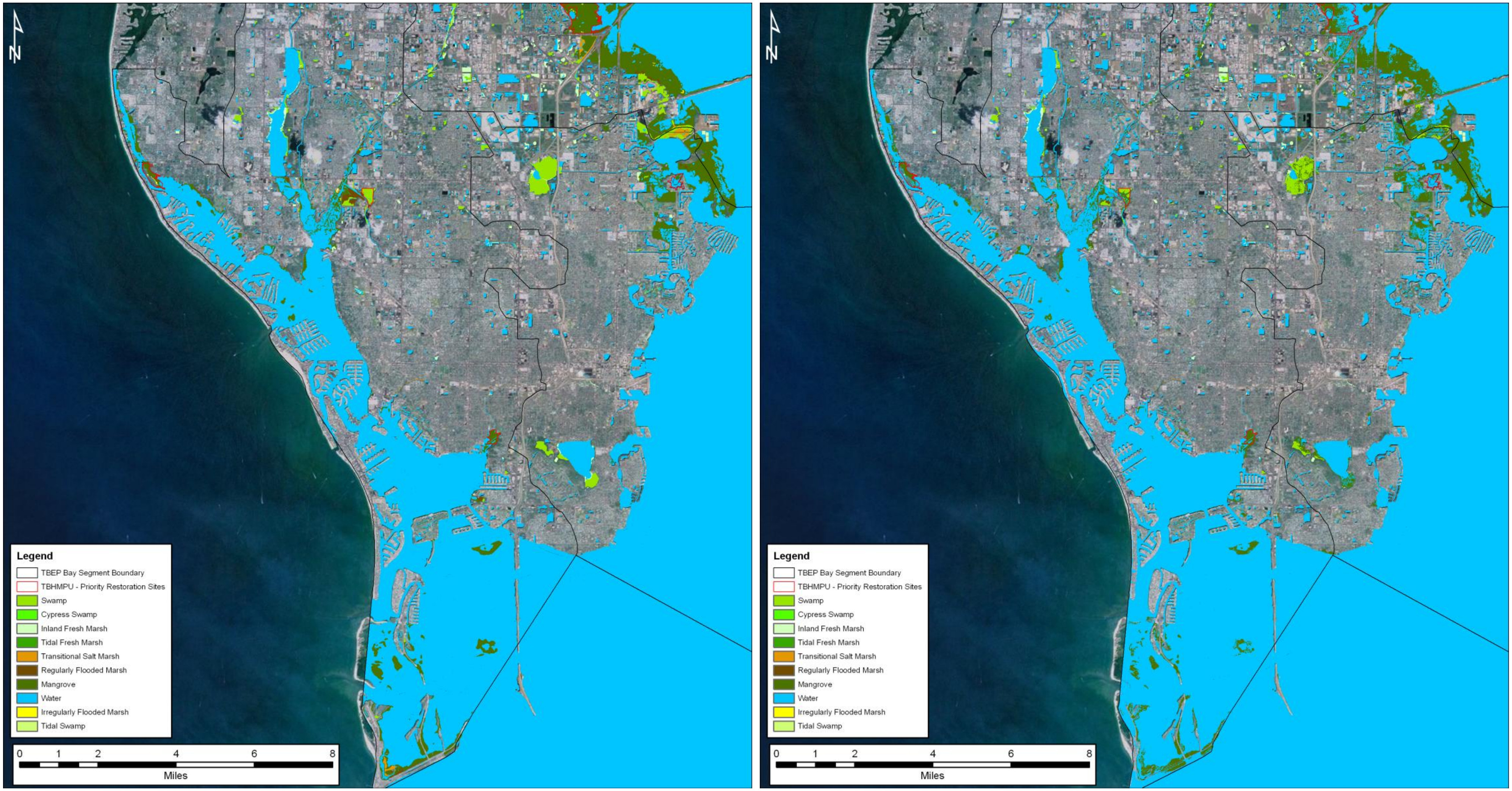


Figure BCB-2: Comparison of current (2007, left) coastal habitat conditions in Boca Ciega Bay relative to a 1.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

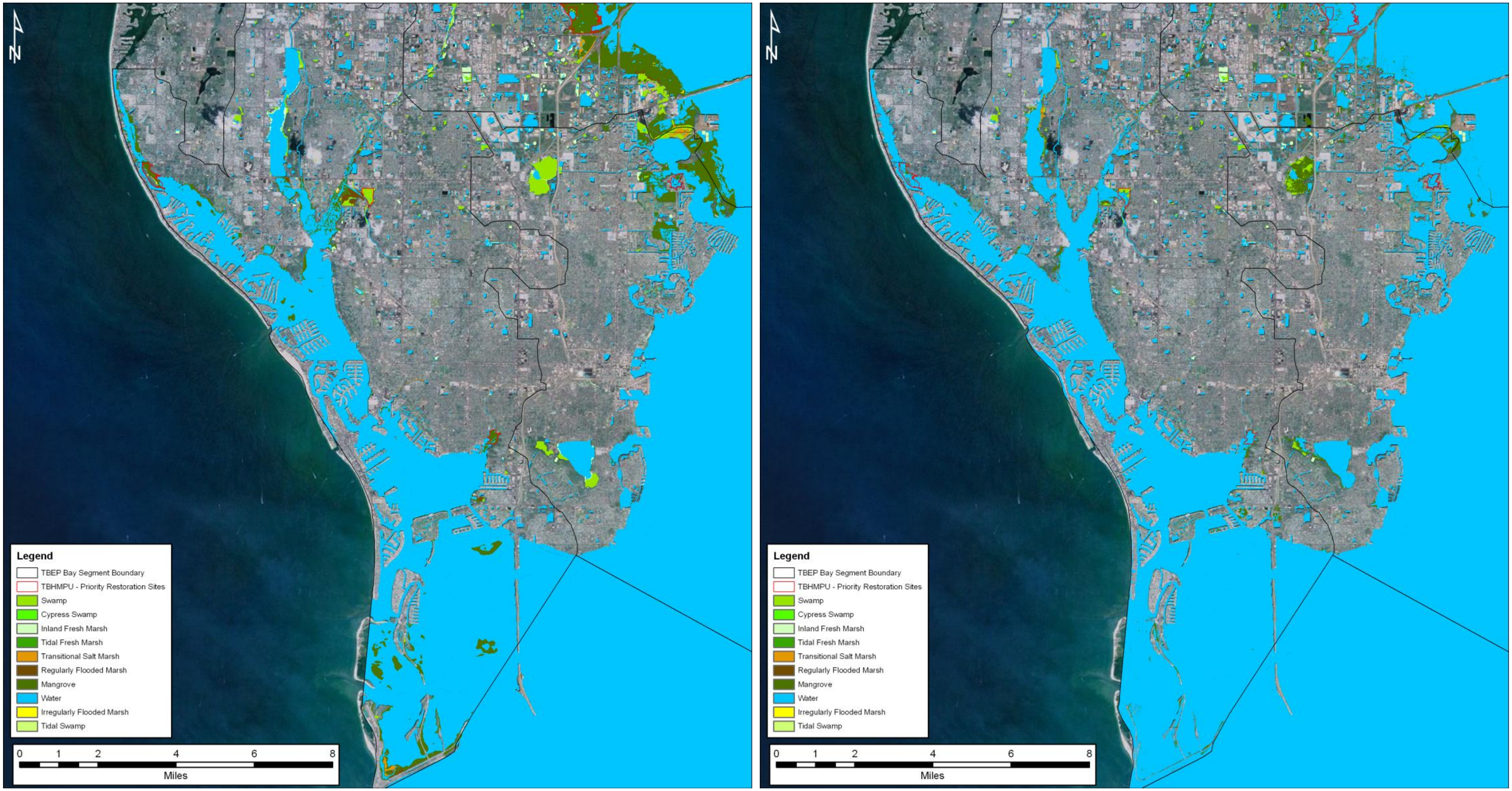


Figure BCB-3: Comparison of current (2007, left) coastal habitat conditions in Boca Ciega Bay relative to a 1.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

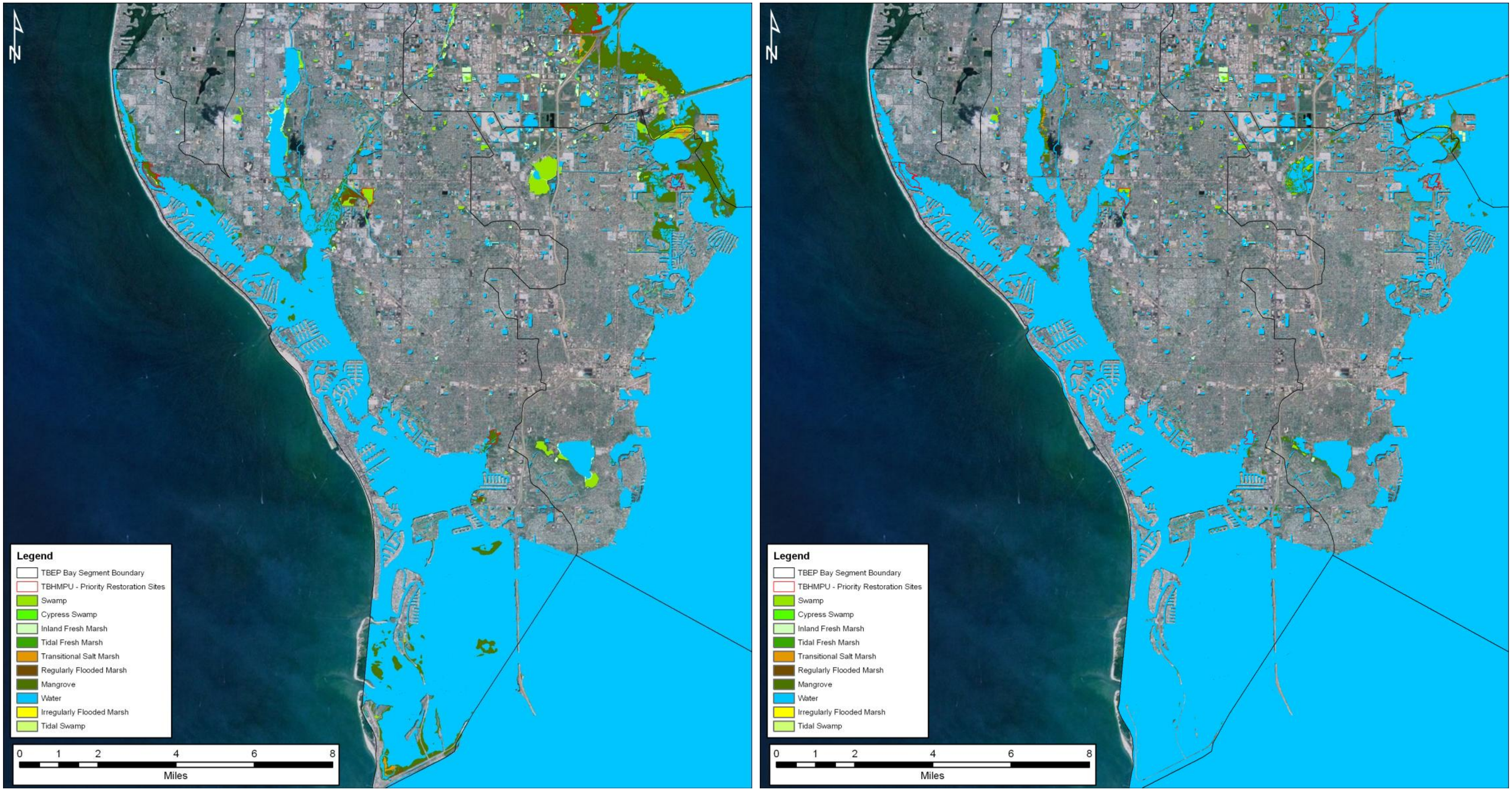


Figure BCB-4: Comparison of current (2007, left) coastal habitat conditions in Boca Ciega Bay relative to a 2.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to protect currently developed dry lands. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

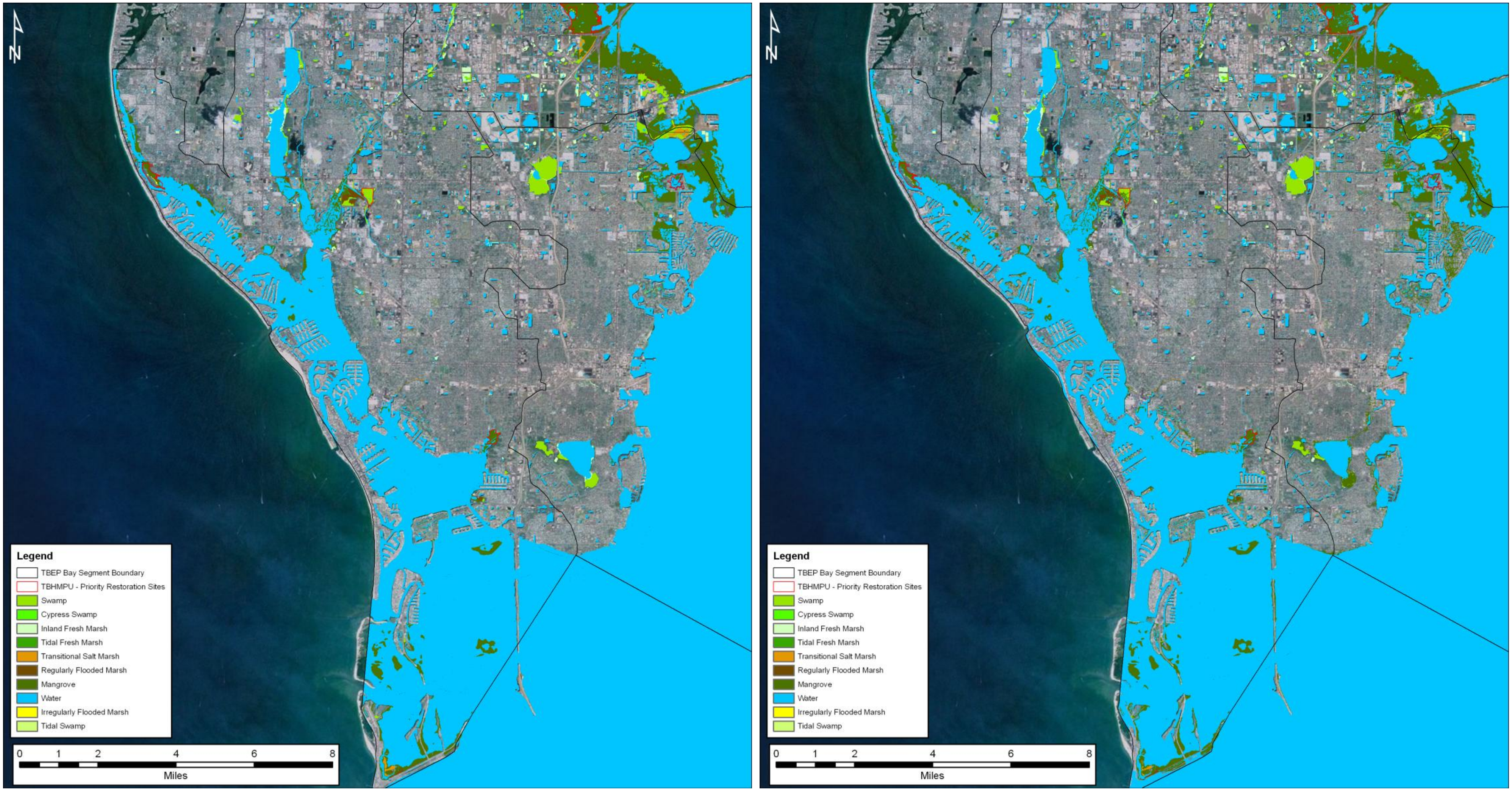


Figure BCB-5: Comparison of current (2007, left) coastal habitat conditions in Boca Ciega Bay relative to a 0.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

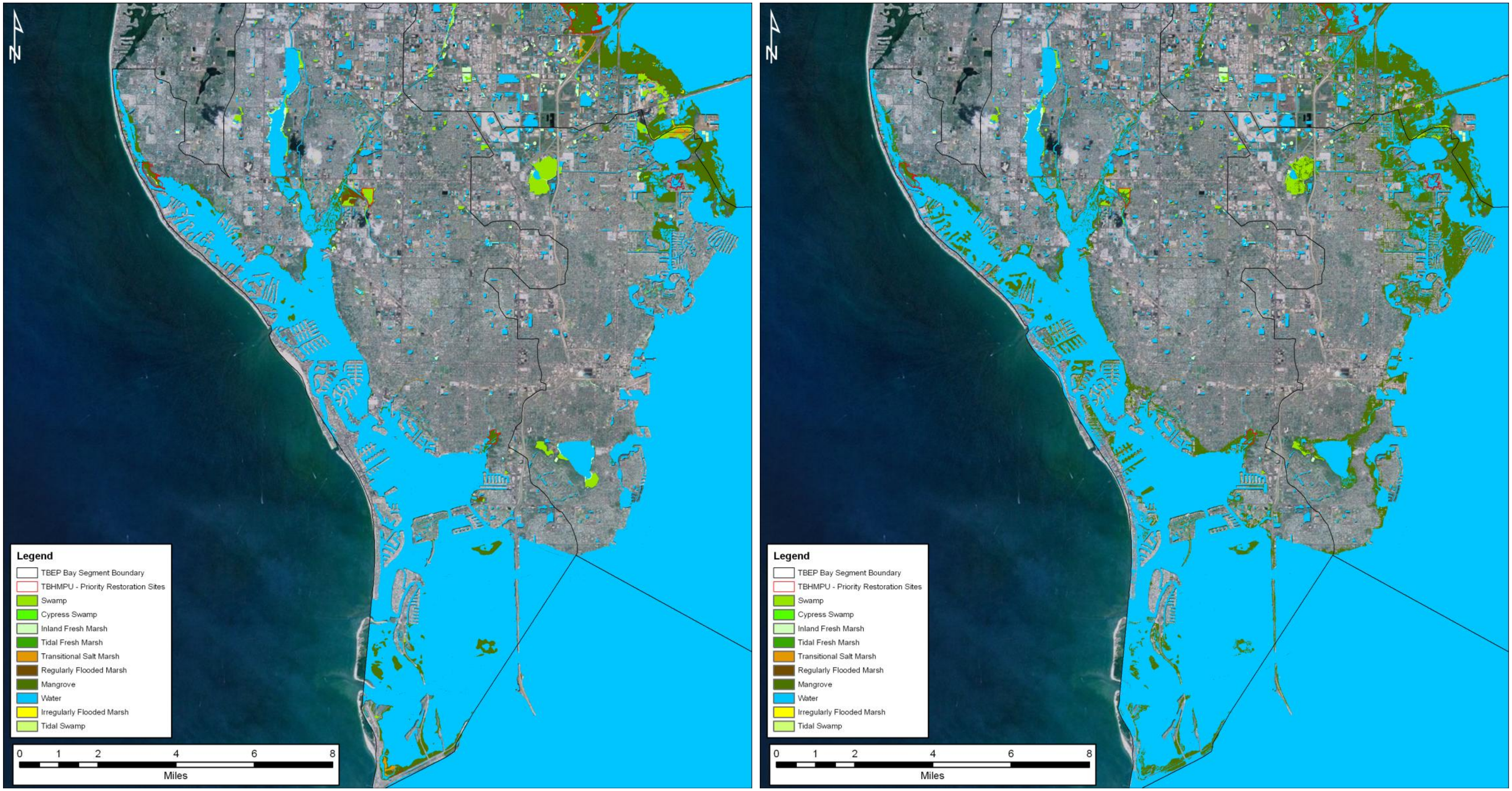


Figure BCB-6: Comparison of current (2007, left) coastal habitat conditions in Boca Ciega Bay relative to a 1.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

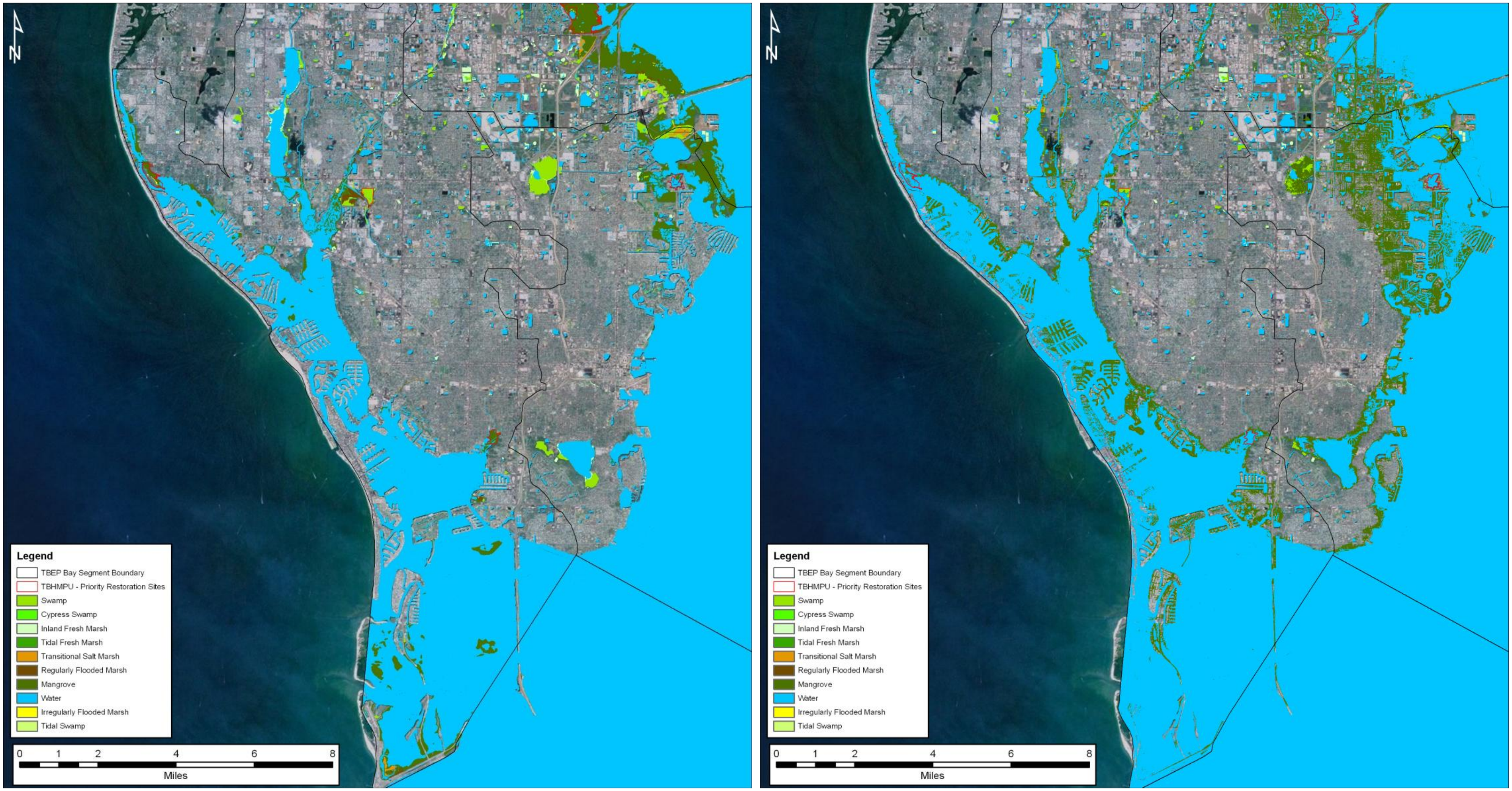


Figure BCB-7: Comparison of current (2007, left) coastal habitat conditions in Boca Ciega Bay relative to a 1.5-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).

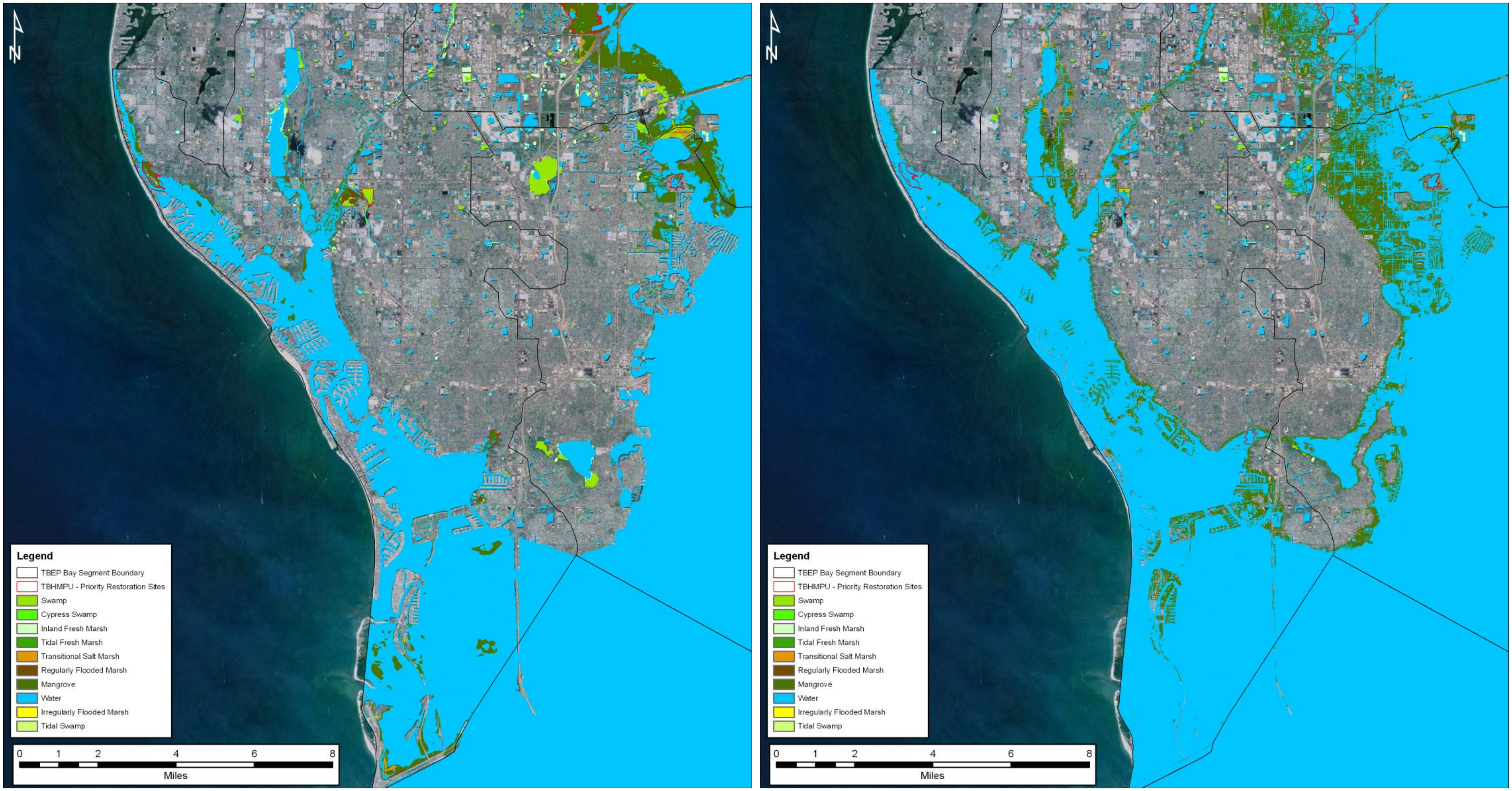


Figure BCB-8: Comparison of current (2007, left) coastal habitat conditions in Boca Ciega Bay relative to a 2.0-m projected sea level rise by 2100 (right) and the future adaptation strategy to allow up-slope migration of coastal habitats. Red polygons indicate priority habitat restoration and acquisition sites within the Tampa Bay watershed as described in the 2010 Habitat Master Plan Update (Robison, 2010).