Habitat Change Analysis

Final Report

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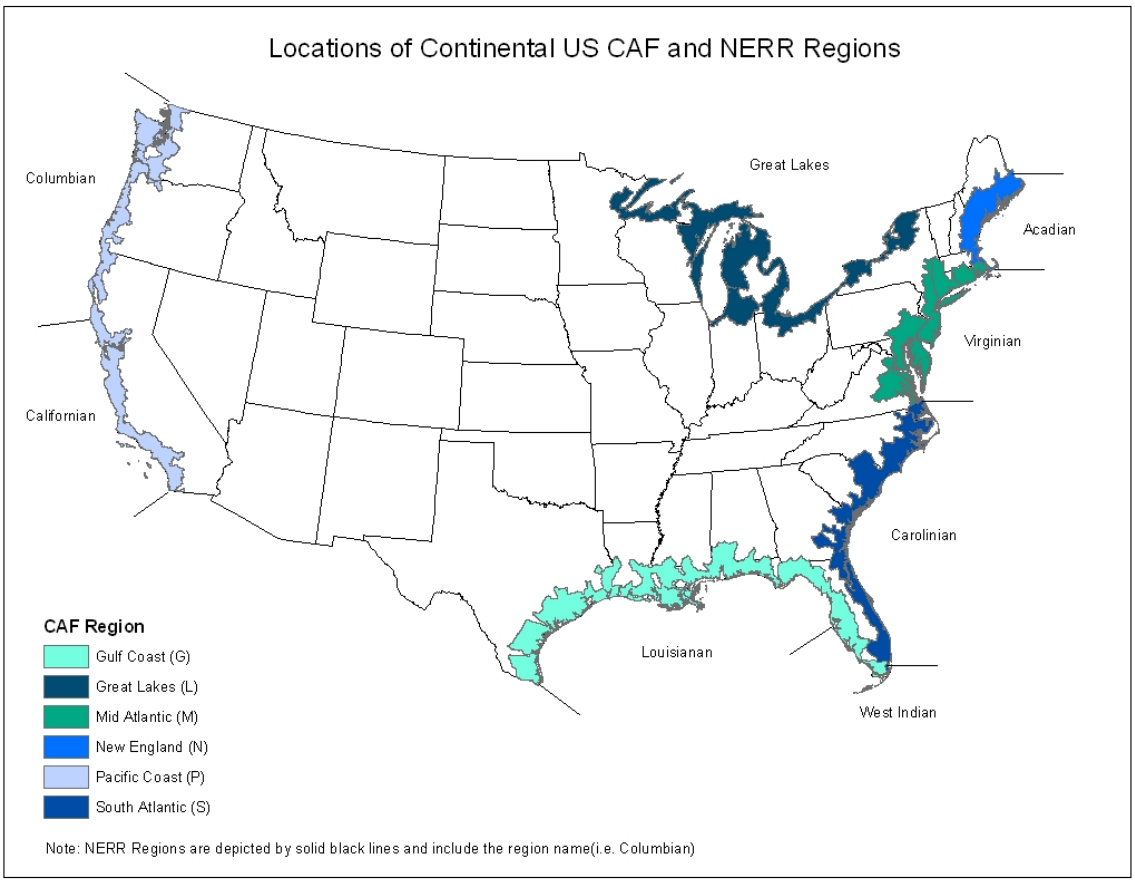
Executive Summary



The central questions that this document seeks to address are: What is the extent and condition of estuarine and Great Lakes wetlands in the continental United States?, and: How have the extent and type of wetland and open water habitats changed during the historical period (1938 to 2004), and more recently (1992 to 2004)?. Also important to determine are the reasons for these changes, derived mostly from analyzing what appears in locations where wetlands are no longer present.

This report assesses the overall conditions of historic and recent degradation and loss of estuary-associated ecosystems (including the Great Lakes), for use in setting regional and national restoration priorities. This analysis was developed for NOAA in support of their efforts under the Estuary Restoration Act. The goals are to:

- assess habitat trends for use by the federal interagency council charged with implementing the Estuary Restoration Act (ERA), including creation of an estuary habitat restoration strategy
- assess agency priorities of NOAA Restoration Program, for which habitat status and trends data is essential

- guide strategic restoration planning and policy-making at the national level, and will help local groups target limited resources toward restoration of the most threatened habitats in their regions.

This report was based on a non-statistical sampling method and captured change within 11.5 x 1.5 mile transects, one placed in each Coastal Assessment Framework (CAF) region except in the Pacific CAF which comprised two transects. This analysis approach was used due to limited availability of land cover datasets for several time periods. The findings represent the results of change within these transects as well as further examination by local experts to determine ranges of loss or gain within each time period.

The major findings for the coastal continental U.S. and individual Coastal Assessment Framework regions from 1938-57 to 2004 and the subset time period from 1992 to 2004 are as follows:

- Overall wetlands loss estimated at 12-28% during the reviewed 1938-57 to 2004 historic time period, with 7-15% lost from 1992-2004. There appears to be an acceleration of the rate of losses in the recent period as compared with the historic period. The observed phenomenon of faster rates of decline in wetland categories in the more recent period than in the historic period bears closer examination. There are a number of factors that could explain these results.

    - *Population* - In the most recent time period, expansion has been associated with a housing boom that began during the 1990's and accelerated with the decline in interest rates from 2001. Most new construction has been concentrated in suburban areas, spreading further from urban cores. Combined with the continuing movement of the United States population to cities near the coastlines, these socioeconomic factors have contributed to the observed increase in rates of decline.
    - *Fragmentation* - Previously, wetlands tended to be strung out along lines of water flow, either tidal or riverine, and were connected. Agricultural, commercial, and residential development has fragmented the wetland landscape. Most coastal wetlands now exist as patches in a more developed matrix. The process of fragmentation tends to lead to a point where losses become much faster as patches become too small to survive disturbances or maintain their previous hydrological and vegetative character.
    - *Regulations* - Fragmentation also has implications on the regulatory side for wetlands. Changes in the U.S. Army Corps of Engineers rules on development of wetlands relaxed restrictions on development of small, isolated wetlands. This has led to an increase in the rate of conversion that is observed in the data from this study.

  Although there are regional variations, one theme is quite clear: losses have tended to be due to increased development around cities and along transportation corridors. The rate of wetland loss to developed area

roughly tracks the rate of population increase in each region. This trend is strongest in the CAFs and transects that are closest to urban centers. Only in the Gulf Coast CAF are there substantial wetland losses due to agricultural expansion, especially in the recent period.

- Emergent wetlands declined at an estimated 14-32% historically across the coastal continental US, while recent losses were estimated between 6 and 14%. The Gulf Coast shows a decrease in rate of loss during the past 10-15 years due to increased regulatory controls to protect these resources.

- Woody wetlands show an overall decline of 11-26% during the analyzed historic period and 7-15% lost in the recent time period. Individually, the CAFs displayed roughly the same percentage of loss except for the Pacific Coast which actually had an overall gain in woody wetlands of up to 4%. This slight increase is estimated as natural shifts from more delicate wetland types like emergent wetlands to slightly more robust types such as shrub-scrub and forested wetlands. Since 1992, the percentage loss for the CAF regions were roughly 5-16% except for the Mid Atlantic and New England Coasts, which estimated losses up to 38% due to increased development. Palustrine forested wetlands saw significant reductions in the Great Lakes CAF due to drainage for agricultural use, logging, mining, and urban development, while Gulf Coast losses primarily in bottomland hardwood forests were due to agriculture conversion, siliviculture and urbanization. Estimated losses of mangroves on the Gulf Coast were 5-10% from 1957-2004, due largely to commercial and residential development.

- Overall, there was a 3-8% loss of natural (non-armored) shorelines in these coastal regions. Individually, all the CAFs lost roughly 7-32% of natural shorelines during the historic time period. In the Pacific CAF region, there were estimated gains in shoreline before 1992. The creation of tidal mudflats and small islands through dredge spoil deposition added considerable shoreline and wetland area in the large river mouths such as the Columbia River. However, high losses from other locations in these estuaries during the recent time period have offset these gains. The Pacific Coast dramatically lost an estimated 22-60%, driven largely by increased waterfront development.

- Open water habitat losses were estimated at 1-5% overall during the historic time period. As there was much less detail and mapping available for these habitats, many habitats classes were analyzed on a CAF region basis. In most of the regions, aquatic beds were estimated to have lost 5-10% of their cover from 1938-57 to 2004. Oyster reefs in the Mid Atlantic were estimated at 0-5% loss from 1939 to 2004 due to heavy port and harbor development. Overall losses for open water habitats were reduced in the past 10-15 years due to increased regulatory programs.

- Agriculture has declined in all regions over the historic period at rates ranging from 5 to 35%, in all regions except the Gulf Coast and Great Lakes, where agriculture expanded between 5 and 23%. The rate of decline slowed during the recent time period to the 4-16% range in most of the regions, while the rate of growth in agriculture for the Gulf Coast and Great Lakes slowed to 5 to 16% and 2 to 10% respectively.

- Development is identified as one of the primary factors in wetland losses throughout the coastal United States. Developed lands increased by 30-50% in the historic time period in all regions but the Gulf Coast, where the rate is 56-81% and the Pacific Coast, which shows increases of 50 to 200%. During the more recent time period, the rate of development from historic dates is estimated in the 11-30% range for all but the Gulf Coast and Pacific Coast, where it was estimated at 36-56% and 30 to 93%, respectively, of their historic baseline acreages. This reflects the trend in population growth, since the southern tier states have seen large migrations from northern states.

At the national level, priorities for restoration can be viewed in several ways: (1) areas of rapid loss, as examined above, (2) areas of widespread loss, and (3) locations with the highest potential return on restoration investments. In looking at percentages of wetlands lost over the historical time period (1938-57 to 2004), the Gulf Coast, New England, and Mid-Atlantic have sustained about twice as much loss percentage-wise as the other CAF regions (Figure ES-01). When comparing these changes among CAF regions in terms of absolute acreage, the Gulf Coast clearly stands out with losses up to three times that of the other regions. The Mid Atlantic and New England Coasts have experienced at least half the loss of the South Atlantic and roughly the same loss as the Great Lakes, the latter of which comes in third in terms of acres lost (Figure ES-02). This accentuation of widespread loss is also prevalent in Open Water Habitats. As seen in Figure ES-03, the Mid Atlantic and New England regions have the same 22% loss of open water historically, while the Great Lakes region has a percentage loss of 15%. Yet in terms of acreage, the Great Lakes has sustained the greatest amount of loss, up to 66,000 acres greater than that of New England and the Mid Atlantic.

Overall, the Gulf Coast CAF has lost the largest proportion of historic wetlands and natural shoreline. Specifically, the loss of woody wetlands in this CAF exceeds the losses elsewhere else by between 2 to 10 times, largely attributable to the conversion of forested riparian wetlands to agriculture. Thus these areas may be a good choice for targeting of restoration or preservation efforts.

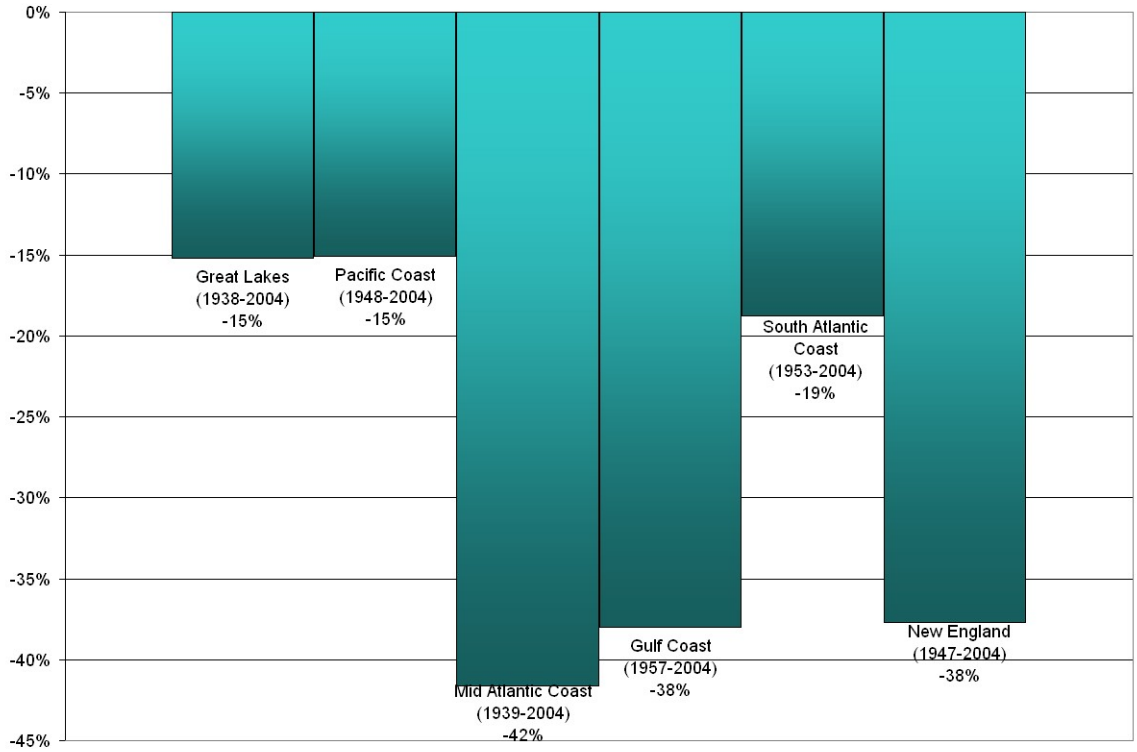


Figure ES-01. Estimated percentages of Wetlands loss or gain by CAF region during respective historical time period. Percentages based on the high range of change in Table 9-02.

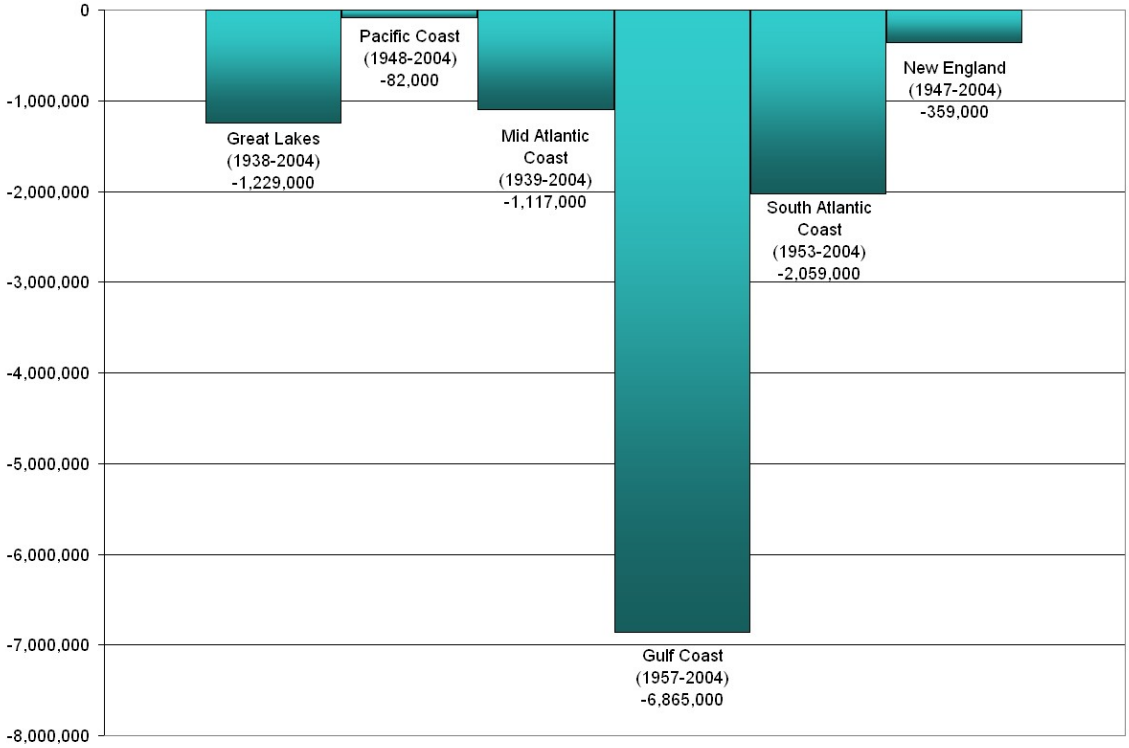


Figure ES-02. Estimated acres of Wetlands loss or gain by CAF region during respective historical time period. Acreages are based on the high range of change in Table 9-04.

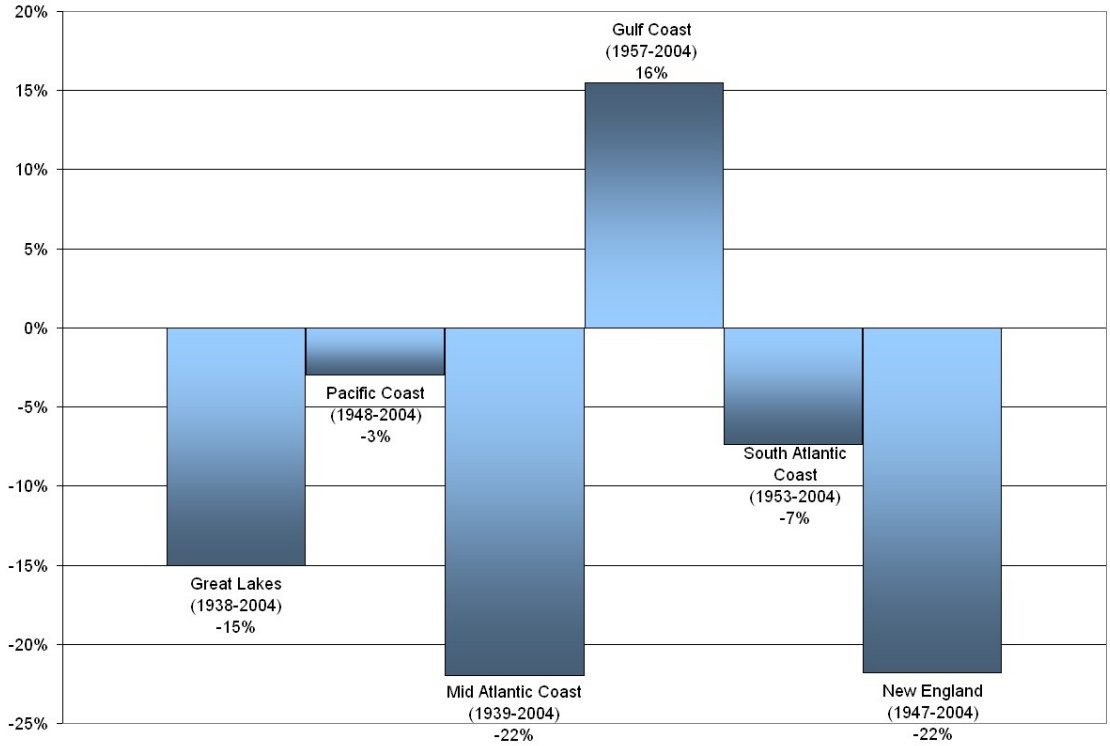


Figure ES-03. Estimated percentages of Open Water Habitats loss or gain by CAF region during respective historical time period. Percentages based on high range of change in Table 9-02.

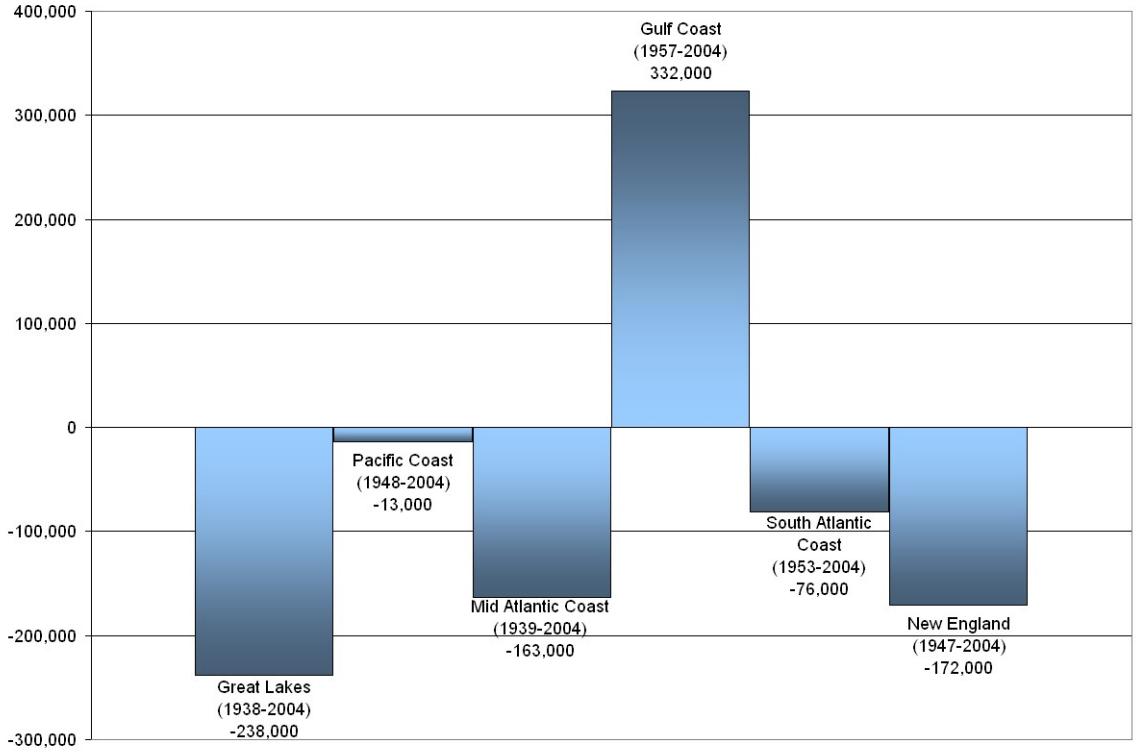


Figure ES-04. Estimated acres of Open Water Habitats loss or gain by CAF region during respective historical time period. Acreages are based on the high range of change in Table 9-04.

Section 1.0 Introduction

Section 1.1 Objective

The objective of this report is to provide the National Oceanic and Atmospheric Administration (NOAA) with an overall view of the variation in the status and trends of estuarine-associated habitats throughout the U.S. coastal areas of the lower 48 states, including the Great Lakes region. This analysis was developed for NOAA in support of their efforts under the Estuary Restoration Act.

The trends analysis was based on a non-statistical sampling method and captured change within multiple 11.5 x 1.5 mile transects. Transects were stratified by the Coastal Assessment Framework (CAF) regions, and when feasible the major and minor National Estuarine Reserve Regions (NERR). Figure 1-01 illustrates the extent of the study area including the CAF and NERR regions.

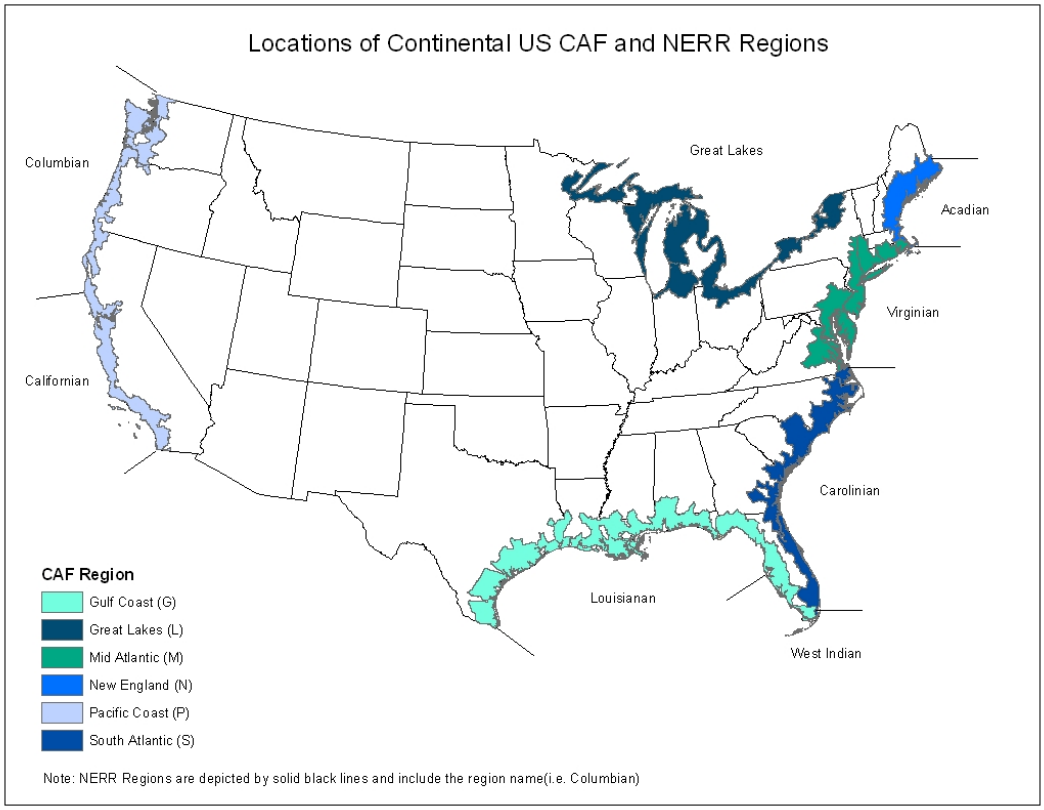


Figure 1-01. Map showing locations of Continental US CAF and NERR Regions

Habitat change was captured within each transect for two time periods: recent and historic. Sanborn collected data from three source dates: the most recent data available (around 2000), five to ten years prior to the most recent (1980's to early 1990's), and historic (1940's to 1960's).

In addition to capturing change within each transect, Sanborn enlisted regional experts to compile a narrative describing the overall status of coastal habitats within each CAF region. These experts have assessed the relationship between the environment where the transects are located and the entire CAF region.

The end result of this analysis provides NOAA with a regional perspective on the types and variation of coastal and estuarine-associated habitats within each CAF region as well as on overview of the change nationwide.

Section 1.2 Report Overview

A description of the methods used for the spatial trends analysis is presented in the Data Analysis Plan (Appendix A). A description of the classification key, class definitions and data layers used in this analysis can also be found in the Data Analysis Plan. This report presents the results and discussion of the trends analysis.

Section 1.3 Analysis Background

There were three possible approaches considered in looking at recent and historical coastal trends:

- total enumeration (not recommended),
- statistical sampling (not feasible), and
- non-statistical sampling (only feasible approach for this project).

Total enumeration would involve producing a wall-to-wall dataset of historic and recent habitats. This would be time consuming, extremely costly, inefficient, and unnecessary. Statistical sampling would be less expensive, but still quite costly. It would require a measure of variation to determine the necessary sample size. Finally, samples would need to be selected in a random fashion. Non-statistical sampling is the only solution available if the others are not possible. This method allows for the observation of trends across the datasets but does not have the powerful properties of a statistical sample.

A statistical sampling approach is not possible for this project for a number of reasons: limited budget, insufficient time, and unknown variance (needed to compute the sample size). However, the major limiting factor preventing a statistical sampling approach is the inability to select a random sample as dictated by the availability of the recent and especially the historic data sets. Therefore, Sanborn is providing NOAA with a non-statistical sampling strategy to observe recent and historic trends in coastal habitats. A transect methodology will be used, and two different time periods will be examined within each transect:

- Recent time period: the most current data available to 5-10 years prior
- Historic time period: the earliest data available to a date within the 1940's – 1960's

In addition to this spatial analysis, Sanborn worked with local experts to provide a narrative describing the general transect environment and the CAF region that it falls in. Based on the evaluations of these transects and their change, an estimate of change has been extrapolated for each CAF region. The experts used these estimates of change within each CAF region to determine an overall change for the Continental US.

Section 2.0 CAF Regions

There were six CAF regions analyzed for this report: the Great Lakes, New England Coast, Mid Atlantic Coast, South Atlantic Coast, Gulf Coast, and Pacific Coast regions (Figure 2-01).

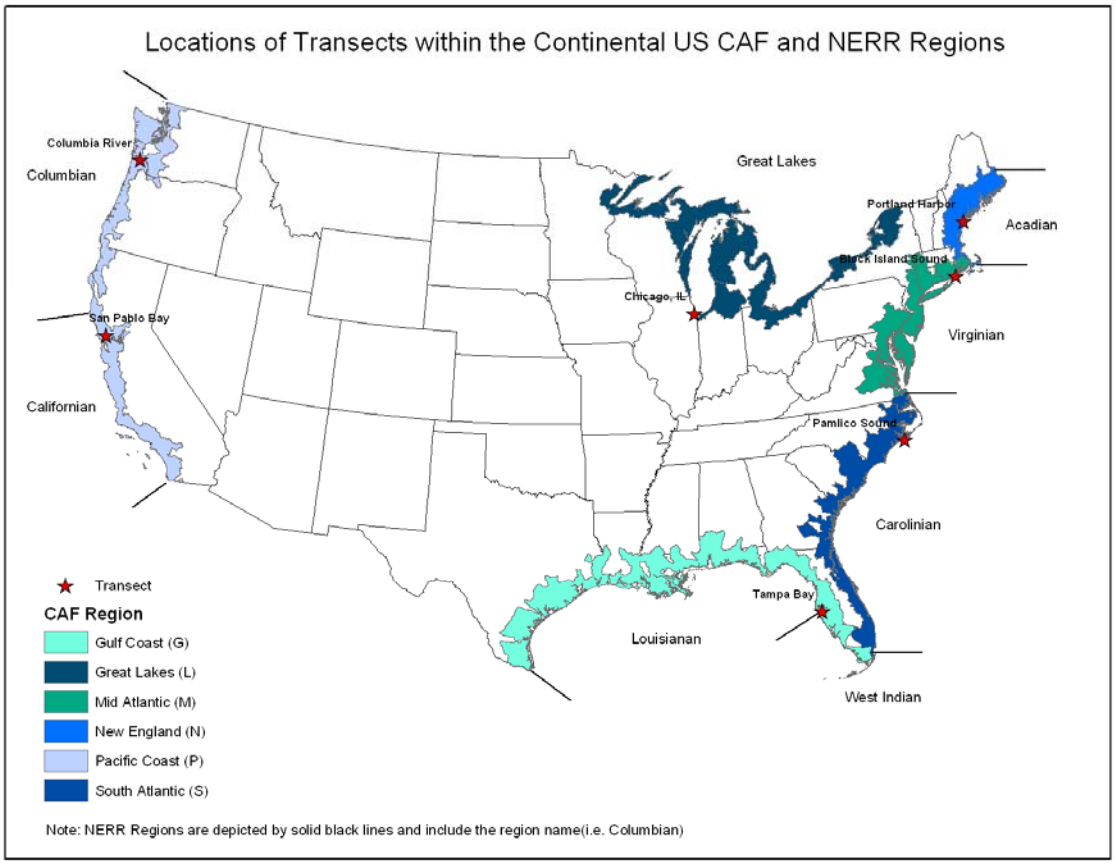


Figure 2-01. CAF Regions Map

Section 2.1 Overview

The following information is provided for each individual CAF region.

- CAF Description
- Recent Land Cover Data Summary
- Transect Analysis Results
- CAF Change Summary

<u>CAF Description</u>

The description narrative provides a consistent set of variables for analysis of wetland change results from around the country which have been determined to aid in the

evaluation of each transect as well as CAF region as a whole. These variables have been selected because they meet several conditions:

1) They provide some explanation of the mechanisms behind wetland conditions and change in wetland extent,
2) They are easily derived from existing data sets, and
3) They are applicable to wetlands in various settings in various locations around the Continental United States.

Condition Variables:

I. *Distance to Coast*
II. *Salinity*
III. *Topography/Elevation Range*
IV. *Urbanization*
V. *Land Ownership*
VI. *Dominant Land Uses*
VII. *Extent of Shoreline Armoring*
VIII. *Shipping*
IX. *Dredging*
X. *Major Natural Disasters*

I. *Distance to Coast - Marine or Estuarine*

The distance to coast variable is intended provide a coarse filter for separating between marine and estuarine wetlands, and to account for differences between coastal and inland wetlands. This is a surrogate variable for the type of wetlands being sampled. Ideally it would be best to stratify between marine/estuarine type wetlands and palustrine and freshwater wetlands, but since that data is not readily available we suggest distance instead. Distance from the coast, in most locations, governs the salinity and also the weather experienced at a location, flooding from inland sources, and the type of substrate likely to be supporting wetlands. The distance variable can be derived from existing map and GIS data and provides a good surrogate for variables describing the type of wetlands and their condition.

The Columbia River Transect is approximately 35 miles inland and represents an estuarine system. While tidal influence is strong, the wetlands are also highly influenced by the flow of the river itself.

On the West Coast, most estuarine wetlands are at the mouth and along large river systems. On the Gulf and East Coasts, these wetlands are usually located behind barrier islands and then extend along the large river systems. Most of the estuarine systems examined in this study extend from the coast inland along river systems. Wetlands that are farther from the coast are more likely to be estuarine as opposed to marine. In general, it is possible to separate those wetlands that are immediately adjacent to the coast or within 2-5 miles inland, from those that are further inland. Those marine wetlands, directly on the coast, are more heavily influenced by coastal currents and weather systems. This is particularly the case with extreme storm systems, from hurricanes on down, that dissipate as they move on shore. Riverine estuaries that are further inland are much more influenced by freshwater

flow conditions and orographic rainfall from weather as it intersects inland mountain ranges and other areas of the watershed.

II. Salinity - Saltwater or Brackish or Freshwater

Salinity is another variable that is easily acquired from coastal and river surveys. It serves as a direct measure of the influence of salt and salt water on the observed wetlands. Wetlands can be separated into three classes based on salinity: saltwater (greater than 15 ppt), brackish (5-15 ppt), and freshwater (less than 5 ppt).

III. Elevation

This is another coarse filter for the region as a whole. It separates those areas likely to be coastal wetlands from uplands. Elevation within the transect is easily derived from DEM data or USGS topographic maps. The elevation provides a good indication of whether wetlands are likely to be found and the type of wetlands likely to be on site.

Most coastal wetland sites are below 100 feet in elevation above mean sea level. In locations where the elevation range is greater than 100 feet it is a good indication if wetlands are present, they are not coastal. This indicator will also help to distinguish the boundaries of coastal sites that may have non-wetland coastal forms such as rocky shores.

IV. Urbanization – Percent Urban

Urban development is a major cause of habitat loss. This is true for wetlands as well as other natural habitats. The percent of a given land area that is urbanized provides a good integrative variable to wetland condition. The trends in urbanization tend to be mirrored by trends in wetland condition and extent. Urban areas are typically based around historic port locations, and usually occupy the lowest elevation lands first, before spreading to higher elevations and locations further from the urban center. Urbanization around major estuaries has resulted in huge wetland losses. Continuing urbanization will cause continued declines in wetland extent. Data for this variable is readily available from census and other surveys. It can also be easily estimated from information on maps and in GIS layers.

V. Land Ownership - Percent Public vs. Percent Private

Land ownership is a good predictor of the likelihood of development and future potential for wetland losses. Public lands, in most cases, are typically more stable and likely to continue to stay in current land use categories. Private lands are available for development, in most cases, and would be locations that NOAA and other government agencies might want to concentrate upon for protection.

The nation as a whole has a large percentage of lands around the coast that have been preserved as public lands, but often there is an equally large amount in private land. The relative percentage of these two land ownership categories provides both some explanation of wetland changes and a predictor of future change.

VI. Dominant Land Uses - Agricultural vs. Developed vs. Protected Open Space

Land use is a very good predictor of vegetation cover. At the transect scale it is particularly important to examine the land use to determine if the vegetation classifications are probable and realistic.

Land use can also be estimated at a larger scale from GIS data layers that are available at State and local scales. The relative percentage of land use provides a very good way to judge how representative the transect may be of conditions at larger scales and areas.

The Columbia River Transect is dominated by land in the agricultural land use. These lands have seen the largest reductions in the amount of wetland area within the transect by absolute numbers.

VII. Extent of Shoreline Armoring

Shoreline armoring directly eliminates the smoothly sloping or flat transition from water to land that constitutes the substrate for coastal wetlands. This variable serves as a good surrogate variable for the degree of coastal development. This “hardened” shoreline also influences habitat-forming processes in rivers and on coastlines by limiting erosion and channel migration.

Shoreline armoring is quite visible in aerial and satellite photos. It is also noted on most topographic maps and navigational charts.

VIII. Shipping

Shipping is another variable that can assist in evaluating wetland condition and trends. Ships have small-scale effects on riverine and coastal wetlands through wake-action. This effect is a factor when high ship traffic changes the hydrology or substrate stability of wetland areas. Shipping data has been kept for centuries, and is readily accessible for major ports over the historic time period of interest.

IX. Dredging

Dredging has major effects on coastal and riverine wetland condition and extent. The movement of wetland substrate through dredging usually results in large decreases in wetland area. Dredge spoil deposition, or fill, has been used to create wetland areas. This trend is likely to continue as channel-dredging projects are increasingly linked to restoration.

The U.S. Army Corps of Engineers has jurisdictional responsibility over dredge and fill in navigable waters of the United States. It tracks the location, amount of fill and removal. The Corps also takes on many dredging and filling projects themselves. Ample data is available from this agency and from state agencies with related responsibilities.

X. Major Natural Disasters

As mentioned in the section on the distance from coast variable, it is often the largest weather systems that have a structuring impact on coastal wetlands. This is particularly true in the Southeast and Gulf Coasts where hurricanes regularly reshape barrier islands, coastal channels, and wetlands. Especially on the West

Coast, earthquakes and tsunamis also cause major restructuring of coastal elevations, coastlines, and wetland hydrology. These events occur over a much longer time-span than hurricanes, but their effects continue for centuries. The Puget Sound has been heavily shaped by post-ice age earthquakes resulting from rebound. Coastal islands, wetlands, and river mouths as they exist today are, in many parts of the Sound are a result of these earthquakes. In California, the wetlands around Point Reyes north of San Francisco lie directly on the San Andreas Fault. Their shape, elevation, and extent have been determined by past fault movements.

Recent Land Cover Data Summary

A summary of the recent land cover data for each CAF region is presented. This section includes both figures showing the mapped land cover classes and associated summary tables presenting total acreage of each class. The data were based on the National Land Cover Datasets (NLCD) from 1992, which were used because of their availability and complete coverage of all CAF regions. The NLCD 1992 data was cross-walked into the eighteen land cover classes determined by NOAA for this project (see Table 13-03). A detailed description of these land cover classes can be found in the Data Analysis Plan (Appendix A).

For each CAF region, the land cover datasets were clipped using the CAF regions polygon coverage. While most major islands were included, some small island polygons (especially around the Florida Keys and the tip of Louisiana) were not processed due to time and money constraints of the project.

While the NLCD 1992 is available for all CAF regions, it is limited in that is has generalized land cover classes. For example, NLCD 1992 maps woody wetlands, instead of the more detailed shrub-scrub wetlands and forested wetlands that other datasets like the Coastal Change Analysis Program (C-CAP) provide. This limitation of the NLCD 1992 dataset prevents the estimate of acreage for these more detailed classes. It is important to note that the acreage values provided in the land cover tables are rough estimates of land cover within each CAF region.

Additionally, since complete coverage of the more recent C-CAP data was available for the Great Lakes and Pacific Coast CAF regions, the land cover tables for these CAF regions include percent of habitat loss and/or gain between the NLCD92 and C-CAP (2000/2001) datasets. This is in addition to the change summary tables provided in the CAF Change Summary section.

Transect Analysis Results

A minimum of one transect was analyzed for each CAF region. Each transect was roughly 10,756 acres total (11.5 miles long by 1.5 mi. wide). The transect placement was determined by identifying the best location to capture a representative area of the CAF region and then was dependent on the availability of historical aerial photos for these areas from the 1940-1960’s. The transects provide the initial starting point for the trends analysis.

The following is provided for each transect location:

- Transect Location
- Transect Description
- Recent Change Maps
- Recent Change Tables
- Recent Change Summary
- Historical Change Maps
- Historical Change Tables
- Historical Change Summary

Transect Location

The analysis of the transect examines the location and representation of the transect within the CAF region. The following are questions examined when addressing this section:

- Is the transect area representative of the CAF region? Is there a fair representation of classes?
- What are key factors that might skew this transect as compared to the rest of the CAF region (i.e. largely urban, freshwater vs. saltwater, high population growth).

Transect Description

The description narrative employs the same condition variables used to describe the CAF region (see CAF Description). These variables are useful in detailing the conditions at each of the transects and relating them to the overall conditions of the wetland and open water habitats for that estuary, region, and coastline. The degree to which these variables are the same at different locations will also provide a good indication of how reliably results can be extrapolated from transect results to larger areas.

Recent and Historic Maps

Recent and historic change maps were derived from the respective datasets used for each time period analysis (Appendix C, Table 13-01). The recent maps were derived from crosswalks of the original land cover datasets to the target habitat groups and other land cover classes as described above in the CAF region (Appendix C, Table 13-03). For the historical change, the latest date of land cover was overlaid on top of the historical date photos and recoded accordingly to this historic background.

There are many dataset limitations to note that can introduce change and unexpected results where there might not be actual change. These land cover dataset differences can lead to false errors. Below are limitations that restrict the results of comparing the C-CAP, NLCD 1992, NWI, and historic aerial photo classifications.

- Classification scheme - These datasets were mapped to different classes and definitions. For example, NLCD 1992 contains a general woody wetlands class whereas C-CAP provided more detail by dividing this general class into shrub –scrub wetlands and forested wetlands. Another example of difference shows with NLCD 1992 classification of a

pasture/hay class whereas C-CAP includes pasture/hay classes in grassland. Thus in NLCD 1992 a pasture/hay area would fall in the land cover class agriculture, where as in C-CAP it would fall into the other upland class since it was classified as grassland. This would show a false change.

NWI data provided the most detailed information for these land cover classes of all the datasets but did not always provide complete coverage of a transect.

- Black and white historic aerial photo interpretation – For the historic land cover datasets, the most recent dataset was recoded to represent the historic photo. There are several issues which might lead to false errors of change or indeed no change as the case may be.

  First, we only have one date of photography so we may not capture seasonally or temporarily flooded wetlands in the historical data. It is very difficult to interpret what land might be wet from a black and white photo. Recoding of recent land cover to historic land cover often does not show a lot of change in wetland because unless the wetland is obviously developed or agriculture or has changed successionally (i.e. from shrub-scrub to forested wetlands) then the classification was left untouched.

  Secondly, an area which is now developed in the recent datasets but un-developed in historic photos leads the image interpretation to be highly susceptible to error. For example, an area might obviously be forested, but is it a forested wetland or simply a forested (other upland) area? This is also an error that can result from being unable to determine what is wet from black and white photos.

  Lastly, because the recent datasets are 30 meter pixels, it is hard to capture detail that is evident from the historic photo when recoding these areas to a 30 meter square area.

- Multiple dates of imagery – The datasets were mapped with different imagery/dates. For example, NLCD 1992 was mapped to thematic mapping (TM) imagery for one date, while C-CAP data had multiple dates available. This could lead to seasonally or temporarily flooded wetlands not captured in the NLCD 1992 dataset.

- Mapping priorities – The datasets were mapped for different purposes. In particular, mapping wetlands more accurately was a higher priority in developing the C-CAP data.

- Different scales – The datasets were mapped at difference scales. C-CAP and NLCD datasets are mapped using 30 meter pixel resolution (1:100K). This is not as detailed and accurate when looking at these small areas of transects. Many details can be missed like small acreages of wetlands,

shoreline detail, etc. NWI datasets are generally mapped at 1:24K (polygons) or better which allows for more detail and precision. Comparison of this dataset with the more generalized NLCD and C-CAP datasets can lead to false errors of change.

- Different spatial datasets – This is a similar problem encountered in the difference in scales between the datasets. Namely, NWI has been mapped as a vector coverage allowing for precise polygons that can capture detail in an areas outline as well as small areas. NLCD and C-CAP are both raster format with 30 meter pixels. In addition, registration issues even between two raster datasets can lead to alignment issues that introduce error.

- Differences in image interpretation – One general issue to note is the overall difference in image interpretation from one individual to another. While generally most interpreters might agree, there is also room for differences in opinion between well-qualified, experienced image analysts.

More information about these datasets, classification schemes, and GIS/Remote Sensing methods used can be found in the Data Analysis Plan (Appendix A).

Recent and Historic Change Tables

As in the change maps, the recent and historic land cover and change tables are derived from the respective datasets used for each time period analysis. All dataset limitations apply to these tables as they were derived directly from the comparison of the spatial datasets. These tables display the numerical values in acres of each land cover class within the transect, percent of loss and/or gain, and the original change summary tables calculated between the two datasets.

Recent and Historic Change Summary

The recent and historic change summaries contain observations on the overall effect of change for each time period in the transect. The following questions were considered when addressing this section:

- Does the habitat loss within this transect relate to the whole CAF region or does this loss seem to be underestimated/overestimated?
- Does the habitat gain within this transect relate to the whole CAF region or does this loss seem to be underestimated/overestimated?
- Is the change analysis representative of the entire CAF region? Is the pattern of change consistent over the region or are there other areas that need further study?

CAF Change Summary

The change summary provides an observation of the overall effect of change (recent and historic) for the entire CAF region – mainly focused on the recent change due to limitations (or lack) of historical information. Observations were provided by local

experts familiar with each CAF Region. Local experts were asked to consider the following questions when summarizing the historic and recent change throughout the CAF region:

- What observations can you make based upon the transect results for the whole CAF region, given the similarity of the transect(s) to the rest of the CAF region?
- Please provide an estimate percentage of loss/gain for each land cover class over the entire CAF region based on the results of the transect(s) and your observations of the CAF region (including any ancillary studies or percentages numbers available for the region).
- Which classes in the transect(s) experienced the least amount of loss? What observations can you make based upon this result for the whole CAF region?
- Did any classes experience gain? If so, which classes and what observations can you make based upon this result for the whole CAF region?

In this analysis, an acreage and percentage of loss/gain over the entire CAF region was estimated. The percentage of change was estimated by the local expert by first considering the transect change for each land cover class and time period, then determining if this change portrays an accurate number across the CAF region based on their local expert knowledge and research, and approximating what might be a more accurate percentage for the CAF region if necessary. The NLCD 1992 acreage of the CAF regions for each land cover class was used to calculate a recent and historic acreage of gain/loss based on the percent gain/loss.

In order to be as consistent as possible between time frames, each transect acreage was calculated for the historic date used for the transect up to 2004. The change between these two dates is presented in table form. Included in the table is recent change, from 1992 – 2004, where the 1992-2004 acreage change is a subset of the overall early date-2004 acreage change. This recent analysis represents a subset of the historic analysis.

Section 3.0 Great Lakes CAF

Section 3.1 CAF Description

The Great Lakes Costal Assessment Framework (CAF) Region is approximately 54,984,340 acres in size, and includes areas within New York, Pennsylvania, Ohio, Indiana, Michigan, Illinois, Wisconsin, and Minnesota. The Great Lakes CAF has been sub-divided into 89 different Coastal Drainage Areas by NOAA. The eastern portion of the CAF, in the states of New York, Pennsylvania, and Ohio, extends from the shores of Lake Ontario and Lake Erie to the upper reaches of the Oswego, Genesee, Maumee, Sandusky, Cuyahoga, and Salmon drainage basins. This part of the CAF extends as far as 80 miles inland in the Adirondack Mountains of New York and the till plains of central Ohio, to the much narrow portion of the CAF in western New York and Pennsylvania that is only about 8 to 12 miles wide. Elevations are highest in the Adirondack Mountains, reaching nearly 1,000 meters above sea level. Lower elevations are found towards Pennsylvania and Ohio, averaging between 200 and 400 meters above sea level. The western portion of the Great Lakes CAF, in the states of Michigan, Illinois, Indiana, Wisconsin, and Minnesota, extends from the shores of Lake Erie, Lake Huron and Lake Superior to include most of central Michigan including the Upper Peninsula, as well as the portions of the northern highlands and eastern ridges and lowlands of Wisconsin. The width of the western half of the CAF region varies dramatically, from only 1 mile wide near Chicago, to a maximum of 100 miles wide in southern Michigan. Elevations throughout the western portion of the CAF are generally higher than in New York and Ohio, averaging between 200 and 400 meters above sea level over much of the area. The greatest elevations between 500 and 750 meters above sea level are found in northern Minnesota and the upper peninsula of Michigan. Wetland habitats within the Great Lakes CAF include freshwater marshes, swamps, bogs, fens, shrub-scrub, and forested wetlands.

Only 7.4% of the Great Lakes CAF is composed of densely populated regions, primarily in the larger cities of Buffalo (New York), Erie (Pennsylvania), Cleveland (Ohio), Detroit, Saginaw and Grand Rapids (Michigan), Chicago (Illinois), Milwaukee, Green Bay and Superior (Wisconsin), and Duluth (Minnesota). These urban areas account for a total of 3,013,250 acres, or 5.5% of the total CAF area. Human population growth from 1990 to 2000 has been less than 1%, increasing from 12,910,134 persons to 12,998,832 persons (ESRI, 2000 and ESRI, 2002). The percentage of federally owned land is relatively high in the Great Lakes CAF, accounting for 7,686,086 acres or 14% of the total area. The largest of these areas are operated as National Forests by the US Forestry Service.

Review of data from existing studies provides some insight as to the historical level of wetland loss within the Great Lakes CAF region. The Great Lakes Information Network reports that more than two-thirds of the natural Great Lakes wetlands have already been filled in or drained for agriculture, urban uses, shoreline development, recreation and resource extraction (GLIN, 2005). NOAA's National Marine Fisheries Service reports on wetland loss through the 1980s within the Great Lakes CAF states (NOAA, 2005). This report indicates that New York and Pennsylvania have lost 60% and 56% of their

original wetland base by the mid 1980s, respectively. Higher losses were reported for Ohio, Indiana, and Illinois, with wetland losses of 90%, 98%, and 85%, respectively. Relatively smaller losses of 50%, 46%, and 42% were determined for Michigan, Wisconsin, and Minnesota, respectively. For the period 1992 to 1997, the US Department of Agriculture (USDA) reports a loss of 74,200 acres of palustrine wetlands and a 48,400 acre gain for the midwestern area of the US, which includes most of the Great Lakes CAF region (USDA, 2005a). Causes for these wetland losses were assigned to the following activities: agriculture (51.9%), silviculture (19.3%), development (28.7%), and miscellaneous (0.1%) (USDA, 2005b). These USDA estimates likely provide reasonable estimates of wetland loss within the Great Lakes CAF as a whole.

Section 3.2 Recent Land Cover Data Summary

Complete land cover datasets were available for the Great Lakes CAF region through both the NLCD 1992 and C-CAP 2001. Figure 3-01 shows the land cover classes mapped based on the NLCD 1992 dataset. The land cover classes were also mapped based on the C-CAP 2001 data and area was calculated for each land cover class using both datasets.

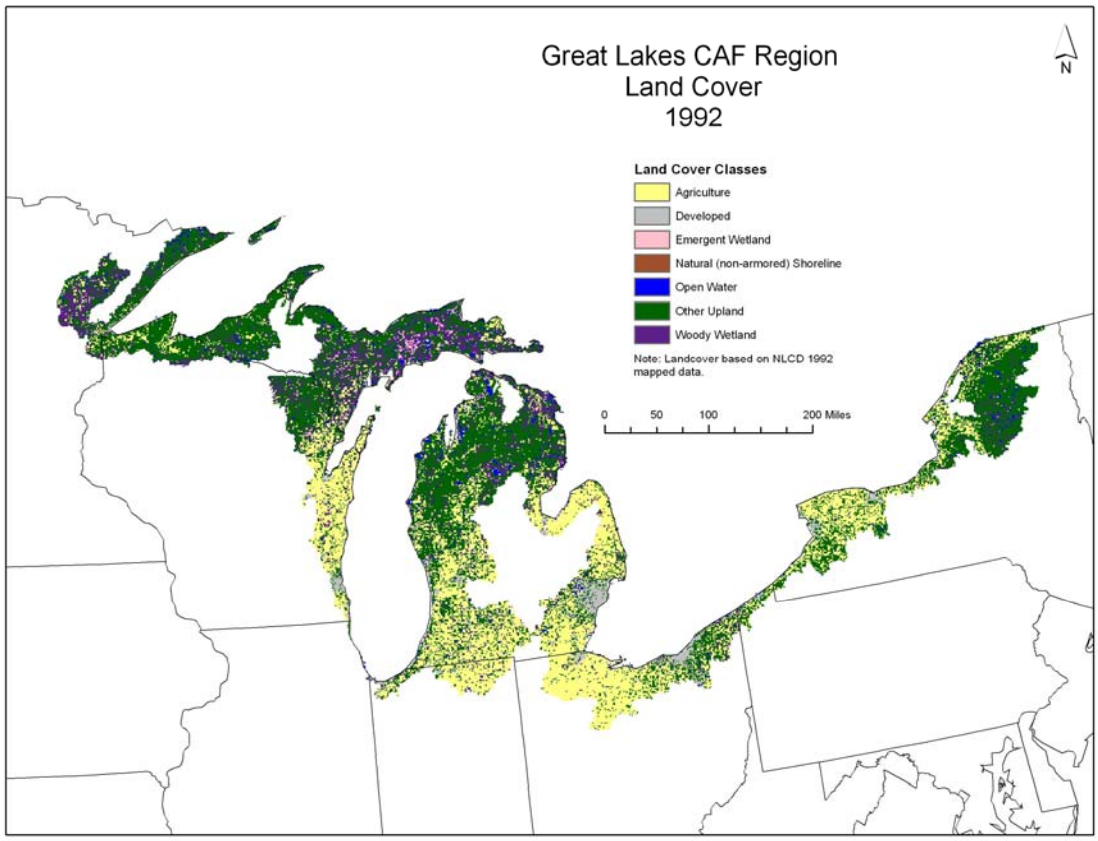


Figure 3-01. Land cover classes for the Great Lakes CAF region, 1992.

Changes within the Great Lakes CAF region from NLCD 1992 classifications to the C-CAP 2001 data show gains in all target habitat groups and other land cover classes with the exception of natural (non-armored) shoreline, open water, and agricultural lands (Table 3-01). This is contradictory to data found within existing studies that show a net wetlands loss. Explanations for the discrepancies can likely be found in differences in dataset resolution and classification methods. As such, these data should be used

primarily to illustrate the relative differences in size between the various target habitat groups and other land cover classes within the Great Lakes CAF, and not to distinguish losses/gains between 1992 and 2001. Based on this information, it is possible to conclude that the other upland class makes up the largest part of the CAF, comprising around 50% of the total CAF area. Agricultural lands make up the next largest part of the CAF, comprising between 20 and 30% of the total CAF area. Wetland areas, including emergent wetlands, woody wetlands, and natural (non-armored) shorelines make up the next largest part of the CAF, averaging between 14 and 17% of the CAF area. Developed lands and open water habitats make up the smallest portion of the CAF, comprising around 4 to 6% and 2% of the total CAF area, respectively.

Table 3-01. Acreage and percent change of land cover classes from 1992 to 2001. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

Great Lakes CAF - Dataset Acreage and Change by Land Cover Classes					
	NLCD92 Acres	**C-CAP01 Acres**	**Change 92-01 Acres**	**Change 92-01 Percent**	**92-00 Gain/Loss**
Wetlands Total	***7,792,973.66***	***9,619,791.36***	***1,826,817.71***	***23.44%[a]***	***gain***
Emergent Wetlands	940,470.97	1,211,759.35	271,288.38	28.85%[b]	gain
Woody Wetlands Total	6,829,426.55	8,399,157.35	1,569,730.80	22.98%[c]	gain
Woody Wetlands (undetermined)	6,829,426.55	0.00	-6,829,426.55	-100.00%	
Shrub-scrub Wetlands	0.00	2,545,768.94	2,545,768.94	100.00%	
Mangroves	0.00	0.00	0.00	0.00%	
Estuarine Forested Wetlands	0.00	0.00	0.00	0.00%	
Palustrine Forested Wetlands	0.00	5,853,388.41	5,853,388.41	100.00%	
Natural (non-armored) Shoreline	23,076.14	8,874.67	-14,201.47	-61.54%[d]	loss
Open Water Total	***1,459,780.56***	***1,481,276.13***	***21,495.58***	***1.47%[e]***	***gain***
Open Water	1,459,780.56	1,388,812.57	-70,967.98	-4.86%	
Aquatic Bed Total	0.00	92,463.56	92,463.56	100.00%	
Aquatic Bed (undetermined)	0.00	0.00	0.00	0.00%	
Palustrine Aquatic Beds	0.00	92,463.56	92,463.56	100.00%	
Estuarine Aquatic Beds	0.00	0.00	0.00	0.00%	
Coral Reefs	0.00	0.00	0.00	0.00%	
Oyster Reefs/Shell Bottom	0.00	0.00	0.00	0.00%	
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	0.00	0.00	0.00	0.00%	
Developed	***2,162,283.24***	***3,271,146.93***	***1,108,863.70***	***51.28%***	***gain***
Agriculture	***18,039,432.61***	***11,533,519.21***	***-6,505,913.41***	***-36.06%***	***loss***
Other Upland	***25,190,644.29***	***28,739,380.72***	***3,548,736.43***	***14.09%***	***gain***
TOTAL	***54,645,114.36***	***54,645,114.36***			

Note: The following footnotes indicate an actual total gain/loss of wetlands or open water habitats of at least/most the indicated amount. These numbers look strictly at change to development which is less likely to be misclassified.

[a] Wetlands total loss of at least .18% (14,204 acres)

[b] Emergent wetlands loss of at least .6% (5689 acres)

[c] Woody wetlands total loss of at least .11% (7591 acres)

[d] Natural shoreline loss of at least 4% (925 acres)

[e] Open water total loss of at least .33% (4813 acres)

Changes in the Great Lakes CAF target habitat groups and land cover classes can be further examined by looking at Table 3-02, which includes percentages of change in wetland and open water habitats due to conversion to development, agriculture, and/or other upland. As shown in the previous Table 3-01, most of the changes show gains in wetland and open water habitat. For example, gains of 22.8% and 4.89% are shown for wetlands and open water habitats, respectively, as the result of conversion from development, agriculture, and/or other upland. Within the wetlands category, the largest gains are shown as a result of conversion from agricultural lands and other upland (6.8% and 16.1%), while a 0.18% loss of wetlands, or 14,204 acres, was found as a result of development. Given that the Great Lakes CAF region has the lowest population growth of all the CAF regions, and the fact that developed lands make up a small percentage of the entire CAF area, this small loss in wetlands due to development seems to be reasonable. Actual gains in wetland area resulting from agricultural and other upland conversion seem unlikely, and may be attributed to the fact that the NLCD 1992 data were based on one date of imagery whereas the C-CAP 2001 data used three dates, thus allowing better detection of wet areas at different times. While fluctuating lake levels may also account for changes between other uplands and wetlands, over the period 1992 to 2001 most of the lakes showed a gradual increase in water levels, followed by a rather sharp decline in water levels to lower than 1992 elevations. Based on this information, we would expect to see wetland loss through conversion to other upland, rather than a gain as shown in Table 3-02, suggesting anomalies in the changes generated from the NLCD 1992 to C-CAP 2001 comparison.

Similar results in Table 3-02 show gains in open water habitats as the result of conversion from developed, agricultural, and other upland habitats. Although these gains are much smaller than those computed for the wetland habitats, showing less than 3% gain for any given conversion, they likely represent spurious findings resulting from the differences in classification schemes. The only conversion that shows an actual loss is for open water habitats conversions to developed land, which shows a loss of 4,813 acres or 0.33%. Given the lower level of development in the Great Lakes CAF region, this value is likely fairly representative of actual conditions.

Table 3-02. Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes from 1992-2001.

Great Lakes CAF Region - Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 92-01 Acres**	**Change 92-01 Percent**	**92-01 Gain/Loss**
Wetlands	Developed, Agriculture, Other Upland	2,420,628.46		
Developed, Agriculture, Other Upland	Wetlands	4,197,151.57		
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		**1,776,523.11**	**22.80%**	**gain**
Open Water Habitats	Developed, Agriculture, Other Upland	124,212.20		
Developed, Agriculture, Other Upland	Open Water Habitats	196,002.38		
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		**71,790.17**	**4.89%**	**gain**

Wetlands	Other Upland	2,283,894.31		
Other Upland	Wetlands	3,542,827.84		
Wetland Habitats Gain/Loss to Other Upland		**1,258,933.53**	**16.15%**	**gain**
Wetlands	Agriculture	71,617.37		
Agriculture	Wetlands	603,411.54		
Wetland Habitats Gain/Loss to Agriculture		**531,794.16**	**6.82%**	**gain**
Wetlands	Developed	65,116.77		
Developed	Wetlands	50,912.19		
Wetland Habitats Gain/Loss to Developed		**-14,204.58**	**-0.18%**	**loss**
Open Water Habitats	Other Upland	96,099.27		
Other Upland	Open Water Habitats	140,771.28		
Open Water Habitats Gain/Loss to Other Upland		**44,672.01**	**3.04%**	**gain**
Open Water Habitats	Agriculture	9,008.10		
Agriculture	Open Water Habitats	40,939.56		
Open Water Habitats Gain/Loss to Agriculture		**31,931.45**	**2.18%**	**gain**
Open Water Habitats	Developed	19,104.83		
Developed	Open Water Habitats	14,291.54		
Open Water Habitats Gain/Loss to Developed		**-4,813.29**	**-0.33%**	**loss**

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

A more detailed breakdown of changes in target habitat groups and land cover classes between 1992 and 2001 for the Great Lakes CAF region can be seen in Table 3-03. This table shows the distribution and change in number of acres between 1992 and 2001. The table also shows the number of acres that remained unchanged over the recent 9 year period represented in the grey cells. Evaluation of the data show significant changes within the wetland habitat groups, as well as from wetlands to other upland. For example, a total of 227,201 acres of emergent wetlands were converted to other upland between 1992 and 2001, and an even greater area of 2,038,883 acres of woody wetlands was converted to other upland. The large conversions within the wetland habitat groups may be representative of actual conditions, as emergent and woody wetlands were naturally succeeded by shrub-scrub and palustrine forested wetlands. However, the succession of over 2 million acres of woody wetlands into other upland, as shown in Table 3-03, is likely an overestimate resulting from different data resolutions and classification schemes between the 1992 and 2001 datasets.

Changes in the non-wet classes to developed and other upland also show significant losses in agricultural lands. Given the high level of general farming and agricultural use within the Great Lakes CAF region, losses of over 5 million acres to other upland during the 1992 to 2001 time period is unlikely. On the other hand, conversions from agricultural to developed land show much smaller losses and are likely representative of the region as whole. Finally, the large changes shown for other upland to shrub-scrub and palustrine forested wetlands are generally not accurate, and most likely an artifact of differences between the two datasets.

Table 3-03. Change matrix for the Great Lakes CAF region representing change in acres between land cover classes from 1992 to 2001. Acreage was estimated based on the NLCD92 and C-CAP 2001 land cover classifications. Values in the gray shaded cells are acres of no change.

Great Lakes CAF Region Land Cover Change NLCD 1992 to C-CAP 2001 (by acres)										
			1992							
			Wetland Habitats			Open Water Habitats	Non-Wet Land Cover			
			Emergent Wetlands	Woody Wetlands	Natural Non-armored) Shoreline	Open Water	Developed	Agriculture	Other Upland	Acreage Totals for 2001 Classification
2001	Wetland Habitats	Emergent Wetlands	176,430.74	442,083.19	839.10	72,392.42	11,091.05	129,091.10	379,831.75	1,211,759.35
		Shrub-scrub Wetlands	207,465.28	1,206,959.62	415.66	49,161.72	12,815.28	190,107.14	878,844.24	2,545,768.94
		Palustrine Forested Wetlands	255,835.05	2,940,477.57	232.63	64,207.18	26,274.40	283,516.31	2,282,845.28	5,853,388.41
		Natural (Non-armored) Shoreline	630.27	396.97	957.41	4,155.00	731.46	696.99	1,306.57	8,874.67
	Open Water Habitats	Open Water	27,885.20	70,705.56	750.81	1,133,067.82	12,447.89	29,978.38	113,976.92	1,388,812.57
		Palustrine Aquatic Beds	10,201.03	30,063.56	15.57	12,584.21	1,843.65	10,961.18	26,794.36	92,463.56
	Non-Wet	Developed	16,780.58	46,680.02	1,656.17	19,104.83	1,496,625.16	967,573.79	722,726.38	3,271,146.93
		Agriculture	18,041.56	53,176.84	398.98	9,008.10	75,440.56	10,483,299.04	894,154.13	11,533,519.21
		Other Upland	227,201.26	2,038,883.22	17,809.83	96,099.27	525,013.79	5,944,208.69	19,890,164.66	28,739,380.72
		Acreage Totals for 1992 Classification	940,470.97	6,829,426.55	23,076.14	1,459,780.56	2,162,283.24	18,039,432.61	25,190,644.29	**54,645,114.36**

Section 3.3 Transect Analysis Results

Section 3.3.1 Chicago, IL Transect

Transect Location

The location of the Chicago, IL transect in the Great Lakes CAF region is illustrated in Figure 3-02. The placement of the transect can be seen in more detail in Figure 3-03. This transect spans the South Chicago area, starting in Calumet Harbor in Lake Michigan, and extends in a southwest direction across Lake Calumet towards the town of Harvey, Illinois. The transect includes portions of the Calumet River, Calumet Harbor, the Little Calumet River, and the Cal-Sag Channel. The confluence of the Calumet River and Lake Michigan form the central part of Calumet Harbor, which is protected by two breakwaters, and which serves as a major port and transportation area for southern Lake Michigan. Most of the shoreline areas within the Calumet Harbor portion of the transect are protected with seawalls and bulkheads serving primarily commercial uses. Further inland towards Lake Calumet, the river has been historically dredged and straightened, and is now lined with docks, bulkheads and other shore protection structures. The Calumet River area has a long history of alteration by man, starting in the early 1900s, as communities throughout the southern Lake Michigan region expanded with industrial growth. During this time, the low-lying wetland and shallow lake areas in the Calumet region that had been formed as prehistoric Lake Chicago slowly receded were used for dumping grounds for industrial and municipal waste. In addition, as part of development of the Illinois Waterway System, the Cal-Sag Channel was dredged to connect the Calumet River to the larger waterway system and the Chicago area. This alteration reversed the flow of the river away from Lake Michigan, a change that still exists today. Over the years, much of Lake Calumet was filled in and parts of the river have been dredged and or reconfigured. As such, many of the original wetlands have been destroyed; however, remnants of the wetlands can still be found.

In general, the Chicago transect provides a poor representation of habitat conditions in the Great Lakes CAF region. The transect contains a much higher percentage of commercial, industrial, and transportation facilities than most other portions of the CAF, with the exception of the larger metropolitan areas of Buffalo, Detroit, Milwaukee, Cleveland, and Toledo. In addition, land use within the Chicago transect dramatically under represents the agricultural and forested habitats that make up most of the non urban parts of the Great Lakes CAF. As such, the distribution of target habitats, as well as the ecological and anthropogenic pressures on the habitats, are likely quite different between the Chicago transect and the CAF region as a whole. A description of the Chicago, Illinois transect using the condition variables listed in Section 3.1 is given below, along with a discussion of changes in habitat area as seen over two different time periods, recent (1992 to 2001) and historical (1938 to 2001).

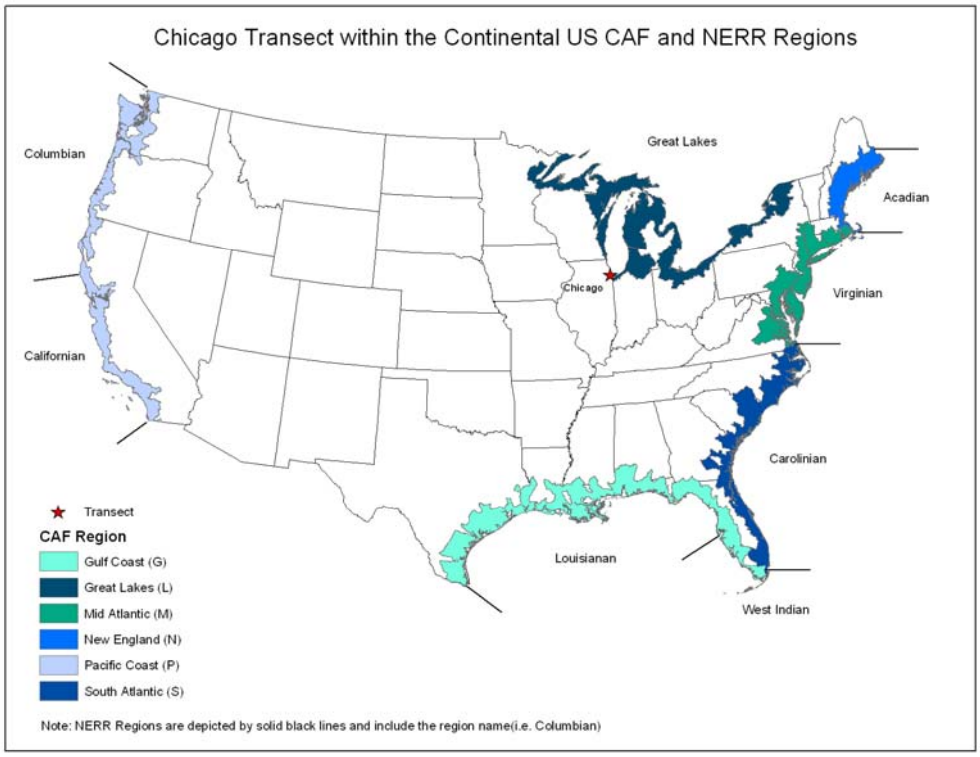


Figure 3-02. Location of Chicago, IL transect within Great Lakes CAF region.

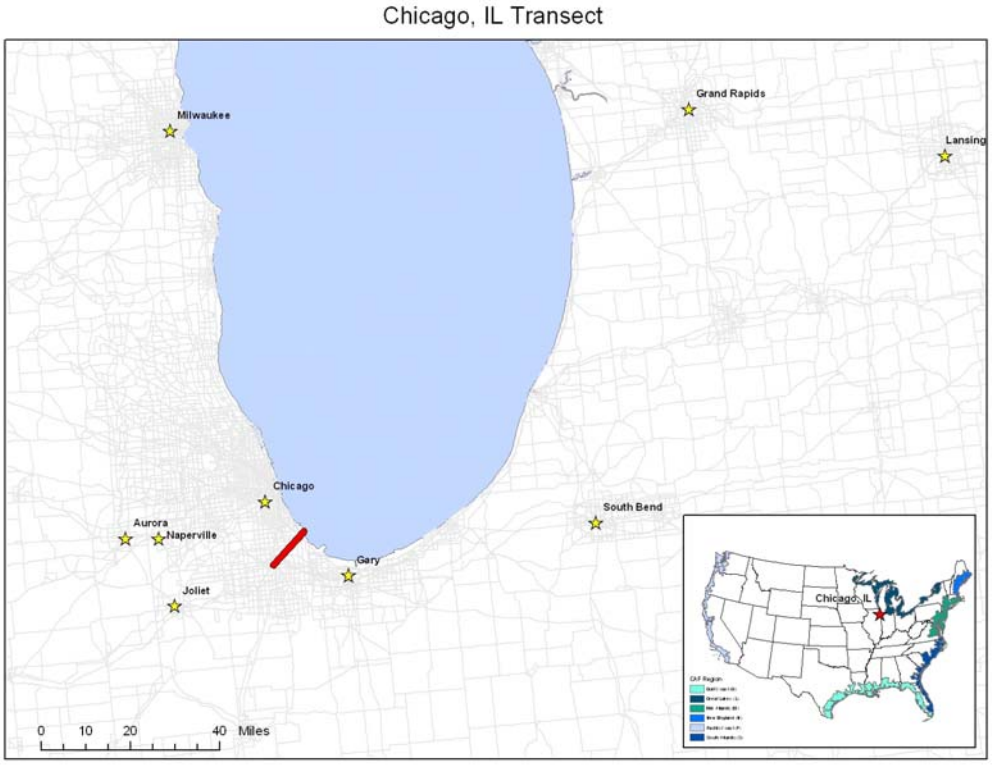


Figure 3-03.Chicago, IL transect placement. Transect is mapped in red.

Transect Description

I. Distance to Coast
   a. The Chicago, Illinois transect is located perpendicular to the coast line, and generally follows the axis of the Calumet River system. As such, the types of wetlands present within the transect will be representative of most nearshore and fluvial wetlands throughout much of the Great Lakes CAF.
   b. Anthropogenic pressures on wetlands of the Chicago transect have been significant, resulting primarily from commercial and industrial development. These pressures are likely much greater within the Chicago transect than elsewhere in the CAF region, and as such, wetland losses caused by development pressures will be greater for the Chicago transect.
   c. The wide boundaries of the CAF suggest that attempts to characterize the CAF with one or two transects that do not adequately represent the distribution of wetland types and are apt to be both imprecise and inaccurate.

II. Salinity
   a. The Chicago transect is located exclusively in a freshwater system and salinity is not a factor in controlling wetland distributions.

III. Topography/Elevation Range
   a. Elevations values within the Chicago transect range from 175 to 180 meters above sea level, with little change in elevation from the coast inland.
   b. Elevations at the Chicago transect are generally representative of nearshore elevations nearest the coastline, approximately 2 to 17 miles inland, throughout Lake Michigan, Lake Huron, and Lake Erie. In Lake Ontario, near coast elevations are lower and give rise to a more steeply sloping topography, ranging in elevation from 50 to 200 meters above sea level over approximate distances of 10 to 20 miles inland. Near coast elevations in Lake Superior are also quite different than those in the Chicago transect, as the Lake Superior elevations rise rather steeply from about 180 meters above sea level to 200-400 meters above sea level over inland distances of 5 to 10 miles.

IV. Proximity to City
   a. The Chicago transect is located in one of the six largest urban areas within the CAF. As these urban areas account for only 5.5% of the total CAF area, development within the transect is not representative of trends in most other areas of the CAF.
   b. The population density in the greater Chicago area is estimated to be 5,685 people per square mile, which is roughly equal to the average population density of the other large cities within the Great Lakes CAF; however, it is significantly greater than the average population density within the entire CAF. As such, the loss of wetlands within the Chicago transect as related to human population growth will be an overestimate for the entire CAF.
   c. Population growth in the Chicago transect was relatively low over the ten year period between 1990 and 2000, showing an approximate 5 to 10%

increase in the number of people. Despite the low growth rate for the transect, it is still higher than the average growth rate of 0.68% for the entire CAF region. Overall, then the Chicago transect overestimates the average growth rate in the CAF, suggesting that the transect data will also overestimate the loss of wetlands due to human development.

V. Land Ownership

a. There is no federally owned property within the Chicago transect area; most of the land in the transect is owned by private, state, or municipal interests.

VI. Dominant Land Uses

a. The largest percentage of land within the Chicago transect is classified as urban or developed (approximately 75%). These urban areas are dispersed evenly throughout the transect area. Other land use types within the transect include residential, agricultural, and open water areas.
b. As compared with land use throughout the Great Lakes CAF, the Chicago transect shows a significantly higher percentage of urban or built-up land. Overall, throughout the CAF region the percentage of urban or built-up land is only 5.48%, as compared with the nearly 75% for the Chicago transect. This will likely have the result of showing greater wetland loss of the Chicago transect due to urban development.
c. In addition, the Chicago transect shows significantly less forest land and agricultural land use than is represented by the entire CAF region. This should underestimate the loss of wetlands as a result of agricultural conversion.

VII. Extent of Shoreline Armoring

a. Most of the shoreline areas within the Chicago transect are armored with shore protection structures such as bulkheads, seawalls, retaining walls, and revetments. These structures have been installed to support the heavy industrial uses of the area.
b. While the heavy shoreline armoring within the Chicago transect is characteristic of the other large urban cities located on the Great Lakes, it is not representative of the degree of shore protection found throughout the remaining portions of the Lakes region. Most of the non urban portions of the Great Lakes shorelines are natural sandy beaches, forested shorelines, or cliffed banks. This will likely result in lower wetland losses for the Chicago transect than are occurring throughout the CAF, as many of the more natural shorelines and wetlands in the CAF are disappearing due to erosion.

VIII. Shipping

a. The Chicago transect contains the Calumet Harbor area, which is a major center for shipping and commerce that was originally authorized by the US Army Corps of Engineers in 1899. Shipping activities extend from the entrance of Calumet Harbor, through the Calumet River to Lake Calumet, and through the Cal-Sag Channel to the Illinois Waterway Project.

b. Principal commodities transported through the Chicago transect include taconite, limestone, cement, chemical fertilizers, petroleum products, grains, steel, salt and miscellaneous freight.
c. The Great Lakes region has approximately 26 major port facilities spread throughout the five lake areas. Despite this large number of port facilities, the high level of shipping within the Chicago transect likely results in greater wetland loss from dredging as well as construction and/or maintenance of port facilities (e.g., docks, over water structures) than occurs on average within the entire CAF region. In addition, degradation of wetland habitats is likely greater within the Chicago transect, due to reduced water quality from boat wastes and upland runoff as well as introduction of invasive plant and/or animal species.

IX. Dredging.

a. The Chicago transect covers a number of open water bodies that have historically been dredged for navigation purposes. The earliest dredging of the harbor began in 1899, and has continued since this time. Dredging of both the Calumet River and the harbor portion of the area take place approximately every 2 to 5 years.
b. Extensive dredging and filling of Lake Calumet has occurred historically over the years, primarily as the result of industrial and development activities. These projects have resulted in removal and/or burial of wetland resources during the actual dredging and also during disposal of the dredged materials.
c. Likely disposal sites for the dredged materials have been offshore, nearshore in harbor areas, nearshore upland fill, or remote upland sites. Adverse impacts to wetlands from dredging have likely occurred from increased turbidity and changes in sediment substrata.
d. Major dredging projects are routinely conducted in many other coastal areas within the Great Lakes CAF region, ranging from the larger sites like Buffalo, Detroit, and Milwaukee, to the smaller harbors and rivers where recreational boating is common. As such, impacts from dredging on wetlands within the Great Lakes CAF region is represented reasonably well by the changes observed in the Chicago transect.

X. Major Natural Disasters

a. Tornados and droughts are the only natural disasters that affect the Chicago transect. These disaster types have impacts both socially, economically, and environmentally.
b. Wetland impacts from tornados are generally minimal on wetland habitats; however wetland impacts from drought conditions can be significant. Droughts can cause a lowering of the groundwater table resulting in a loss of wetland habitat, as well as a natural progression towards woody and forested wetlands.

Recent Transect Maps

Figures 3-04 shows the 1998 Digital Orthophoto Quarter Quadrangles (DOQQs) of the Chicago, IL transect. The DOQQs were used as a visual reference for interpreting recent land cover. Figure 3-05 and 3-06 depict the changes in wetland habitats and open water habitats from 1992 to 2001 respectively. The wetlands change map shows areas that changed from wetland to non-wetland classes and non-wetland to wetland classes. Likely, the open water change map displays open water to non-open water classes and non-open water to open water classes. These maps are helpful in determining where wetlands and open water habitat changes occurred and which classes they changed between.

Figure 3-04. 1998 DOQQ of Chicago, IL transect

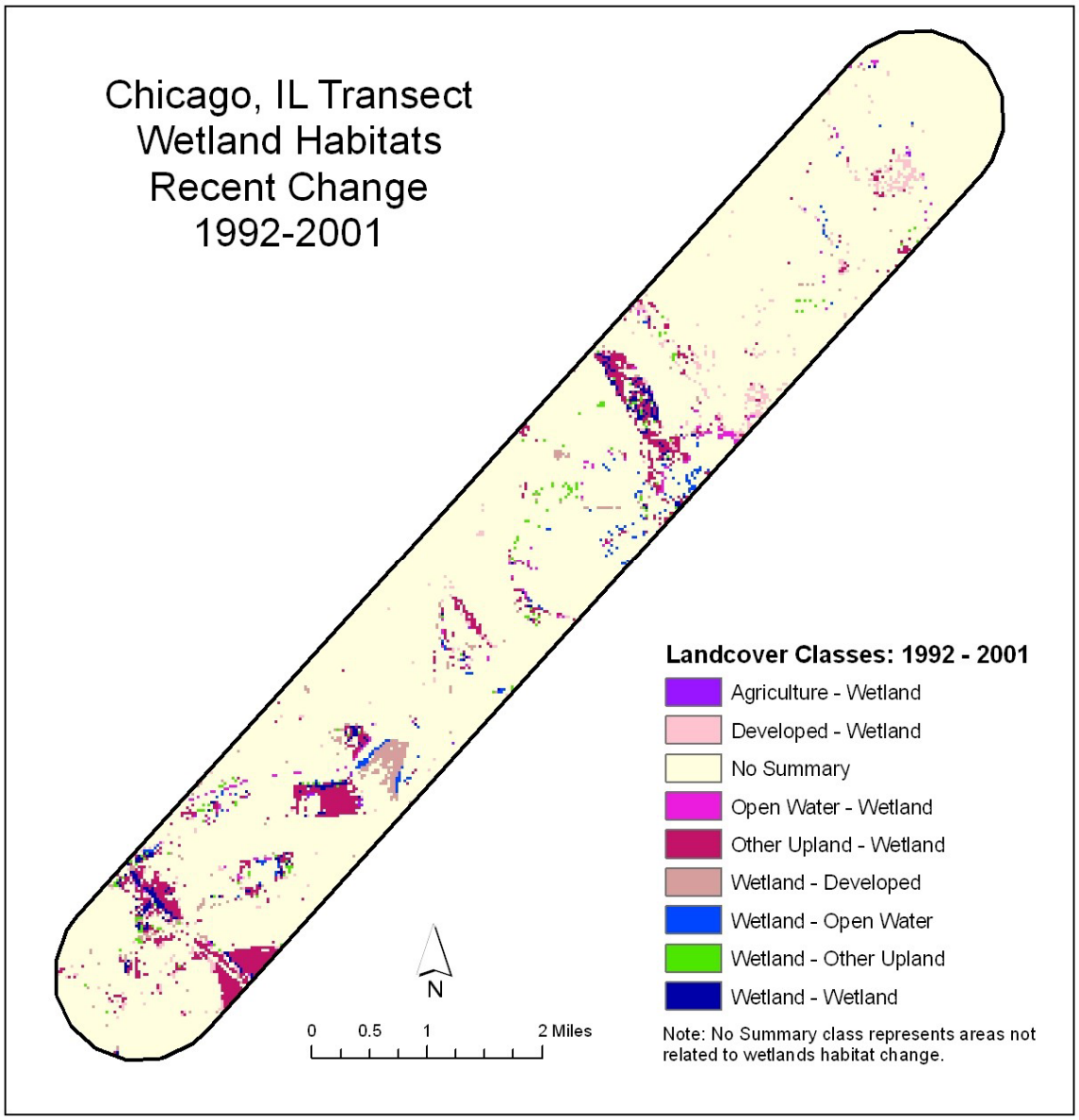


Figure 3-05. Wetland change from 1992-2001, Chicago, IL transect.

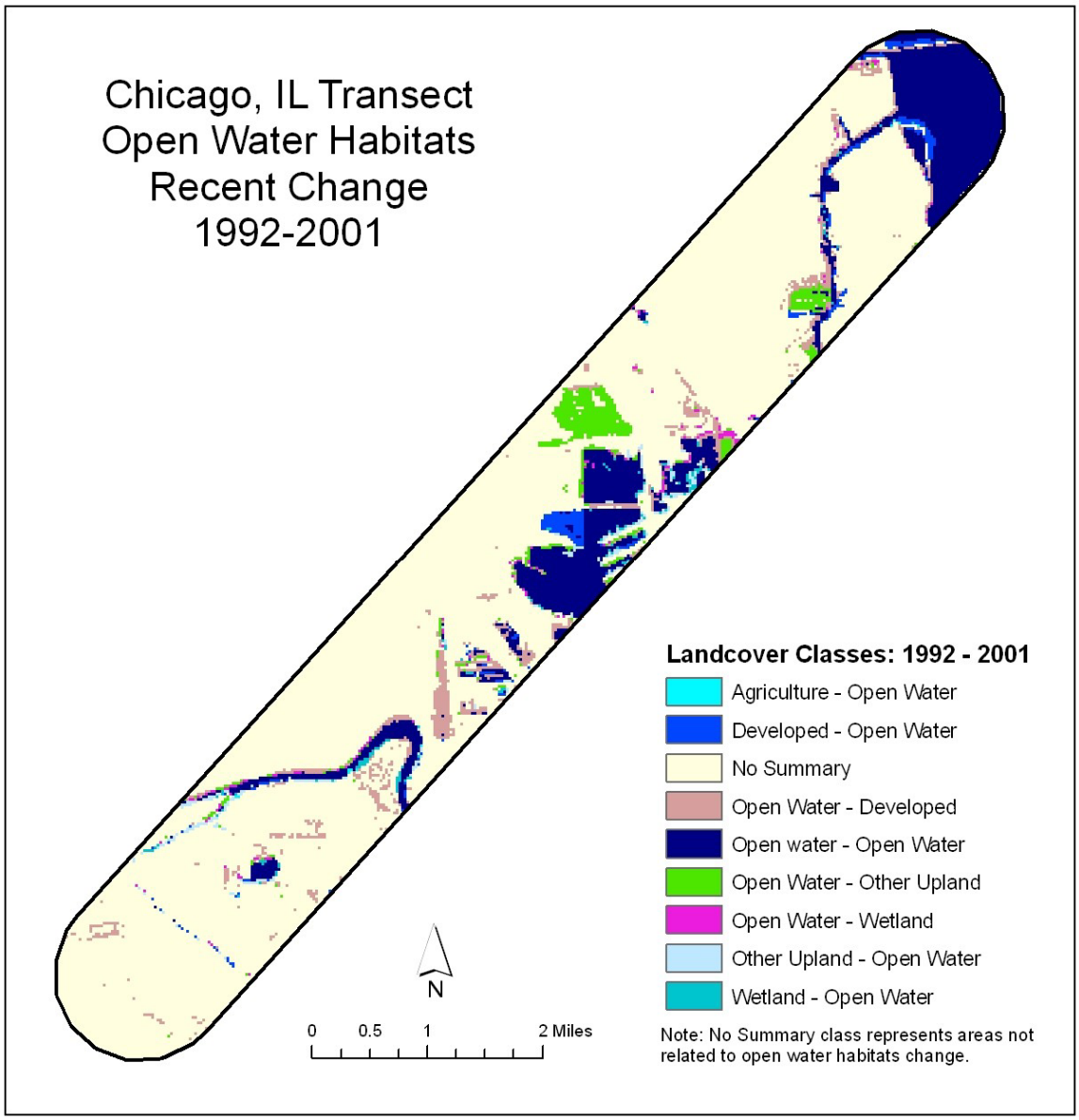


Figure 3-06. Open Water change from 1992-2001, Chicago, IL transect.

<u>Recent (1992 – 2001) Change Tables</u>

The datasets analyzed for this recent change included an overlay of the NLCD 1992 data with C-CAP data from 2001. Overall, the Chicago transect contains approximately 10,756 acres of habitat. Comparison between the 1992 and the 2001 datasets show several changes in a number of habitat groups (Table 3-04). Most of the wetland habitat classes show a gain in total area, including wetlands total, emergent wetlands, and woody wetlands. Gains of 100% are also shown in Table 3-04 for shrub-scrub wetlands, palustrine forested wetlands, and natural (non-armored) shoreline; however, these should not be considered actual increases as they are the result of different classification schemes between the two different data sources. For example, the NLCD 1992 data does not map "shrub-scrub and forested wetlands", or natural (non-armored) shoreline, while the C-CAP 2001 data did map these. As a result, the change in area for these three target

habitat groups shows an erroneous 100% gain. These differences in classification also impact the changes shown for the more general class of woody wetlands by overestimating a gain of 275% or 473 acres. Again, this should not be considered a true gain of 275% for woody wetlands, but rather an overestimate. Emergent wetlands show a 3.97% gain between the 1992 and 2001 datasets, accounting for a total of 6.89 new acres of emergent wetlands. This change is small enough to be considered within the error of the analysis, but may also represent a real change caused by changes in lake levels. Finally, the 139% gain in the wetlands totals is likely an overestimate resulting from classification and resolution issues with the two datasets; however, several areas of the transect show large changes in wetland area which may account for some of the wetland gain. An increase in wetlands occurred in the shoreline area immediately south of the entrance to Calumet Harbor and to the north of Lake Calumet, while a large reduction in wetland occurred around the bend in the Little Calumet River. Further review of the tables in this section may help to shed some light on the validity of the wetland change numbers.

For the overall open water total the data show a loss of open water habitats of approximately 463 acres, or -20.98%. This summarized value likely provides a reasonable estimate of the actual change, as large areas along the northern edge of Lake Calumet were converted to a golf course and thus classified as other upland. Other smaller losses in open water were also seen along the Calumet River between the Harbor and Lake Calumet; however, these may be more a result of differences in classification between the two datasets.

Review of Table 3-04 shows a gain in developed land over the 1992 to 2001 time period, amounting to a 15.76% gain or 874 acres. This value likely provides an overestimate of the increase in developed lands, as the differences between the 1992 and 2001 datasets resulted in fewer instances of identification of developed lands in the 1992 dataset, and a greater area of developed land in the 2001 dataset. Changes in agricultural land are shown as a loss of 102 acres or 100% of the 1992 land area. This value provides an overestimate of losses in agricultural land, likely due to differences in classification. In reality, little to no change can be expected in agricultural land within the Chicago transect, as very little of this class has existed in the transect area for a number of decades. Finally, the other upland class shows a loss in acreage, on the order of 30.9% or 789 acres. Most of these changes are due to conversion of other upland to palustrine forested wetland near the southwest end of the transect, below the Cal-Sag Channel. While it is certainly possible that these upland areas converted to forested wetlands over the nine-year study period, it is more likely that the 30% loss is overestimated due to the scales and resolution in which the datasets were mapped.

Table 3-04 Acreage and percent change of land cover classes from 1992 – 2001. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

Chicago, IL Transect - Dataset Acreage and Change by Land Cover Classes					
	NLCD92 Acres	**C-CAP01 Acres**	**Change 92-01 Acres**	**Change 92-01 Percent**	**92-01 Gain/Loss**
Wetlands Total	***345.16***	***826.64***	***481.48***	***139.50%[a]***	***gain***
Emergent Wetlands	173.47	180.36	6.89	3.97%[b]	gain
Woody Wetlands Total	171.69	645.17	473.48	275.78%[c]	gain
Woody Wetlands (undetermined)	171.69	0.00	-171.69	-100.00%	
Shrub-scrub Wetlands	0.00	155.45	155.45	100.00%	
Mangroves	0.00	0.00	0.00	0.00%	
Estuarine Forested Wetlands	0.00	0.00	0.00	0.00%	
Palustrine Forested Wetlands	0.00	489.71	489.71	100.00%	
Natural (non-armored) Shoreline	0.00	1.11	1.11	100.00%	
Open Water Total	***2,208.83***	***1,745.35***	***-463.47***	***-20.98%[d]***	***loss***
Open Water	2,208.83	1,745.35	-463.47	-20.98%	loss
Aquatic Bed Total	0.00	0.00	0.00	0.00%	
Aquatic Bed (undetermined)	0.00	0.00	0.00	0.00%	
Palustrine Aquatic Beds	0.00	0.00	0.00	0.00%	
Estuarine Aquatic Beds	0.00	0.00	0.00	0.00%	
Coral Reefs	0.00	0.00	0.00	0.00%	
Oyster Reefs/Shell Bottom	0.00	0.00	0.00	0.00%	
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	0.00	0.00	0.00	0.00%	
Developed	***5,545.86***	***6,419.87***	***874.01***	***15.76%***	***gain***
Agriculture	***102.97***	***0.00***	***-102.97***	***-100.00%***	***loss***
Other Upland	***2,553.32***	***1,764.26***	***-789.06***	***-30.90%***	***loss***
TOTAL	***10,756.13***	***10,756.13***			

Note: The following footnotes indicate an actual total gain/loss of wetlands or open water habitats of at least/most the indicated amount. These numbers look strictly at change to development which is less likely to be misclassified.

[a] Wetlands total gain of at most 16.3% (56 acres)

[b] Emergent wetlands loss of at least 11.5% (20 acres)

[c] Woody wetlands total gain of at most 44.44% (76 acres)

[d] Open water total loss of at least 14% (308 acres)

The potential causes for these changes in the target habitat groups and other land cover classes can be further examined by looking at Table 3-05, which includes percentages of change in wetland and open water habitats due to conversion to development, agriculture, and/or other upland. These data show a net gain of 475.7 acres of wetland habitat from non-wet classes, which translates to a gain of 137.83%. Of this gain, nearly all (119%) can be attributed to conversion from other upland, while only 1.61% comes from agricultural conversion, and 16.3% comes from developed lands. As described previously, much of this conversion from other upland to wetland habitat occurred in the southwest portion of the transect along the Little Calumet River. Since there is no evidence of any major wetlands restoration projects in this area, and anthropogenic pressures are not likely responsible for the conversion from upland to wetland, this large

gain in wetlands is likely erroneous, resulting from differences in habitat classification between the two datasets.

Table 3-05 also shows a loss of approximately 20.7% of open water habitats (457 acres) due primarily to conversion to other upland (6.92%) and developed land (13.9%). These values are likely representative of actual changes in open water habitats, resulting from increased development such as the large golf course at Lake Calumet and other anthropogenic development pressures.

Table 3-05. Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes from 1992-2001.

Chicago, IL Transect - Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 92-01 Acres**	**Change 92-01 Percent**	**92-01 Gain/Loss**
Wetlands	Developed, Agriculture, Other Upland	187.92		
Developed, Agriculture, Other Upland	Wetlands	663.63		
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		**475.70**	**137.83%**	**gain**
Open Water Habitats	Developed, Agriculture, Other Upland	712.33		
Developed, Agriculture, Other Upland	Open Water Habitats	254.64		
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		**-457.69**	**-20.70%**	**loss**
Wetlands	Other Upland	59.60		
Other Upland	Wetlands	473.48		
Wetland Habitats Gain/Loss to Other Upland		**413.88**	**119.91%**	**gain**
Wetlands	Agriculture	0.00		
Agriculture	Wetlands	5.56		
Wetland Habitats Gain/Loss to Agriculture		**5.56**	**1.61%**	**gain**
Wetlands	Developed	128.32		
Developed	Wetlands	184.59		
Wetland Habitats Gain/Loss to Developed		**56.27**	**16.30%**	**gain**
Open Water Habitats	Other Upland	255.75		
Other Upland	Open Water Habitats	102.75		
Open Water Habitats Gain/Loss to Other Upland		**-153.01**	**-6.92%**	**loss**
Open Water Habitats	Agriculture	0.00		
Agriculture	Open Water Habitats	3.56		
Open Water Habitats Gain/Loss to Agriculture		**3.56**	**0.16%**	**gain**
Open Water Habitats	Developed	456.58		
Developed	Open Water Habitats	148.34		
Open Water Habitats Gain/Loss to Developed		**-308.24**	**-13.94%**	**loss**

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

A more detailed breakdown of changes between 1992 and 2001 for the Chicago transect can be seen in Table 3-06. This table shows the distribution and change in number of acres between 1992 and 2001. The table also shows the number of acres that remained unchanged over the recent nine-year period. These data support the findings from Table 3-05, which indicate that the greatest changes in the transect occurred within the other upland category. More specifically, large conversions were seen from other upland to developed land (1089 acres) and to forested wetlands (328 acres); however, these values should be considered high, resulting from differences in habitat classification and dataset resolution. Within the wetland category, approximately 108 acres of emergent wetlands were lost to developed lands and other upland, while around 77 acres of woody wetlands were lost to these same non-wet classes. These values likely provide an accurate representation of wetland changes within the Chicago transect. Changes shown for the open water habitat indicate a total of 711 acres lost due to development (456 acres) and other upland (255 acres). Work around Lake Calumet to construct a new golf course can account for much of the conversion to other upland and thus likely provides a good estimate for losses to other upland; however, the open water losses to development should be considered an upper limit.

Recent (1992 – 2001) Change Summary

Overall, the nine-year period between 1992 and 2001 for the Chicago transect saw a loss in the wetland target habitat classes of emergent wetlands and woody wetlands on the order of 108 acres and 77 acres respectively. These habitat classes were lost to increases in developed lands as well as other upland. Considerably larger areas of open water were lost to development and other upland, at 456 acres and 255 acres, respectively. Overall, the transect data show a loss of 20.7% of the original open water habitats from 1992; however, due to scale, image resolution and classification issues, this value should likely be reduced to approximately 7 to 10%, more closely approximating the losses due to conversion to other upland. Within the non-wet classes, few real changes in agriculture were seen in the Chicago transect, primarily a result of the minimal use of agricultural land. Finally, the loss of over 1,000 acres of other upland to developed land should be considered an upper limit, with a more realistic approximation closer to 250 to 500 acres. The smaller losses are consistent with the relatively low population growth in this area, while the larger loss is likely an overestimate caused by differences in dataset resolution and scale.

Table 3-06. Change matrix representing change in acres between land cover classes from 1992 to 2001. Values in gray shaded cells represent acres of no change.

Chicago, IL Land Cover Change NLCD 1992 to C-CAP 2001 (by acres)									
		1992							
			Wetland Habitats		Open Water Habitats	Non-Wet Land Cover			
			Emergent Wetlands	Woody Wetlands	Open Water	Developed	Agriculture	Other Upland	Acreage Totals for 2001 Classification
2001	Wetland Habitats	Emergent Wetlands	5.56	22.46	10.67	64.05	0.89	76.73	180.36
		Shrub-scrub Wetlands	6.45	9.34	27.80	43.14	0.44	68.28	155.45
		Palustrine Forested Wetlands	13.12	44.26	22.68	77.17	4.00	328.48	489.71
		Natural (Non-armored) Shoreline	0.00	0.00	0.67	0.22	0.22	0.00	1.11
	Open Water Habitats	Open Water	40.03	16.01	1,434.67	148.34	3.56	102.75	1,745.35
	Non-Wet Land Cover	Developed	84.29	44.03	456.58	4,688.97	56.27	1,089.73	6,419.87
		Other Upland	24.02	35.58	255.75	523.96	37.58	887.36	1,764.26
		Acreage Totals for 1992 Classification	173.47	171.69	2,208.83	5,545.86	102.97	2,553.32	**10,756.13**

Historical Transect Maps

Figure 3-07 shows the 1938 aerial photos of the Chicago, IL transect. The 1938 aerial photography was used to classify land cover for the historic time period. Figures 3-08 and 3-9 depict the changes in wetland habitats and open water habitats from 1938 to 2001 respectively. The wetlands change map shows areas that changed from wetland to non-wetland classes and non-wetland to wetland classes. Similarly, the open water change map displays open water to non-open water classes and non-open water to open water classes. These maps are helpful in determining where wetlands and open water habitat changes occurred and which classes they changed between.

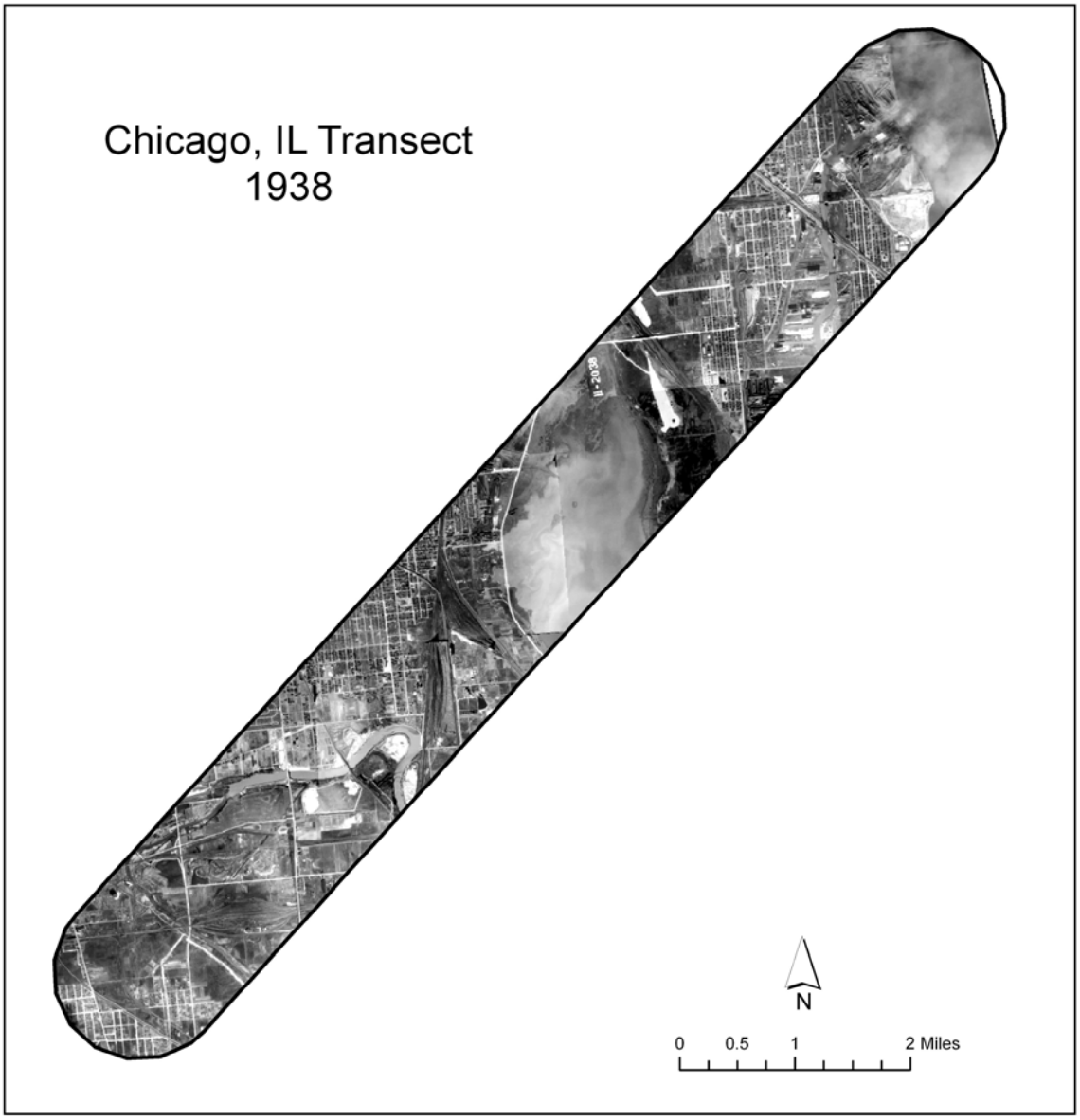


Figure 3-07 1938 Aerial photos of Chicago, IL transect.

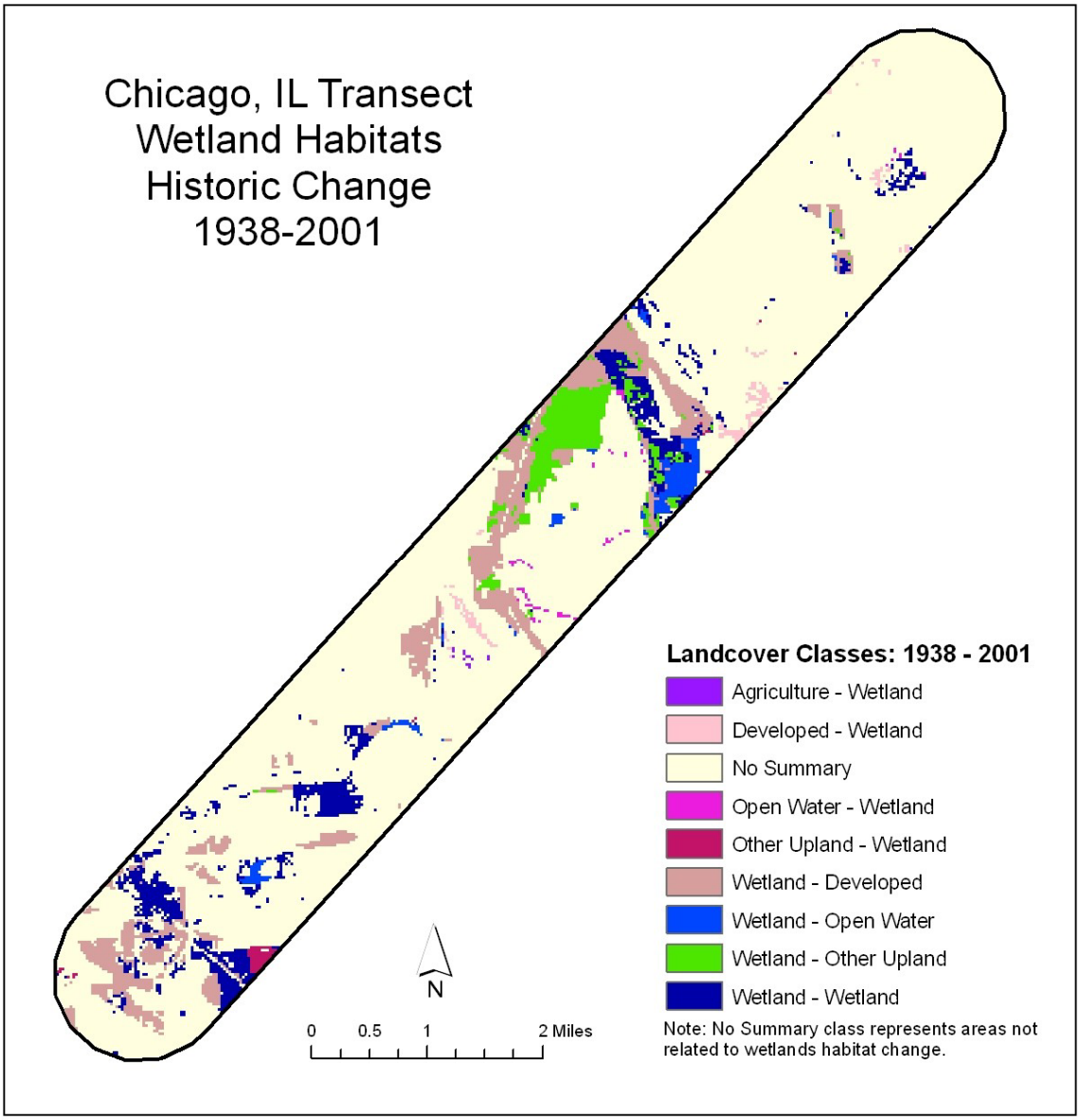


Figure 3-08. Wetland change from 1938-2001, Chicago, IL transect.

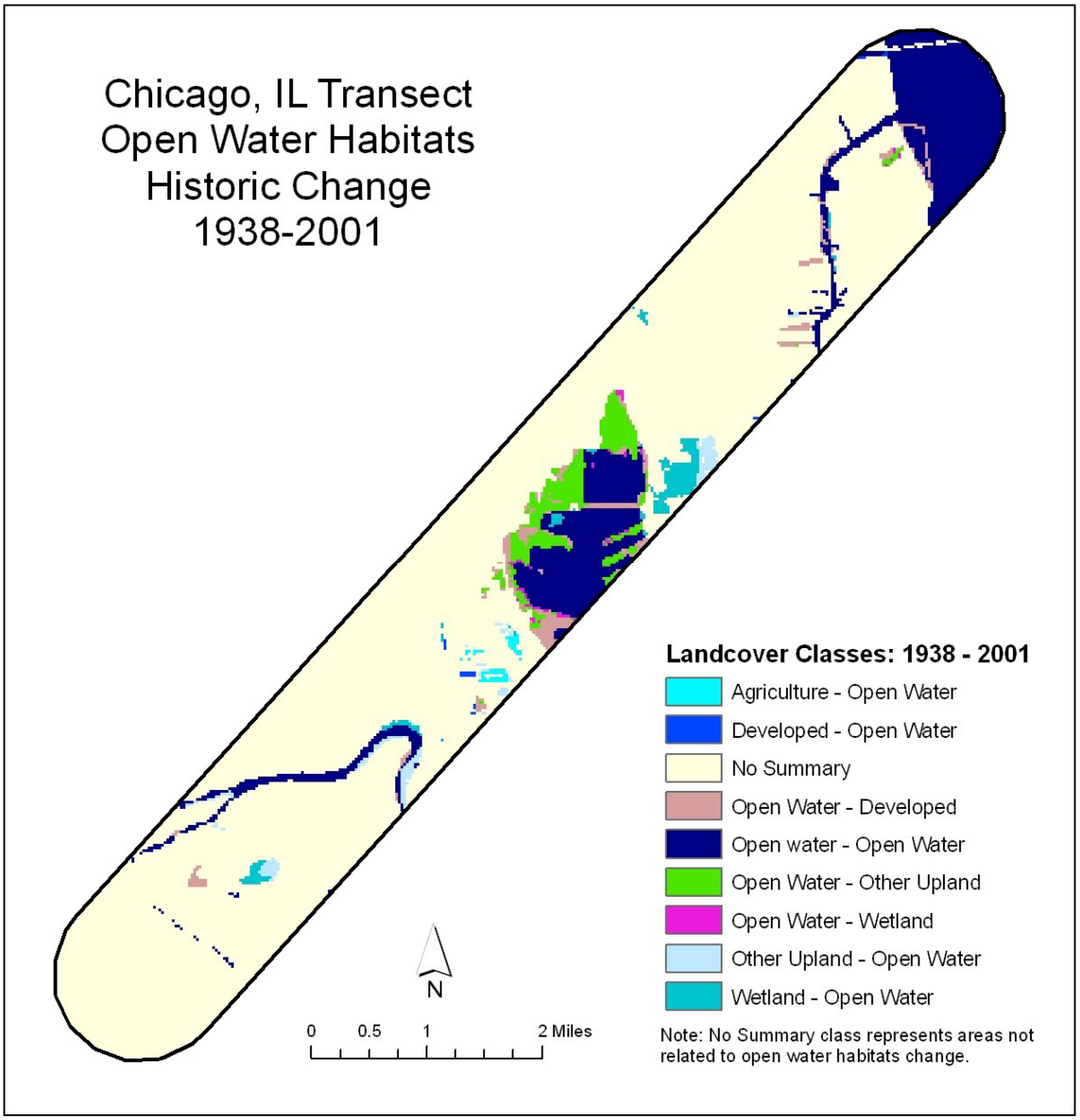


Figure 3-09. Open water change from 1938-2001, Chicago, IL transect.

Historical (1938 – 2001) Change Tables

The datasets analyzed for this historical change included an overlay created from aerial photographs from 1938 with C-CAP data from 2001. Comparison between the 1938 and 2001 datasets shows several significant changes in target habitat groups (Table 3-07). In general, the data shows a loss of wetland and open water habitats along with a gain in developed lands. Within the wetlands total, losses were experienced in emergent wetlands, shrub-scrub wetlands, and natural (non-armored) shorelines, on the order of 88.16%, 66.31%, and 97.53%, respectively. The most significant losses were seen in emergent wetlands which recorded a loss of 1,339 acres, primarily in the vicinity of Lake Calumet and to the south of Little Calumet River. Although such significant losses seem extraordinary, they are likely reliable given the large degree of industrialization and man-induced alterations that have taken place within the transect. Smaller overall losses of

shrub-scrub wetlands (235 acres) were associated with the alterations around Lake Calumet. Losses in natural (non-armored) shoreline should generally be considered insignificant as they only represent 17 acres, and are likely within the error associated with the analysis procedures. Also, within the wetland target habitat groups, an actual gain was recorded in the palustrine forested wetlands group, on the order of 174% or 288 acres. As found with the more recent time period, this rather significant gain shown by the data is likely the result of erroneous classification of palustrine forested wetland in the 2001 dataset in the vicinity of Little Calumet River. While a natural progression from woody and/or shrub-scrub wetlands to forested wetlands can be expected, a much lower gain on the order of 10 to 20% is more likely. Because the woody wetlands total is influenced by changes found within the palustrine forested wetlands, the gain of 10.22% most likely is erroneous.

Changes in open water habitat within the Chicago transect are shown to be on the order of an 11.98% loss, or 240 acres. Most of this loss occurred around the fringes of Lake Calumet, where development of a golf course and a number of shipping facilities has required filling of open water habitat areas. Within the non-wet classes, developed lands showed a gain of 83.55% or 2,954 acres, while both agricultural and other upland showed overall losses. The gain in developed land over the sixty-three-year period between 1938 and 2001 likely provides a good estimate given the high degree of industrialization and population growth within the Chicago transect. High losses in agricultural lands and other upland are also likely reasonable given the heavy development of the area.

Table 3-07. Acreage and percent change of land cover classes from 1938 – 2001. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

Chicago, IL Transect - Dataset Acreage and Change by Land Cover Classes					
	HIST38 Acres	**C-CAP01 Acres**	**Change 38-01 Acres**	**Change 38-01 Percent**	**38-01 Gain/Loss**
Wetlands Total	***2,057.82***	***753.47***	***-1,304.35***	***-63.38%*** [a]	***loss***
Emergent Wetlands	1,519.85	179.92	-1,339.93	-88.16% [b]	loss
Woody Wetlands Total	519.96	573.11	53.15	10.22% [c]	gain
Woody Wetlands (undetermined)	0.00	0.00	0.00	0.00%	
Shrub-scrub Wetlands	354.50	119.43	-235.07	-66.31% [d]	loss
Mangroves	0.00	0.00	0.00	0.00%	
Estuarine Forested Wetlands	0.00	0.00	0.00	0.00%	
Palustrine Forested Wetlands	165.46	453.69	288.22	174.19% [e]	gain
Natural (non-armored) Shoreline	18.01	0.44	-17.57	-97.53% [f]	loss
Open Water Total	***2,008.67***	***1,768.04***	***-240.63***	***-11.98%*** [g]	***loss***
Open Water	2,008.67	1,768.04	-240.63	-11.98%	loss
Aquatic Bed Total	0.00	0.00	0.00	0.00%	
Aquatic Bed (undetermined)	0.00	0.00	0.00	0.00%	
Palustrine Aquatic Beds	0.00	0.00	0.00	0.00%	
Estuarine Aquatic Beds	0.00	0.00	0.00	0.00%	
Coral Reefs	0.00	0.00	0.00	0.00%	

	HIST38 Acres	C-CAP01 Acres	Change 38-01 Acres	Change 38-01 Percent	38-01 Gain/Loss
Oyster Reefs/Shell Bottom	0.00	0.00	0.00	0.00%	
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	0.00	0.00	0.00	0.00%	
Developed	***3,536.97***	***6,491.93***	***2,954.96***	***83.55%***	***gain***
Agriculture	***252.20***	***0.00***	***-252.20***	***-100.00%***	***loss***
Other Upland	***2,908.04***	***1,750.25***	***-1,157.79***	***-39.81%***	***loss***
TOTAL	***10,763.69***	***10,763.69***			

Note: The following footnotes indicate an actual total gain/loss of wetlands or open water habitats of at least/most the indicated amount. These numbers look strictly at change to development which is less likely to be misclassified.

[a] Wetlands total loss of at least 43.35% (892 acres)

[b] Emergent wetlands loss of at least 45.22% (687 acres)

[c] Woody wetlands total loss of at least 38.73% (201 acres)

[d] Shrub-scrub loss of at least 47.46% (168 acres)

[e] Palustrine forested wetlands of at least 20% (33 acres)

[f] Natural shoreline loss of at least 22.22% (4 acres)

[g] Open water total loss of at least 10.06% (202 acres)

The potential causes for these changes can be further examined by looking at Table 3-08, which includes percentages of change in wetland and open water habitats due to conversion to development, agriculture, and/or other upland. These data show significant losses in wetland and open water habitats as a result of conversion to non-wet categories. For example, 58% of the 1938 wetlands were lost by 2001, accounting for a net loss of 1,194 acres of wetland. Most of this loss was a result of conversion from wetland to developed land (43.35%) with losses to other upland running a close second at 14.88%. These values likely provide reasonable estimates of wetland loss. Within the open water habitats, Table 3-08 shows a loss of 17.4% or a net loss of 350 acres. These losses are nearly equally distributed between conversions to other upland and developed land. As discussed previously, these losses occurred primarily in the Lake Calumet area where large expanses of open water were filled for development and port facilities.

Table 3-08. Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes from 1938 to 2001. Wetlands includes Emergent, Woody, and Shoreline Habitats.

Chicago, IL Transect - Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 38-01 Acres**	**Change 38-01 Percent**	**38-01 Gain/Loss**
Wetlands	Developed, Agriculture, Other Upland	1,316.13		
Developed, Agriculture, Other Upland	Wetlands	121.65		
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		-1,194.48	-58.05%	loss
Open Water Habitats	Developed, Agriculture, Other Upland	497.27		
Developed, Agriculture, Other Upland	Open Water Habitats	146.78		
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		-350.49	-17.45%	loss

From	To	Change 38-01 Acres	Change 38-01 Percent	38-01 Gain/Loss
Wetlands	Other Upland	340.26		
Other Upland	Wetlands	34.03		
Wetland Habitats Gain/Loss to Other Upland		-306.24	-14.88%	loss
Wetlands	Agriculture	0.00		
Agriculture	Wetlands	3.78		
Wetland Habitats Gain/Loss to Agriculture		3.78	.18%	gain
Wetlands	Developed	975.87		
Developed	Wetlands	83.84		
Wetland Habitats Gain/Loss to Developed		-892.03	-43.35%	loss
Open Water Habitats	Other Upland	284.22		
Other Upland	Open Water Habitats	107.86		
Open Water Habitats Gain/Loss to Other Upland		-176.36	-8.78%	loss
Open Water Habitats	Agriculture	0.00		
Agriculture	Open Water Habitats	27.13		
Open Water Habitats Gain/Loss to Agriculture		27.13	1.35%	gain
Open Water Habitats	Developed	213.05		
Developed	Open Water Habitats	11.79		
Open Water Habitats Gain/Loss to Developed		-201.27	-10.02%	loss

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

A more detailed breakdown of changes between 1938 and 2001 for the Chicago transect can be seen in Table 3-9. This table shows the distribution and change in number of acres between 1938 and 2001. The table also shows the number of acres that remained unchanged over the historical sixty-three-year period. This table shows the greatest changes for emergent wetlands and open water, where over 1,000 acres of emergent wetlands were lost to the non-wet classes of developed and other upland. Losses in open water were about half of the emergent wetlands class, showing losses of nearly 500 acres to developed and other upland areas. Within the non-wet classes, the largest changes were seen in other upland, where 1,770 acres was converted to developed land.

Historical (1938 – 2001) Change Summary

Overall, the sixty-three-year period between 1938 and 2001 for the Chicago transect saw a significant loss in wetland habitat (63%) with a smaller loss in open water habitat (11.9%). Emergent wetlands were reduced by nearly 88% (1,339 acres) of their 1938 area, primarily in the vicinity of Lake Calumet and south of the Little Calumet River. Most of the loss in emergent wetland can be attributed to increases in developed land and other upland. Smaller losses in shrub-scrub wetlands contributed to the overall loss in wetlands, also primarily in association with development around Lake Calumet. Open water losses on the order of 500 acres, or 11.9% of the original 1938 area also resulted from development around Lake Calumet. Finally, significant gains in developed lands occurred within the Chicago transect over the historical time period, resulting in an 83.5% increase over the 1938 developed area. Small losses in agricultural land were seen along with moderate losses in other upland.

Table 3-09. Change matrix representing change in acres between land cover classes from 1938 to 2001. Values in gray shaded cells reflect acres of no change.

Chicago, IL Land Cover Change Aerial Photos 1938 to C-CAP 2001 (by acres)											
		1938									
			Wetland Habitats				Open Water Habitats	Non-Wet Land Cover			
			Emergent Wetlands	Shrub-scrub Wetlands	Palustrine Forested Wetlands	Natural Non-armored) Shoreline	Open Water	Developed	Agriculture	Other Upland	Acreage Totals for 2001 Classification
2001	Wetland Habitats	Emergent Wetlands	116.09	19.13	0.00	0.00	4.00	38.25	0.00	2.45	179.92
		Shrub-scrub Wetlands	36.25	47.59	2.67	1.56	4.89	22.68	0.89	2.89	119.43
		Palustrine Forested Wetlands	252.42	28.91	103.64	0.67	13.57	22.91	2.89	28.69	453.69
		Natural (Non-armored) Shoreline	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.44
	Open Water Habitats	Open Water	69.16	61.16	0.00	2.00	1,488.93	11.79	27.13	107.86	1,768.04
	Non-Wet Land Cover	Developed	725.45	190.81	55.38	4.23	213.05	3,324.80	207.49	1,770.71	6,491.93
		Other Upland	320.47	6.89	3.78	9.12	284.22	116.53	13.79	995.44	1,750.25
		Acreage Totals for 1938 Classification	1,519.85	354.50	165.46	18.01	2,008.67	3,536.97	252.20	2,908.04	**10,763.69**

This table presents estimates of acreage by classification and the number of acres that changed classification between the two dates. The data shows the numbers of acres that have changed from the 1938 date to the 2001 date. The table reads down (1938/from) and to the left (2001/to).

Section 3.4 CAF Change Summary (1938 – 2004)

A summary of estimated habitat and other land cover change within the Great Lakes CAF region for the period 1938 to 2001 is shown in Table 3-10. The table shows actual measured acres lost and gained for the Chicago transect for both the historical and recent time periods. In addition, the percent of acres lost and gained for the transect are also shown. These specific transect data were used in conjunction with regional information regarding the CAF, to develop estimates for change within the CAF as a whole.

Computed values for change within the Chicago transect provide a rough basis for estimating change within the much larger Great Lakes CAF region; however, due to differences in the level of port and industrial development between the Chicago transect and the CAF, as well as the differences in land use throughout the various lake areas, a number of adjustments were required. Overall, most target habitat groups and other land cover classes were reduced in areal extent; the only exceptions were for the non-wet classes of developed land and agricultural land.

Within the wetlands habitats, emergent wetlands were estimated to decrease by 10 to 20% over the historical time period, and by 5 to 14% over the more recent 1992 to 2004 time period. Estimates provided for the historic time period are considerably less than those computed for the Chicago transect, primarily because of the extraordinarily high degree of human alteration around Lake Calumet in the Chicago transect, which inflated the transect losses. Historically, similar large-scale alteration of wetlands was not common throughout the Great Lakes CAF. Over the more recent time period from 1992 to 2004 the rate of loss in emergent wetlands has decreased somewhat due to increased regulatory controls designed to protect these resources. Losses in total woody wetlands for the historical time period was estimated to range from 7 to 15%. For the recent period, the loss was estimated at 5 to 9%, compared to the historical baseline. These losses are considerably higher than those computed for the Chicago transect, as they reflect changes that are more characteristic of the CAF region as a whole, such as loss of wetlands due to drainage for agricultural use, forestry, logging, mining, and urban development. Little data for the shrub-scrub wetlands was provided by the Chicago transect, and as such an estimate of change ranging from a 5% loss to a 5% gain is estimated for the entire Great Lakes CAF region. Losses in palustrine forested wetlands for the CAF were estimated to be between 5 and 10% based on existing data for the CAF, which suggests significant reductions in forested wetlands due to forestry, logging, and urban development. This estimate is notably different than the data provided by the Chicago transect for this habitat ; the 174% gain in palustrine forested wetlands at the transect level was estimated to be an anomaly, likely due to dataset resolution and classification differences. Finally, losses in natural (non-armored) shoreline were estimated to be around 7 to 15% historically for the Great Lakes CAF with 5 to 9% lost during the recent period. These losses were primarily the result of shoreline erosion, varying lake levels, and coastal development.

Changes in open water habitat for the Great Lakes CAF region were estimated to be roughly similar to those found for the Chicago transect for the historical time period. As such, losses for total open water habitats for the historical time period were estimated to be 7 to 15%, with a 5 to 7% loss occurring during the recent time period. These values appear to represent the CAF region as a whole, despite the high degree of open water alteration found within the Lake Calumet area of the Chicago transect. Historically, similar filling and development activities have occurred within the small lakes, ponds and coastal regions of the Great Lakes CAF as regulatory controls were not in place to prevent this type of activity. Additionally, heavy development in the major urban centers throughout the CAF region resulted in significant losses of open water habitat. During the more recent time period from 1992 to 2004 these losses have been reduced through the efforts of conservation groups and regulatory programs.

For the non-wet land cover classes, changes seen in the Chicago transect were generally not representative of changes throughout the Great Lakes CAF. For the developed land cover class the historic data from the Chicago transect overestimates the average level of development within the CAF, and as such, the CAF estimates of change were reduced to gains of 20 to 30%. This reduction from the transect level data reflects the combination of urban and rural land within the CAF region as a whole. For the more recent time period from 1992 to 2004, gains in developed land within the CAF were estimated to be slightly smaller, at 2 to 17%. This is consistent with the lower rate of population growth within the Great Lakes CAF over the last decade. Changes in agricultural land for the CAF region were not represented well by the Chicago transect due to its high level of urban development. As such, existing data were used to estimate increases in agricultural land for the Great Lakes CAF at 5 to 15% for the historical time period and 2 to 10% for the more recent time period. In many areas, the increase in agricultural land occurred at the expense of wetland habitat. Finally, losses in other upland for the CAF region were estimated to range from 7 to 15% historically, falling below the losses computed for the Chicago transect due to the differences in urban development between the two areas.

Table 3-10. Estimated target habitat group and land cover change from 1938-2004 for the Great Lakes CAF region based on local expert analysis of recent and historic change. Estimated acreages were calculated using estimated percent change in conjunction with the NLCD 1992 acres for each target habitat group and land cover type (Table 3-01). Also see Appendix C, Tables 13-04a – 04b for further detailed acreage values.

		Chicago, IL Transect				Great Lakes CAF Region			
		1938-2001 Historic Acres Gain/Loss	1938-2001 Historic Percent Gain/Loss	1992-2001 Recent Acres Gain/Loss	1992-2001 Recent Percent Gain/Loss	Historic 1938 to 2004 Estimated Acres Gain/Loss	Historic 1938 to 2004 Estimated Percent Gain/Loss	Recent 1992 to 2004 Estimated Acres Gain/Loss	Recent 1992 to 2004 Estimated Percent Gain/Loss
Wetland Habitats	***Wetlands Total[1]***	***-1,304.35***	***-63.38%***	***481.48***	***139.50%***	***-643,796 to -1,229,463***	***-8% to -15%***	***-389,666 to -826,361***	***-5% to -10%***
	Emergent Wetlands	-1,339.93	-88.16%	6.89	3.97%	-99,284 to -199,875	-10% to -20%	-47,029 to -141,088	-5% to -14%
	Woody Wetlands Total[2]	53.15	10.22%	473.48	275.78%	-488,353 to -1,084,701	-7% to -15%	-341,480 to -682,960	-5% to -9%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	-235.07	-66.31%	no data	no data	no data	5% to -5%	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	288.22	174.19%	no data	no data	no data	-5% to -10%	no data	no data
	Natural (non-armored) Shoreline	-17.57	-97.53%	1.11	100.00%	-1,654 to -3,674	-7% to -15%	-1,157 to -2,313	-5% to -9%
Open Water Habitats	***Open Water Total[3]***	***-240.63***	***-11.98%***	***-463.47***	***-20.98%***	***-104,913 to -238,204***	***-7% to -15%***	***-73,360 to -117,376***	***-5% to -7%***
	Open Water	-240.63	-11.98%	-463.47	-20.98%	no data	no data	no data	no data
	Aquatic Bed Total[4]	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed (undetermined)**	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***2,954.96***	***83.55%***	***874.01***	***15.76%***	***367,640 to 573,918***	***20% to 30%***	***43,252 to 324,388***	***2% to 17%***
	Agriculture	***-252.20***	***-100.00%***	***-102.97***	***-100.00%***	***876,218 to 2,588,316***	***5% to 15%***	***360,796 to 1,803,978***	***2% to 10%***
	Other Upland	***-1,157.79***	***-39.81%***	***-789.06***	***-30.90%***	***-1,801,323 to -4,000,993***	***-7% to -15%***	***-1,259,572 to -2,519,144***	***-5% to -9%***

1 "Emergent Wetlands", "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", "Palustrine Forested Wetlands", and "Natural (non-armored) Shoreline" have been summarized in "Wetlands Total".

2 "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", and Palustrine Forested Wetlands" have summarized in "Woody Wetlands Total".

3 "Aquatic Beds", Palustrine Aquatic Beds", Estuarine Aquatic Beds", "Coral Reefs", "Oyster Reefs/Shell Bottom", "Hard Bottom" and "Soft Bottom" have been summarized in "Open Water Total".

4 "Aquatic Beds", "Palustrine Aquatic Beds", and "Estuarine Aquatic Beds" have been summarized in "Aquatic Bed Total".

* "Woody Wetlands (undetermined)" includes wetlands not specifically identified by system (palustrine, estuarine, etc.) and/or type of woody vegetation (shrub-scrub, forested, etc.).

** "Aquatic Bed (undetermined)" includes aquatic beds not specifically identified by system (palustrine, estuarine, etc.).

Section 4.0 New England CAF

Section 4.1 CAF Description

The New England Coastal Assessment Framework (CAF) Region is approximately 13,763,100 acres in size, and includes areas within Maine, New Hampshire, and part of Massachusetts. The New England CAF has been sub-divided into 20 Estuarine Drainage Areas and 6 additional Coastal Drainage Areas by NOAA. The northern portion of the CAF, in the states of Maine and New Hampshire, extends from the coastal zone inland to the upper reaches of the Penobscot, Kennebec, Androscoggin, and Saco drainage basins. This part of the CAF extends as far as 100 miles inland, and reaches maximum elevations of 3,444 feet above sea level in the northern end of the White and Appalachian Mountains. Wetland types range from sandy beaches along the coast (primarily in the south), to seasonally flooded wetlands and forested swamps along rivers and streams at the higher elevations. The southern portion of the CAF, in lower New Hampshire and Massachusetts, contains the Merrimack, Massachusetts Bay, and Cape Cod Bay Estuarine Drainage Areas, as well as the Cape Cod Coastal Drainage Area. The maximum inland extent of the CAF is only about 50 miles, with elevations that range from sea level to approximately 400 ft above sea level in southern New Hampshire. Coastal wetlands are much more predominant in this southern part of the CAF, as the elevations are much lower.

The morphology of the New England CAF is most directly related to glacial activity during the Pleistocene, with the ensuing inundation by the sea during the past 11,000 years. The bedrock outcroppings are particularly important in shaping the morphology, as they form cliffed coasts in extreme eastern Maine, broad deep embayments with numerous island and peninsulas in central Maine, and finally a straighter coast along southern Maine, New Hampshire, and northern Massachusetts where bedrock promontories are separated by gently curved embayments filled with unconsolidated sediments.

Nearly 11% of the New England CAF is composed of densely populated regions, primarily in the larger cities of Bangor (Maine), Augusta (Maine), Portland (Maine), Portsmouth (New Hampshire), and greater metropolitan Boston (Massachusetts). These urban areas account for a total of 913,150 acres, or 6.6% of the total CAF area. Human population growth from 1990 to 2000 has been slightly over 5.5%, increasing from 3,631,325 persons to 3,831,479 persons (ESRI, 2000 and ESRI, 2002). The percentage of federally owned land is relatively small in the New England CAF, accounting for 517,184 acres or 3.8% of the total area. The largest of these areas are owned by the United States Forest Service (USFS) and are located in the White Mountains of New Hampshire.

Review of data from existing studies provides some insight as to the historical level of wetland loss within the New England CAF. NOAA's National Marine Fisheries Service reports on wetland loss through the 1980s within states contained within the New England CAF (NOAA, 2005). This report indicates that Maine lost approximately 20%

of its estimated original wetlands base by the mid 1980s, while New Hampshire and Massachusetts lost 9% and 28%, respectively. For the period 1992 to 1997, the US Department of Agriculture (USDA) reports a loss of 57,000 acres of palustrine and estuarine wetlands and a 15,400 acre gain for the entire northeast region (Maine to Maryland; USDA, 2005a). Causes for these wetland losses were assigned to the following activities: development (67.2%), silviculture (16.3%), agriculture (9.0%), and miscellaneous (7.5%) (USDA, 2005b). These USDA estimates likely overestimate wetland losses within the New England CAF, as agriculture and development are not as widespread in Maine, New Hampshire, and Massachusetts, as they are in Connecticut through Maryland.

Section 4.2 Recent (1992) Land Cover Data Summary

Figure 4-01 shows the mapped target habitat groups and other land cover classes for the New England CAF region. The data was based on the 1992 USGS National Land Cover Dataset (NLCD).

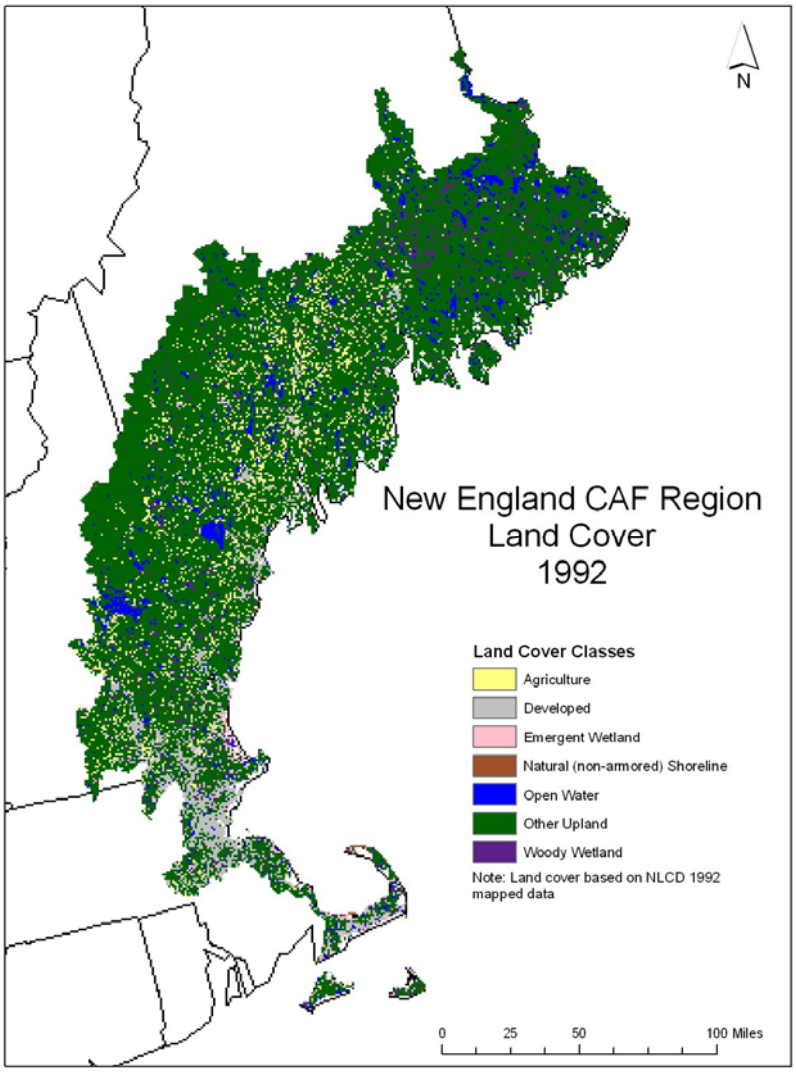


Figure 4-01. New England CAF Region land cover classes, 1992.

Rough estimates of total area of land cover, based on the 1992 NLCD classification, are presented in Table 4-01. Unlike for the Great Lakes CAF region, it was not possible to compile a change matrix for this CAF due to the lack of complete land cover data available for two separate dates.

Of the total acreage within the New England CAF region, the other upland class comprises nearly three-fourths of the area. Following this, wetlands, open water habitats, developed, and agricultural lands each comprise between 5.3% and 6.5% of the total CAF area. Within the wetland category, emergent and woody wetlands contribute most of the acreage, with natural (non-armored) shorelines making up the smallest habitat area. Overall, the 1992 NLCD dataset shows that wetlands and open water habitats comprise approximately 11.8% of the New England CAF.

Table 4-01. Total area of target habitat groups and other land cover classes within the New England CAF region (1992).

New England CAF Region - Total Area by Habitat Group and Other Land Cover Class	
	NLCD 1992 Acres
Wetlands Total[1]	***884,705.67***
Emergent Wetlands	255,716.70
Woody Wetlands Total[2]	596,413.73
Woody Wetlands (undetermined)*	596,413.73
Shrub-scrub Wetlands	0.00
Mangroves	0.00
Estuarine Forested Wetlands	0.00
Palustrine Forested Wetlands	0.00
Natural (non-armored) Shoreline	32,575.24
Open Water Total[3]	***720,153.08***
Open Water	720,153.08
Aquatic Bed Total[4]	0.00
Aquatic Bed (undetermined)**	0.00
Palustrine Aquatic Beds	0.00
Estuarine Aquatic Beds	0.00
Coral Reefs	0.00
Oyster Reefs/Shell Bottom	0.00
Hard Bottom	0.00
Soft Bottom	0.00
Developed	***831,891.83***
Agriculture	***816,500.66***
Other Upland	***10,324,719.28***
TOTAL	***13,577,970.52***

1 "Emergent Wetlands", "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", "Palustrine Forested Wetlands", and "Natural (non-armored) Shoreline" have been summarized in "Wetlands Total".

2 "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", and Palustrine Forested Wetlands" have summarized in "Woody Wetlands Total".

3 "Aquatic Beds", Palustrine Aquatic Beds", Estuarine Aquatic Beds", "Coral Reefs", "Oyster Reefs/Shell Bottom", "Hard Bottom" and "Soft Bottom" have been summarized in "Open Water Total". 4 "Aquatic Beds", "Palustrine Aquatic Beds", and "Estuarine Aquatic Beds" have been summarized in "Aquatic Bed Total".
* "Woody Wetlands (undetermined)" includes wetlands not specifically identified by system (palustrine, estuarine, etc.) and/or type of woody vegetation (shrub-scrub, forested, etc.). ** "Aquatic Bed (undetermined)" includes aquatic beds not specifically identified by system (palustrine, estuarine, etc.).
Note: Acreage totals are a rough estimate. Totals may not represent all of each CAF region due to clipping of raster datasets.

Section 4.3 Transect Analysis Results

Section 4.3.1 Portland Harbor, ME Transect

Transect Location

The location of the Portland Harbor transect in the New England CAF region is illustrated in Figure 4-02. The placement of the transect can be seen in more detail in Figure 4-03. The Portland Harbor transect provides a good representation of estuarine habitat conditions in the northern half of the New England CAF. The transect spans the greater Portland Harbor area, which was formed as sea level inundated the rocky headlands of the coast, and thus is very similar in nature to the rugged and rocky shoreline found within the northern half of the CAF. The lower part of the Portland Harbor estuary extends inland to the Fore River, which is a tidally influenced wetland, while the northern portion of the estuary includes the drainage area formed at the mouth of the Presumpscot River. This northern portion of the estuary is similar to the neighboring systems to the north, such as Penobscot, Kennebec, and Androscoggin, which are drowned river valleys. The types of wetlands present along the Portland Harbor transect, and the pressures on the wetlands, are similar to those northern areas of the CAF above Portland. For those areas in the southern half of the New England CAF, the Portland Harbor transect provides a much less accurate representation of estuarine habitat conditions. The coastal geomorphology in the lower portion of the CAF, south of Portland, changes dramatically. The occurrence of rocky headlands and steep-banked estuaries gives way to more low-lying beaches, coves, and bays with unconsolidated sediments. As such, the distribution of estuarine habitats, as well as the ecological and man induced pressures are different than for those areas north of Portland. A description of the Portland, Maine transect using the condition variables listed in Section 3.1 is given below, along with a discussion of changes in habitat area as seen over two different time periods, recent (1986 to 1997) and historical (1947 to 1997).

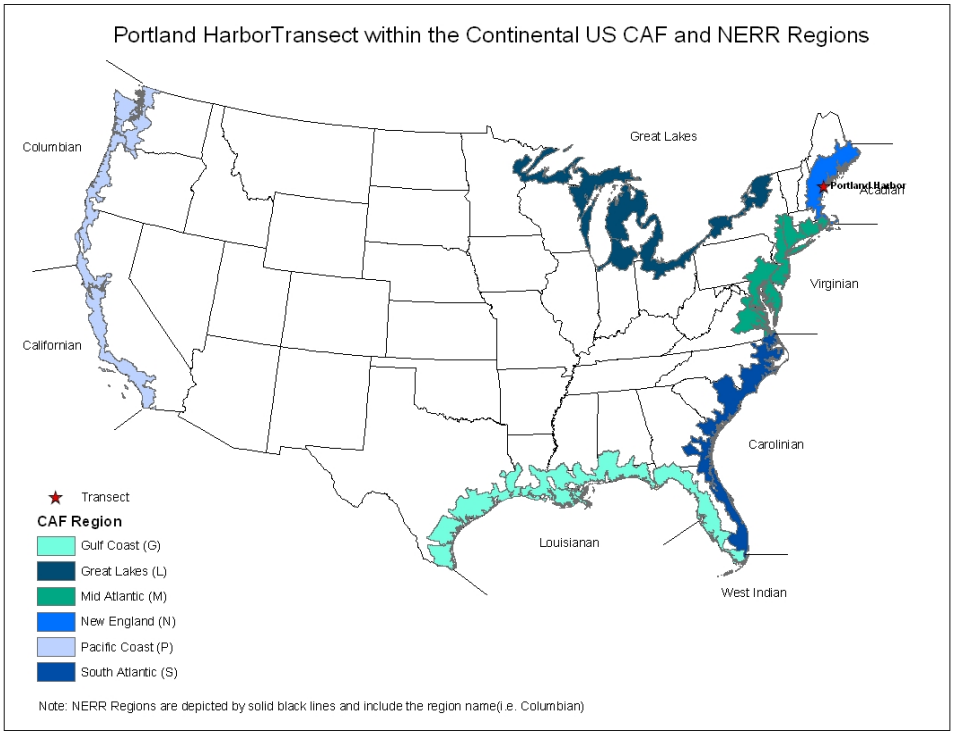


Figure 4-02. Location of the Portland Harbor, ME transect within New England CAF region.

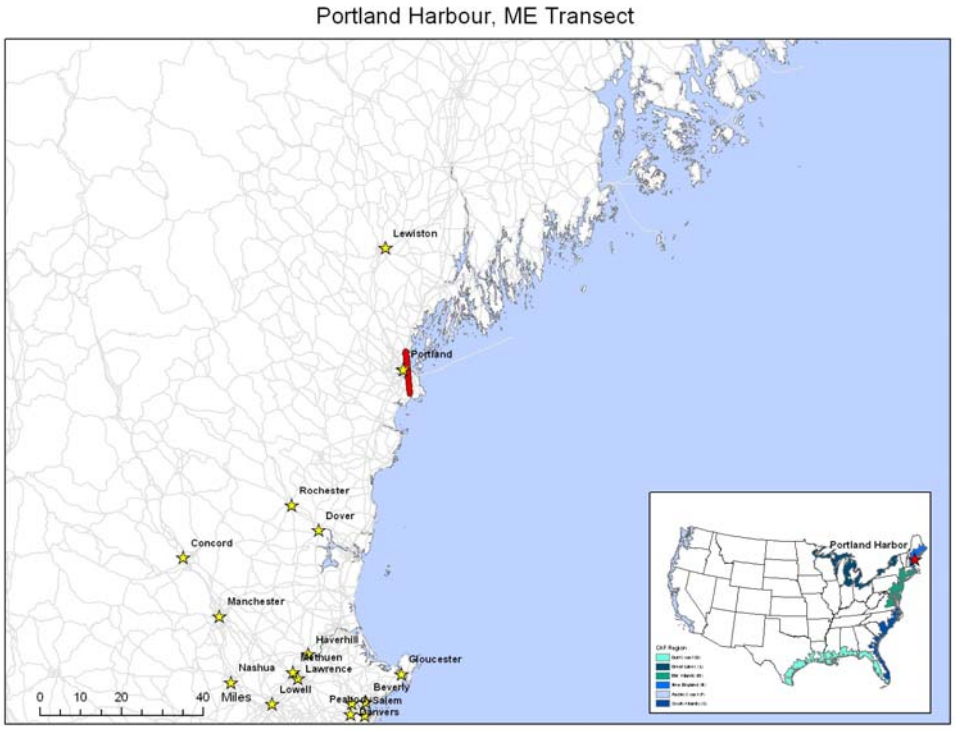


Figure 4-03 Portland Harbor, ME transect placement. Transect is mapped in red.

Transect Description

I. Distance to Coast
   a. The Portland Harbor transect is located along the coast line, and thus wetland status and trends observed within the transect will be representative of most coastal wetlands throughout the northern portion of the CAF. Because of the change in coastal geomorphology south of Portland, the wetland status and trends found at the Portland Harbor transect are not representative of estuarine habitat changes within the southern half of the New England CAF.
   b. Due to its proximity to the coastal zone, the data derived from the Portland Harbor transect will not be representative of changes that have occurred within the palustrine wetlands of the CAF.
   c. Anthropogenic pressures on wetlands of the Portland Harbor transect are the result of coastal development primarily from marine related activities and human population growth. These pressures are different than those acting on inland wetlands.
   d. The wide boundaries of the CAF suggest that attempts to characterize the CAF with one or two transects that do not span the range of wetland types are apt to be both imprecise and inaccurate.

II. Salinity
   a. Most of the Portland Harbor transect is located in an area of saline water with values ranging from 31 to 32 ppt.
   b. The northern end of the transect, located at the mouth of the Presumpscot River, crosses an area of lower salinity water, where fresh water from the river mixes with saline ocean water. Salinities at the northern end of the transect are on the order of 5 to 25 ppt.
   c. The Portland Harbor transect is not representative of freshwater conditions found at more inland locations within the New England CAF.

III. Topography/Elevation Range
   a. Elevation values throughout the transect range from sea level to 30 meters above sea level. This range is representative of conditions nearest the coastline, approximately 5 to 15 miles inland, for most of the CAF.
   b. The lowest elevations occur in the immediate vicinity of the harbor, where values range from sea level to 9 meters above sea level. The southern end of the transect contains somewhat higher elevations, on the order of 16 to 30 meters above sea level.
   c. Elevation ranges at the Portland Harbor transect are not representative of those found at more inland wetland or habitat locations, where the elevation gradients are much steeper, and average elevations range from 50 to 200 meters above sea level.

IV. Proximity to City
   a. The Portland Harbor transect is located in one of the five largest urban areas within the CAF. As these urban areas account for only 6.6% of the total CAF area, development within the transect is not representative of trends in most other areas of the CAF.

b. The population density in the city of Portland is estimated to be 3,039 people per square mile, which is higher that the average population density of 1,860 people per square mile for the other urban centers within the CAF. The only other area with higher population density is the greater metropolitan Boston area. As such, the loss of wetlands within the Portland Harbor transect as related to human population growth will be an overestimate for the entire CAF.
c. Population growth in the Portland and South Portland areas of the transect was very low over the ten year period between 1990 and 2000, showing a 0.1% increase in the number of people. This low growth rate is also reflected in the increase in number of housing units over the same time period, which shows a 2.8% increase. Overall, the Portland Harbor transect underestimates the average growth rate in the CAF for the 1990 to 2000 time period, which saw a population increase of 8.0%.

V. Land Ownership
a. There is no federally owned property within the Portland Harbor transect area; most of the land in the transect is owned by private, state, or municipal interests.

VI. Dominant Land Uses
a. The largest percentage of land within the Portland Harbor transect is classified as urban (approximately 48.5%). These urban areas are primarily located in the immediate vicinity of the shoreline, and thus represent the downtown commerce center and port related facilities. Other highly developed areas such as residential, commercial, transportation, communications, etc. account for an additional 11.6% of the transect area.
b. The remaining land areas within the transect in order of decreasing acreage are forested land (23.1%), agricultural (6.8%), wetland (3.6%), and barren land (0.3%).
c. As compared with land use throughout the New England CAF, the Portland transect shows a significantly higher percentage of urban or build-up land. Overall, throughout the CAF region the percentage of urban or built-up land is only 10.0%, as compared with the nearly 60.0% for the Portland transect. This will likely have the result of showing greater wetland loss for the Portland area due to urban development.
d. In addition, the Portland transect shows significantly less forest land than is represented by the entire CAF region. This should have little impact on estimates of wetland change.
e. Finally, the extent of agricultural land within the New England CAF is represented quite well by the Portland transect. As such, estimates of conversion to wetland from agricultural use, or vice versa, for the Portland transect should translate to the CAF region as a whole.

VII. Extent of Shoreline Armoring
a. Most of the shoreline areas within the Portland Harbor transect are either naturally armored rocky outcrops, or have been stabilized for port and/or harbor development, or for transportation purposes.

b. While the natural shoreline armoring present within the Portland transect is characteristic of the northern half of the CAF region, it does not adequately represent the sandy, more erosive shoreline conditions present within the southern half of the CAF.
c. With the exception of the Boston Harbor area, with is also highly armored for port and harbor operations, the extent of shoreline armoring in the Portland transect likely overestimates armoring for the CAF region as a whole. This will likely result in lower wetland losses for the Portland transect than are occurring throughout the CAF, as many of the wetlands in the southern portion of the CAF are disappearing due to erosion.

VIII. Shipping

a. Portland Harbor is a port of entry, and is the commercial center of the state. The Harbor area serves as a major shipping and receiving site, especially for goods destined for Montreal. Shipping activities related to boat building, fish processing, printing and publishing, foundries, lumbering, paper-milling, chemical and textile industries are all active in Portland Harbor.
b. Boston Harbor is the only other area within the New England CAF that exceeds the shipping activity at Portland Harbor. Portsmouth, New Hampshire also has a busy shipping industry, although its level of traffic does not exceed Portland or Boston Harbors.
c. The high level of port and harbor shipping within this transect likely results in greater wetland loss from dredging as well as construction and/or maintenance of port facilities (e.g., docks, over water structures). In addition, degradation of wetland habitats is likely greater at the Portland Harbor transect, due to reduced water quality from boat wastes and upland runoff as well as the possible introduction of invasive plant and/or animal species.

IX. Dredging.

a. Dredging has routinely been carried out in the major port area of the Portland Harbor transect for many decades. Potential impacts from this activity include removal of wetland resources during the actual dredging, as well as possible burial of valuable resources during disposal. Likely disposal sites are offshore, nearshore in harbor areas, nearshore upland fill, or remote upland sites. Adverse impacts to wetlands from dredging can also result from increased turbidity and changes in sediment substrata.
b. Major dredging projects are routinely conducted in many other coastal areas within the New England CAF region, ranging from the larger sites like Boston Harbor to the smaller harbors and rivers where recreational boating is common. As such, impacts from dredging on wetlands within the CAF region is represented reasonably well by the changes observed in the Portland Harbor transect.

X. Major Natural Disasters

a. Hurricanes are the only natural disaster that affect the Portland Harbor transect. Although hurricane damages are much more common in the

mid-Atlantic and south-Atlantic US states, hurricanes do occasionally impact the New England area.

b. Wetland impacts from hurricanes include increased shoreline erosion from waves, as well as saltwater inundation and flooding.

Recent Transect Maps

Figures 4-04 shows the 1997 Digital Orthophoto Quarter Quadrangles (DOQQs) of the Portland Harbor, ME transect. The DOQQs were used as a visual reference for interpreting recent land cover.

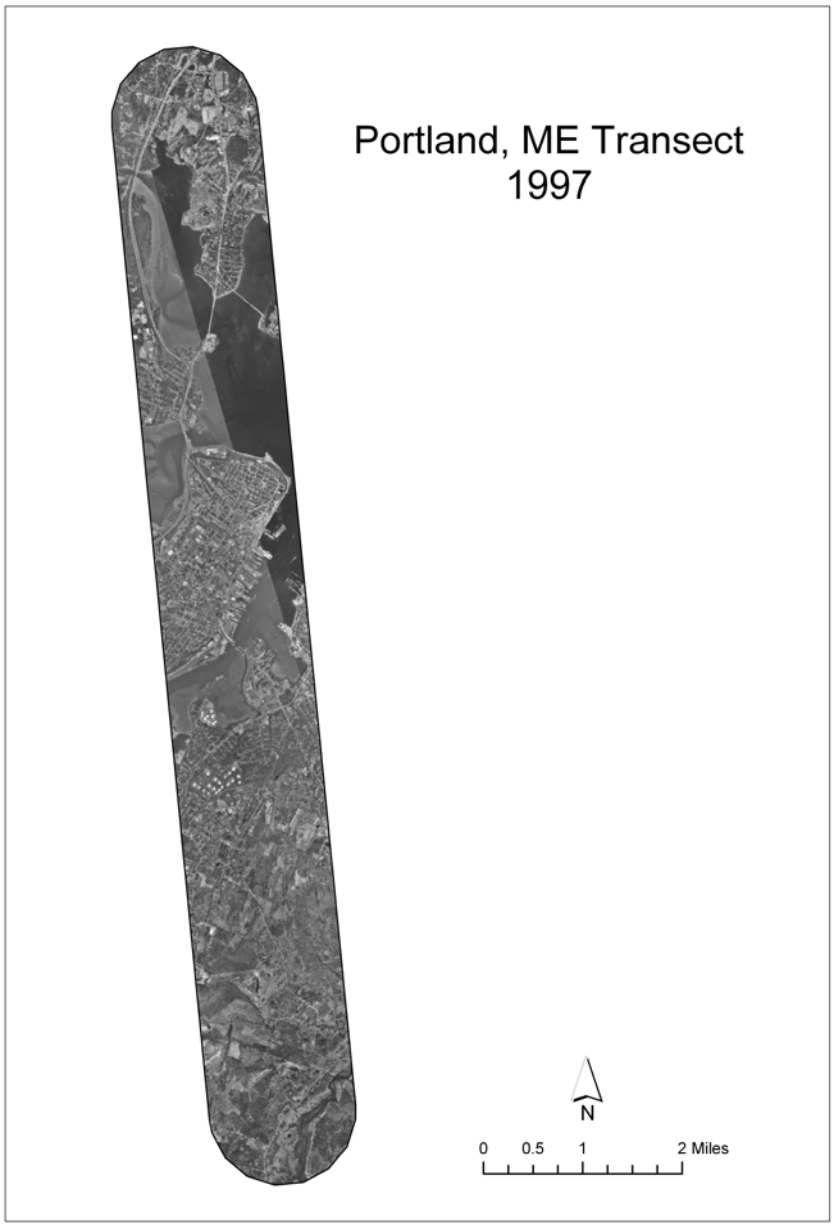


Figure 4-04. 1997 DOQQ of Portland, ME transect.

Figure 4-05 and 4-06 depict the changes in wetland habitats and open water habitats from 1986 to 1997 respectively. The wetlands change map shows areas that changed from wetland to non-wetland classes and non-wetland to wetland classes. Similarly, the open water change map displays open water to non-open water classes and non-open water to open water classes. These maps are helpful in determining where wetlands and open water habitat changes occurred and which classes they changed between.

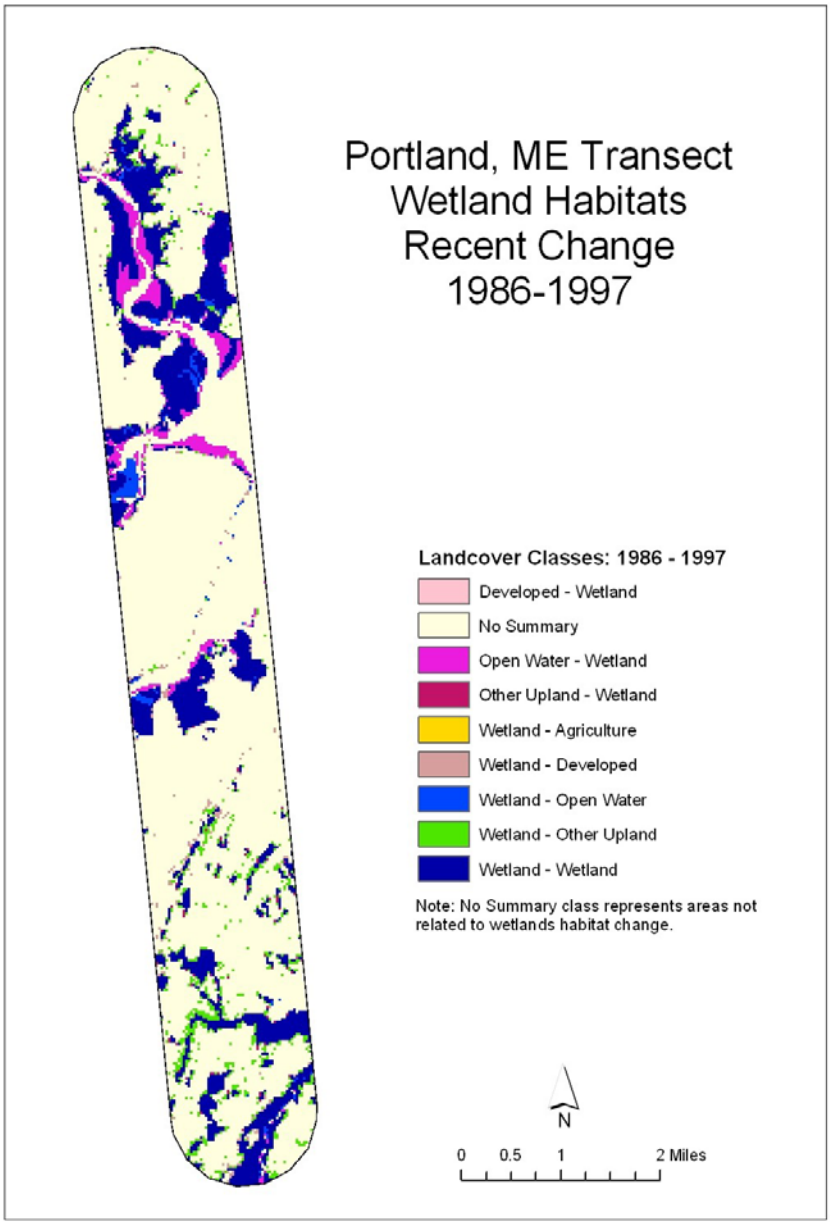


Figure 4-05. Wetland habitat change from 1986-1997, Portland, ME transect.

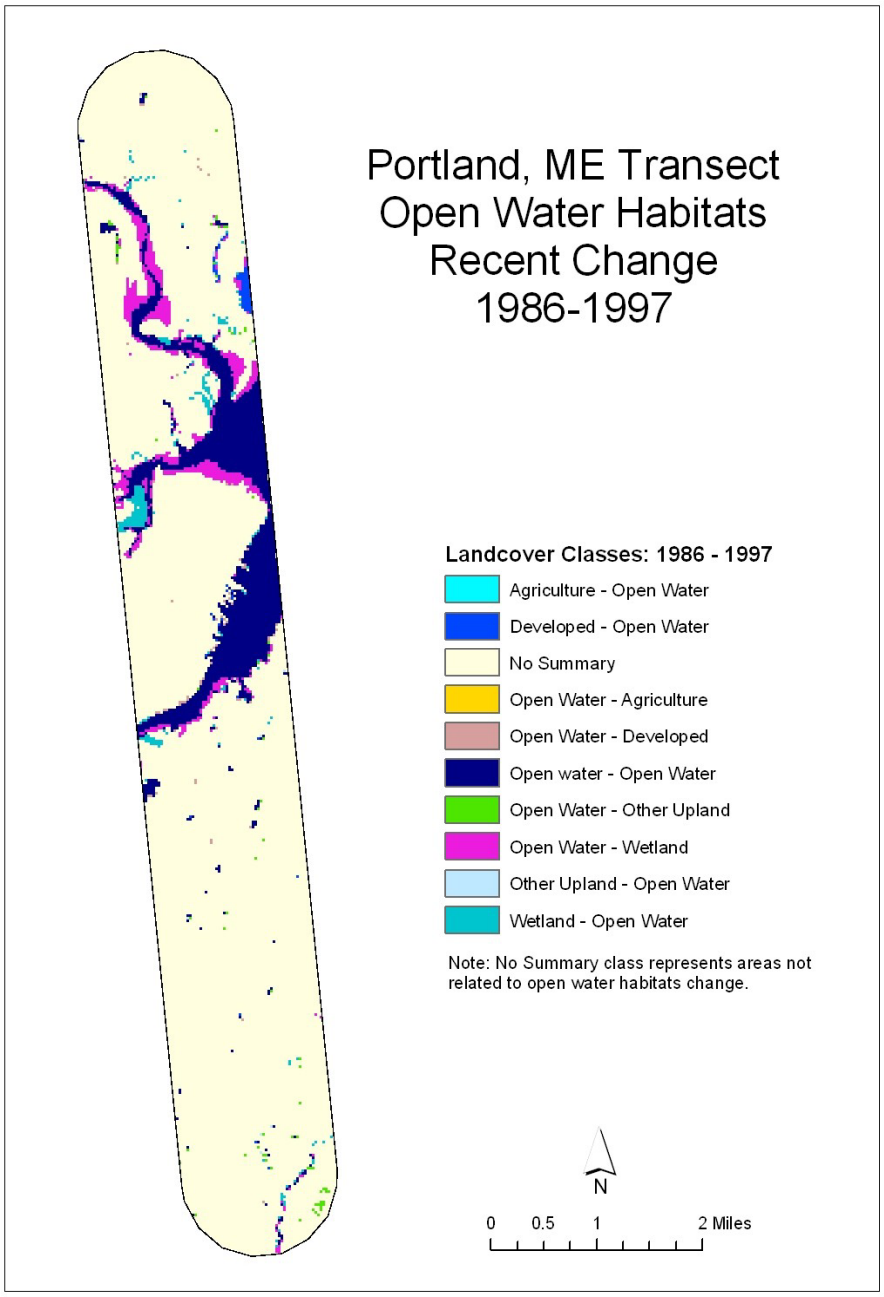


Figure 4-06. Open water habitat change from 1986-1997, Portland, ME transect.

Recent (1986 – 1997) Change Tables

The datasets analyzed for recent change included an overlay of National Wetlands Inventory (NWI) data from 1987 with C-CAP data from 1986. The 1997 land cover is from the Gulf of Maine Habitat Mapping Project through the US Fish and Wildlife Service (FWS).

Overall, the Portland Harbor transect contains approximately 10,709 acres. Emergent, shrub-scrub, and palustrine forested wetlands experienced the highest losses during the period 1986 to 1997, with declines of 21.88%, 59.65%, and 31.47%, respectively (Table 4-02). In contrast, areas of open water increased by over 2,000%. This is likely a gross overestimate, as many areas within the harbor were classified as soft bottom in the 1986/1987 dataset, but generalized as open water in the 1997 dataset. The only wetland habitat type to show an apparently true gain in size was the natural (non-armored) shoreline, which increased by 11.80%. When summarized into the broader habitat groups (wetlands, open water, developed, agricultural, and other upland) the data show overall losses for both wetlands (8.17%) and open water habitats (18.45%). In contrast, the areal extent for the developed, agriculture, and other upland categories increased by 6.78%, 0.98%, and 7.34%, respectively.

Table 4-02. Acreage and percent change of target habitat groups and other land cover classes from 1986-1997. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

Portland, ME Transect - Dataset Acreage and Change by Land Cover					
	C-CAP86-NWI87 Acres	**GOMLC97 Acres**	**Change 86-97 Acres**	**Change 86-97 Percent**	**86-97 Gain/Loss**
Wetlands Total	***2,431.44***	***2,232.84***	***-198.60***	***-8.17%[a]***	***loss***
Emergent Wetlands	576.45	450.35	-126.10	-21.88% [b]	loss
Woody Wetlands Total	523.96	294.45	-229.51	-43.80% [c]	loss
Woody Wetlands (undetermined)	0.00	0.00	0.00	0.00%	
Shrub-scrub Wetlands	229.29	92.52	-136.77	-59.65% [d]	loss
Mangroves	0.00	0.00	0.00	0.00%	
Estuarine Forested Wetlands	0.00	0.00	0.00	0.00%	
Palustrine Forested Wetlands	294.67	201.93	-92.74	-31.47% [e]	loss
Natural (non-armored) Shoreline	1,331.03	1,488.04	157.01	11.80% [f]	gain
Open Water Total	***1,519.85***	***1,239.41***	***-280.44***	***-18.45% [g]***	***loss***
Open Water	50.04	1,187.59	1,137.55	2273.33% [h]	gain
Aquatic Bed Total	56.71	51.82	-4.89	-8.63% [i]	loss
Aquatic Bed (undetermined)	44.03	39.59	-4.45	-10.10%	loss
Palustrine Aquatic Beds	0.00	0.00	0.00	0.00%	
Estuarine Aquatic Beds	12.68	12.23	-0.44	-3.51%	loss
Coral Reefs	0.00	0.00	0.00	0.00%	
Oyster Reefs/Shell Bottom	0.00	0.00	0.00	0.00%	
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	1,413.10	0.00	-1,413.10	-100.00%	
Developed	***2,776.60***	***2,964.97***	***188.37***	***6.78%***	***gain***
Agriculture	***22.68***	***22.91***	***0.22***	***0.98%***	***gain***
Other Upland	***3,959.30***	***4,249.74***	***290.45***	***7.34%***	***gain***
TOTAL	***10,709.87***	***10,709.87***			

Note: The following footnotes indicate an actual total gain/loss of wetlands or open water habitats of at least/most the indicated amount. These numbers look strictly at change to development which is less likely to be misclassified.

[a] Wetlands total loss of at least 4.58% (112 acres)

[b] Emergent wetlands loss of at least -8.16% (47 acres)

[c] Woody wetlands total loss of at least 5.92% (31 acres)
[d] Shrub-scrub loss of at least 10% (25 acres)
[e] Palustrine forested wetlands of at least 2.7% (7 acres)
[f] Natural shoreline loss of at least 2.4% (32 acres)
[g] Open water total loss of at least 1% (17 acres)
[h] Open water loss of at least 14% (7 acres)
[i] Aquatic bed total gain of at most 3.57% (2 acres)

The potential causes for loss in wetland habitat can be further examined by looking at Table 4-03, which includes percentages of change in wetland and open water habitats due to conversion to development, agriculture, and/or other upland. These data show a net loss of 439.67 acres of wetland habitat to non-wet land cover classes. This conversion translates to a loss of 18.02% of the original 1986/87 wetland area. Most of this loss can be attributed to conversion from wetland to other upland (13.42%). This may reflect a natural shift or progression of wetlands, or it may be an artifact of the data resolution. Only about 4.58% of the original wetland area was lost to development, a finding consistent with the lower levels of population growth in the Portland area. Table 4-03 also shows a relatively small loss of 2.57% of open water habitat to non-wet land areas, specifically other upland and developed areas. Wetland losses due to conversion to agricultural land were negligible.

Table 4-03. Change in Wetlands and Open Water Habitats due to Conversion to Development, Agriculture, or Other Upland Classes from 1986-1997.

Portland, ME Transect - Change in Wetlands and Open Water Habitats due to Conversion to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 86-97 Acres**	**Change 86-97 Percent**	**86-97 Gain/Loss**
Wetland Habitats	Developed, Agriculture, Other Upland	481.26		
Developed, Agriculture, Other Upland	Wetland Habitats	41.59		
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		-439.67	-18.02%	loss
Open Water Habitats	Developed, Agriculture, Other Upland	57.16		
Developed, Agriculture, Other Upland	Open Water Habitats	17.79		
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		-39.36	-2.57%	loss
Wetlands	Other Upland	359.83		
Other Upland	Wetlands	32.47		
Wetland Habitats		-327.37	-13.42%	loss
Wetlands	Agriculture	0.44		
Agriculture	Wetlands	0.00		
Wetlands Habitats		-0.44	-0.02%	gain
Wetlands	Developed	120.98		
Developed	Wetlands	9.12		
Wetlands Habitats		-111.86	-4.58%	loss
Open Water Habitats	Other Upland	29.58		
Other Upland	Open Water Habitats	7.56		

From	To	Change 86-97 Acres	Change 86-97 Percent	86-97 Gain/Loss
Open Water Habitats Gain/Loss to Other Upland		-22.02	-1.44%	loss
Open Water Habitats	Agriculture	0.22		
Agriculture	Open Water Habitats	0.22		
Open Water Habitats Gain/Loss to Agriculture		0.00	0.00%	
Open Water Habitats	Developed	27.35		
Developed	Open Water Habitats	10.01		
Open Water Habitats Gain/Loss to Developed		-17.35	-1.13%	loss

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

A more detailed breakdown of changes in land cover classes between 1986/87 and 1997 for the Portland Harbor transect can be seen in Table 4-04. This table shows the distribution and change in number of acres for each land cover class between 1986/87 and 1997. The table also shows the number of acres that remained unchanged between 1986/87 and 1997. These data support the findings reported in Table 4-03, which indicate that conversion from wetland to other upland made up the greatest loss in wetland area. Specifically, losses in emergent, shrub-scrub, and palustrine forested areas contributed the greatest loss. Other notable losses were from soft bottom habitat to natural (non-armored) shoreline and open water habitat areas; however, as discussed previously, these changes are likely the result of different classification schemes between the two data sets used, and should not be interpreted as actual changes between habitat types.

Recent (1986 – 1997) Change Summary

Overall, the ten-year period between 1986/87 and 1997 for the Portland Harbor transect saw a reduction in wetland and open water habitats, along with an increase in non-wet areas. Most of the wetland losses were attributed to conversion to other upland and developed lands (approximately 18.02%). The data also show a net change of open water habitat to wetlands (soft bottom to natural shoreline); however, this is likely an anomaly due to differing classification schemes between the 1986/87 and 1997 datasets. Corrections for this data limitation would result in a significantly higher loss of wetlands of around 21%, along with a nearly zero change in open water habitat.

Table 4-04. Change matrix representing change in acres among target habitat groups and land cover classes in the transect from 1986 to 1997. Values in the gray shaded cells are acres of no change.

Portland, ME Land Cover Change C-CAP 1986/NWI 1987 - GOMLC 1997 (by acres)														
			1986											
			Wetland Habitats				Open Water Habitats				Non-Wet Land Cover			
			Emergent Wetlands	Shrub-Scrub Wetlands	Palustrine Forested Wetlands	Natural Non-armored) Shoreline	Open Water	Aquatic Bed	Estuarine Aquatic Beds	Soft Bottom	Developed	Agriculture	Other Upland	Acreage Totals for 1997 Classification
1997	Wetland Habitats	Emergent Wetlands	394.53	7.12	1.11	27.35	0.67	0.00	0.44	7.34	2.22	0.00	9.56	450.35
		Shrub-Scrub Wetlands	2.45	78.28	3.34	0.00	0.00	0.00	0.00	0.44	0.89	0.00	7.12	92.52
		Palustrine Forested Wetlands	3.34	2.45	181.70	0.00	0.00	0.00	0.00	0.22	0.00	0.00	14.23	201.93
		Natural (Non-armored) Shoreline	16.46	0.00	0.00	1,119.76	6.45	9.12	4.23	324.47	6.00	0.00	1.56	1,488.04
	Open Water Habitats	Open Water	4.00	1.33	0.00	102.52	12.23	0.00	0.00	1,053.93	7.34	0.22	6.00	1,187.59
		Aquatic Bed	0.44	0.00	0.00	2.22	0.22	34.47	0.00	0.00	0.89	0.00	1.33	39.59
		Estuarine Aquatic Beds	0.22	0.00	0.00	1.56	0.67	0.00	7.34	0.44	1.78	0.00	0.22	12.23
	Non-Wet Land Cover	Developed	48.93	25.80	7.78	38.47	14.23	0.00	0.67	12.45	2,727.01	0.00	89.63	2,964.97
		Agriculture	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.22	0.00	21.57	0.67	22.91
		Other Upland	106.08	113.87	100.74	39.14	15.57	0.44	0.00	13.57	30.47	0.89	3,828.97	4,249.74
		Acreage Totals for 1986 Classification	576.45	229.29	294.67	1,331.03	50.04	44.03	12.68	1,413.10	2,776.60	22.68	3,959.30	**10,709.87**

This table presents estimates of acreage by classification and the number of acres that changed classification between the two dates. The data shows the numbers of acres that have changed from the 1986 date to the 1997 date. The table reads down (1986/from) and to the left (1997/to).

Historical Transect Maps

The Portland Harbor transect is illustrated in Figures 4-07 through 4-09. The 1947 aerial photos presented in (Figure 4-07) were used to classify land cover in the transect from the historic time period.

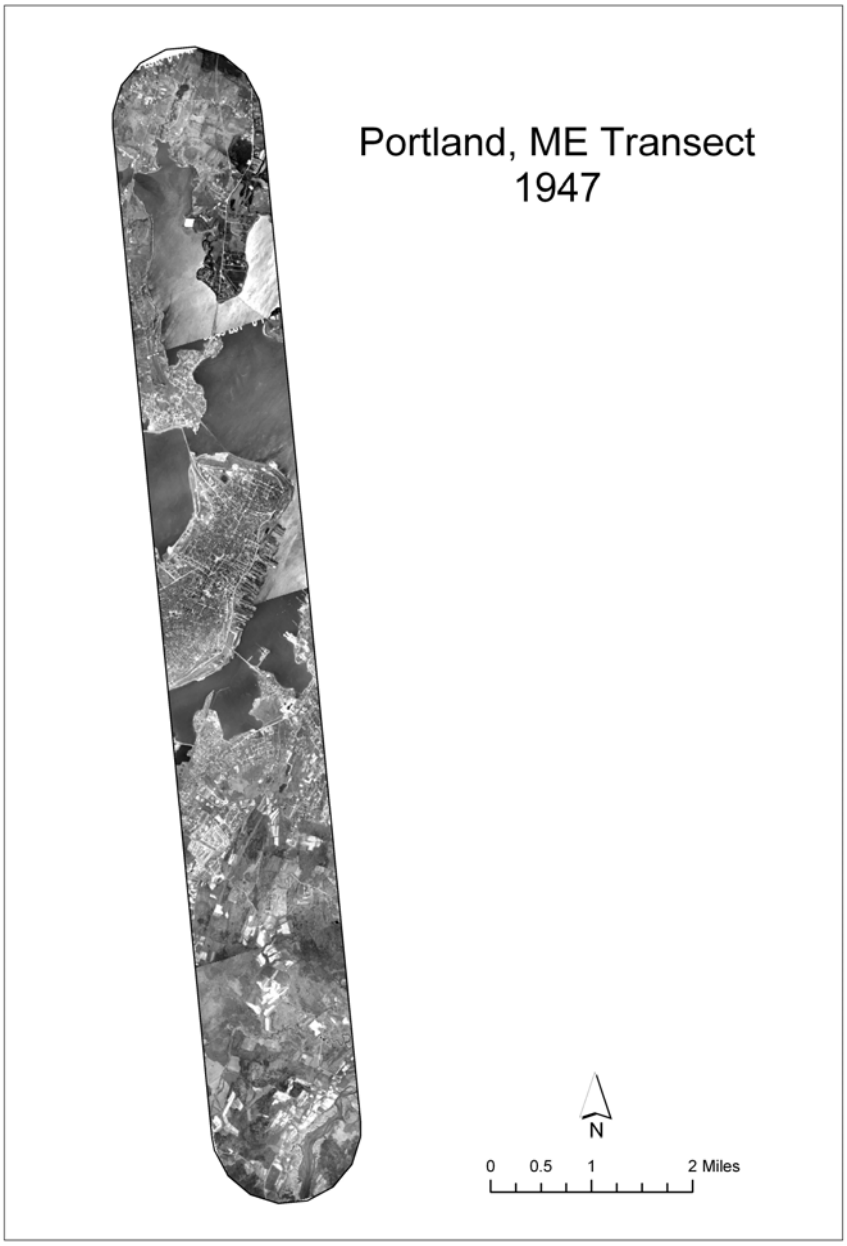


Figure 4-07.1947 aerial photo of Portland, ME transect

Figures 4-08 and 4-09 depict the changes in wetland habitats and open water habitats from 1947 to 1997 respectively. The wetlands change map shows areas that changed from wetland to non-wetland classes and non-wetland to wetland classes. Similarly, the open water change map displays open water to non-open water classes and non-open

water to open water classes. These maps are helpful in determining where wetlands and open water habitat changes occurred and which classes they changed between.

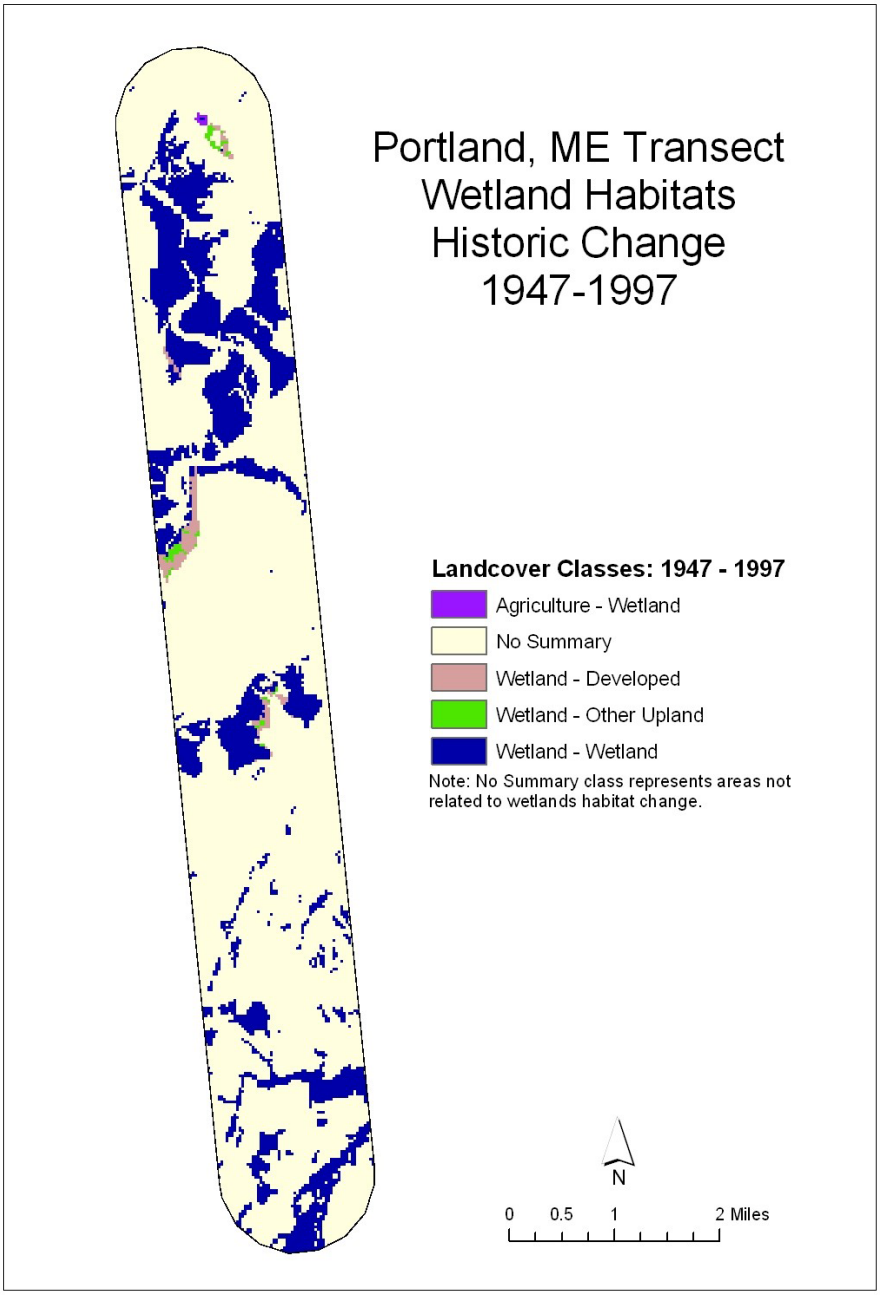


Figure 4-08. Wetland habitats change from 1947-1997, Portland, ME transect

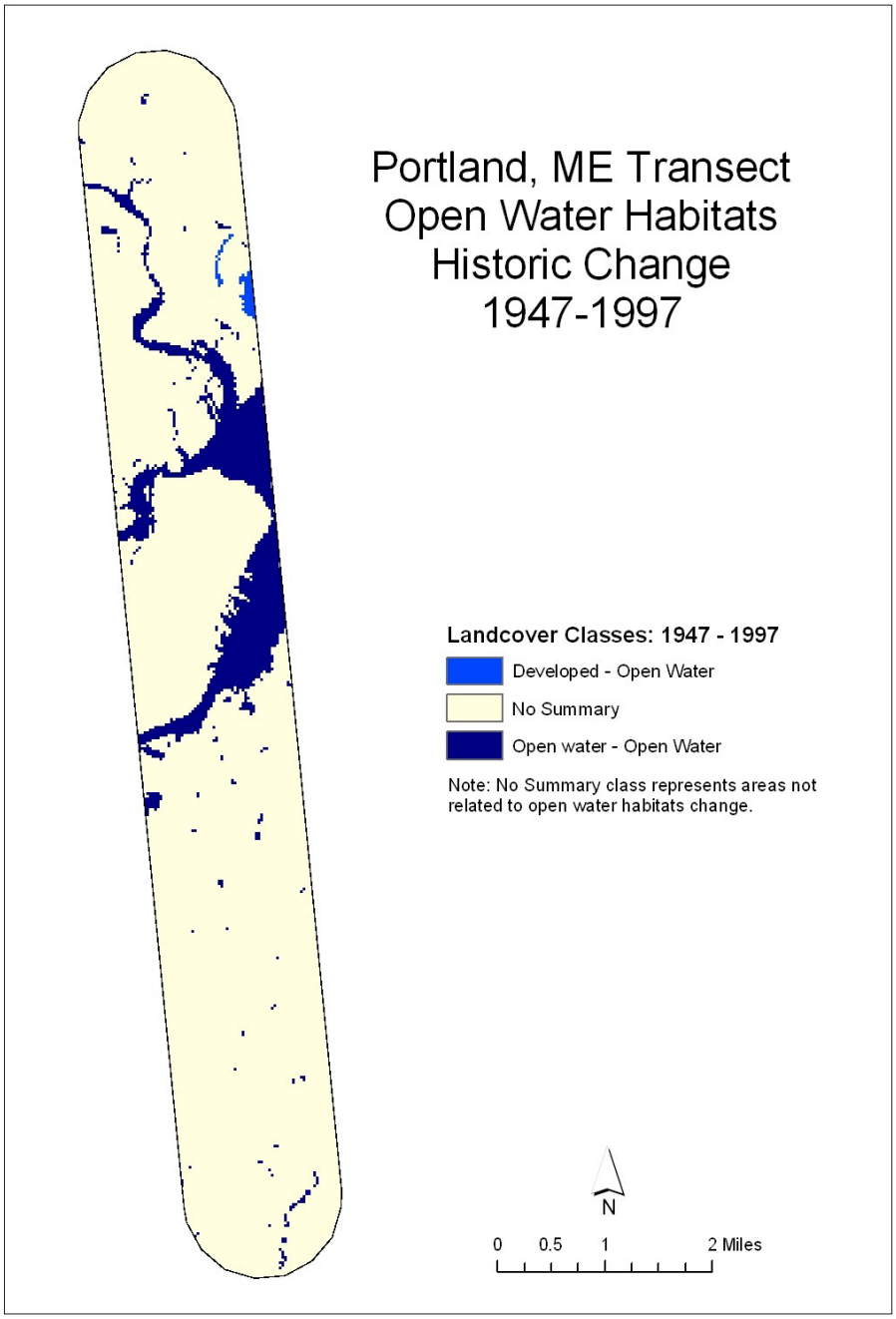


Figure 4-09. Open water habitats change from 1947-1997, Portland, ME transect

Historical (1947 – 1997) Change Tables

Overall, there were few changes in wetland habitat types in the Portland Harbor transect for the historical time period. The greatest land cover changes occurred in the developed and agricultural classes. The data in Table 4-05 show a 44.19% gain in acres of developed land, undoubtedly due to the growth and urbanization of the greater Portland area. Much of this growth in development occurred within the northern end of the transect, around the mouth of the Presumpscot River. On the other hand, the data also show a significant loss in agricultural acreage, 98.24% over the 50-year period of study.

The majority of this agricultural conversion took place in the low-lying areas north of the mouth of the Presumpscot River. Other losses occurred in shrub-scrub wetlands, which were reduced in areal extent by an estimated 18.79%. The loss of this habitat group was almost completely due to the loss in agricultural land, which the lost shrub-scrub wetlands had adjoined. Table 4-05 also shows a 10.0% gain in estuarine aquatic beds; however, review of the data suggests that this may be an artifact of the coarse resolution of the data sets.

Review of the wetland habitat groups in Table 4-05 indicates that little wetland area was lost over the 50-year study period, totaling only 5.42% of the original 1947 area. As noted above, however, major changes were seen in the developed and agricultural classes, where developed areas increased by 44.19% and agricultural lands decreased by 98.24%. Losses in both agricultural and other upland were the primary contributors to the gain in developed land, as 213 acres of agricultural and 591 acres of other upland were developed over the 50-year period.

Table 4-05. Acreage and percent change of land cover from 1947-1997. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

Portland, ME Transect - Dataset Acreage and Change by Land Cover					
	HIST47 Acres	**GOMLC97 Acres**	**Change 47-97 Acres**	**Change 47-97 Percent**	**47-97 Gain/Loss**
Wetlands Total	***2,375.18***	***2,246.41***	***-128.77***	***-5.42%*** [a]	***loss***
Emergent Wetlands	451.02	451.91	0.89	0.20% [b]	gain
Woody Wetlands Total	311.35	295.79	-15.57	-5.00% [c]	loss
Woody Wetlands (undetermined)	0.00	0.00	0.00	0.00%	
Shrub-scrub Wetlands	113.64	92.29	-21.35	-18.79% [d]	loss
Mangroves	0.00	0.00	0.00	0.00%	
Estuarine Forested Wetlands	0.00	0.00	0.00	0.00%	
Palustrine Forested Wetlands	197.71	203.49	5.78	2.92% [e]	gain
Natural (non-armored) Shoreline	1,612.81	1,498.72	-114.09	-7.07% [f]	loss
Open Water Total	***1,235.40***	***1,235.40***	***0.00***	***0.00%***	
Open Water	1,183.81	1,183.81	0.00	0.00%	
Aquatic Bed Total	51.60	51.60	0.00	0.00%	
Aquatic Bed (undetermined)	40.48	40.48	0.00	0.00%	
Palustrine Aquatic Beds	0.00	0.00	0.00	0.00%	
Estuarine Aquatic Beds	11.12	11.12	0.00	0.00%	
Coral Reefs	0.00	0.00	0.00	0.00%	
Oyster Reefs/Shell Bottom	0.00	0.00	0.00	0.00%	
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	0.00	0.00	0.00	0.00%	
Developed	***2,062.27***	***2,973.64***	***911.37***	***44.19%***	***gain***
Agriculture	***744.13***	***13.12***	***-731.01***	***-98.24%***	***loss***
Other Upland	***4,347.15***	***4,295.56***	***-51.60***	***-1.19%***	***loss***
TOTAL	***10,764.13***	***10,764.13***			

Note: The following footnotes indicate an actual total gain/loss of wetlands or open water habitats of at least/most the indicated amount. These numbers look strictly at change to development which is less likely to be misclassified.
[a] Wetlands total loss of at least 4.47% (106 acres)
[b] Emergent wetlands loss/gain of 0%
[c] Woody wetlands total loss of at least 3.05% (9 acres)
[d] Shrub-scrub loss of at least 7.96% (9 acres)
[e] Palustrine forested wetlands loss/gain of 0%
[f] Natural shoreline loss of at least 5.95% (96 acres)

The potential causes for loss in wetland habitat for the historical period can be further examined by looking at Table 4-06, which includes percentages of change in wetland and open water habitats due to conversion to development, agriculture, and/or other upland. These data show a total of 134.55 acres of wetland lost through conversion to non-wet classes. This acreage amounts to nearly all of the wetland area lost for this time period, or 5.42% of the total 1947 wetland area. Most of this loss occurred through conversion to developed land (4.47%) and other upland (1.20%). A very small percentage of wetland area was gained through conversion from agricultural practices (0.24%).

Table 4-06. Change in Wetlands and Open Water Habitats due to Conversion to Development, Agriculture, or Other Upland Classes from 1947-1997.

Portland, ME Transect - Change in Wetlands and Open Water Habitats due to Conversion to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 47-97 Acres**	**Change 47-97 Percent**	**47-97 Gain/Loss**
Wetlands	Developed, Agriculture, Other Upland	134.55		
Developed, Agriculture, Other Upland	Wetland Habitats	5.78		
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		-128.77	-5.42%	loss
Open Water Habitats	Developed, Agriculture, Other Upland	0.00		
Developed, Agriculture, Other Upland	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		0.00	0.00%	
Wetlands	Other Upland	28.47		
Other Upland	Wetlands	0.00		
Wetland Habitats Gain/Loss to Other Upland		-28.47	-1.20%	loss
Wetlands	Agriculture	0.00		
Agriculture	Wetlands	5.78		
Wetland Habitats Gain/Loss to Agriculture		5.78	0.24%	gain
Wetlands	Developed	106.08		
Developed	Wetlands	0.00		
Wetland Habitats Gain/Loss to Developed		-106.08	-4.47%	loss
Open Water Habitats	Other Upland	0.00		
Other Upland	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Other Upland		0.00	0.00%	
Open Water Habitats	Agriculture	0.00		
Agriculture	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Agriculture		0.00	0.00%	
Open Water Habitats	Developed	0.00		

From	To	Change 47-97 Acres	Change 47-97 Percent	47-97 Gain/Loss
Developed	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Developed		0.00	0.00%	

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

A more detailed breakdown of changes in target habitat groups and other land cover classes between 1947 and 1997 for the Portland Harbor transect can be seen in Table 4-07. This table shows the distribution and change in number of acres for the period 1947 to 1997. The table also shows the number of acres that remained unchanged (grey cells) between 1947 and 1997. These data support the findings shown in Table 4-06 which indicate that most of the wetland loss is due to changes from shrub-scrub wetlands or natural shoreline areas to developed and other upland habitats. In total, natural shoreline areas lost 96.5 acres to developed lands. This was likely the result of shoreline armoring associated with port and harbor development. The change matrix also shows that large contributions from agriculture were made towards development (213 acres) and other uplands (511 acres). The other uplands class alone lost 591 acres (13%) of its 1947 acreage to development.

Historical (1947 – 1997) Change Summary

Overall, the historical 50-year period between 1947 and 1997 for the Portland Harbor transect saw a small reduction in wetland habitat (5.42%), along with a large increase in developed land (44.19%). Agricultural lands experienced the greatest loss in areal extent, losing nearly 98.24% of their 1947 area. Almost all of the wetland loss can be attributed to the increase in development, with a small percentage due to conversion to other upland. Most of the agricultural areas were either converted to developed areas or other upland, with only a 5.78 acres converting to wetlands.

Table 4-07. matrix representing change in acres among target habitat groups and land cover classes in the transect from 1947 to 1997. Values in the gray shaded cells are acres of no change.

Portland, ME Land Cover Change Aerial Photos 1947 to GOMLC 1997 (by acres)													
		1947											
			Wetland Habitats				Open Water Habitats			Non-Wet Land Cover			
			Emergent Wetlands	Shrub-Scrub Wetlands	Palustrine Forested Wetlands	Natural Non-armored) Shoreline	Open Water	Aquatic Bed	Estuarine Aquatic Beds	Developed	Agriculture	Other Upland	Acreage Totals for 1997 Classification
1997	Wetland Habitats	Emergent Wetlands	451.02	0.00	0.00	0.89	0.00	0.00	0.00	0.00	0.00	0.00	451.91
		Shrub-Scrub Wetlands	0.00	92.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	92.29
		Palustrine Forested Wetlands	0.00	0.00	197.71	0.00	0.00	0.00	0.00	0.00	5.78	0.00	203.49
		Natural (Non-armored) Shoreline	0.00	0.00	0.00	1,498.72	0.00	0.00	0.00	0.00	0.00	0.00	1,498.72
	Open Water Habitats	Open Water	0.00	0.00	0.00	0.00	1,183.81	0.00	0.00	0.00	0.00	0.00	1,183.81
		Aquatic Bed	0.00	0.00	0.00	0.00	0.00	40.48	0.00	0.00	0.00	0.00	40.48
		Estuarine Aquatic Beds	0.00	0.00	0.00	0.00	0.00	0.00	11.12	0.00	0.00	0.00	11.12
	Non-Wet Land Cover	Developed	0.00	9.56	0.00	96.52	0.00	0.00	0.00	2,062.27	213.50	591.79	2,973.64
		Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.12	0.00	13.12
		Other Upland	0.00	11.79	0.00	16.68	0.00	0.00	0.00	0.00	511.73	3,755.36	4,295.56
		Acreage Totals for 1947 Classification	451.02	113.64	197.71	1,612.81	1,183.81	40.48	11.12	2,062.27	744.13	4,347.15	**10,764.13**

Section 4.4 CAF Change Summary (1947 –2004)

A summary of estimated habitat and other land cover change within the New England Coastal Assessment Framework (CAF) region for the period 1947 to 2004 is shown in Table 4-08. The table shows actual measured acres lost and gained for the transect at Portland Harbor for both the historical and recent time periods. In addition, the percent of acres lost and gained for the transect are also shown. These specific transect data were used in conjunction with regional information regarding the CAF, to develop estimates for habitat and other land cover change within the CAF as a whole.

For the wetland habitats, values slightly higher than the Portland Harbor transect were chosen to reflect the difference in coastal geomorphology between Portland and the southern half of the CAF. The higher values for the CAF were selected to account for greater losses in the lower portion of the CAF where the shorelines are sandier and the elevations are lower. For the natural (non-armored) shoreline habitat group, losses of 10 to 17% were estimated for the historical time period with 7 to 11% lost during 1992 to 2004. These losses represent greater shoreline loss than is shown for the Portland Harbor transect, primarily because the Portland shoreline areas are in many areas naturally armored with bedrock, while much of the CAF region to the south displays a more dynamic shoreline which has been impacted by natural and anthropogenic causes. Additionally, many areas within the CAF to the south of Portland are more susceptible to shoreline loss from sea level rise, reduced sediment supply caused by coastal armoring, and development pressures. As such, the loss of natural (non-armored) shoreline for the CAF was considered to be greater than for the Portland Harbor transect. Changes for the CAF within the emergent wetlands habitat category were estimated to be significantly higher than found for the Portland transect for the historical time period, with losses estimated at 13 to 28%, and roughly coincident with the Portland transect (-22%) for the recent time period, with losses estimated at 9 to 20%). These losses were considered greater for the CAF region as a whole than for the Portland area, primarily due to the increased prevalence of emergent wetlands south of Portland. Losses in woody wetland class totals for the CAF were estimated to be 17 to 43% for the historical period, while losses for the recent 1992-2004 period are estimated at -15 to -38%. The high percentage of recent loss is due primarily to recent increases in development within the CAF, which has tended to impact some of the fringe wetland habitats like the shrub-scrub and forested wetlands.

Changes in open water habitat for the New England CAF region were estimated to be lower than for the Portland Harbor transect from the recent time period. Losses in the CAF for the recent time period were estimated at 8 to 14% versus 18% for the transect. It is likely that the higher losses found at the transect level are the result of port and harbor development, which is much more prevalent at Portland Harbor than for the CAF as a whole. Losses ranging from 10 to 22% were estimated for the CAF region during the historic period. The greater open water loss for the historic time interval reflects an earlier period of infrastructure development (i.e., bridges, coastal roads, etc.) which tended to expand into the open water areas. The rate of this infrastructure development

decreased over the recent time period. Losses in the open water habitat class for the CAF were assumed to be equal to those of the broader open water classification, while changes for the aquatic beds habitats were assumed to have a nearly one-to-one relationship between the CAF and the Portland Harbor transect.

Table 4-08. Estimated target habitat group and land cover change from 1947-2004 for the New England CAF region based on local expert analysis of recent and historic change. Estimated acreages were calculated using estimated percent change in conjunction with the NLCD 1992 acres for each target habitat group and land cover type (Table 4-01). Also see Appendix C, Tables 13-04c – 04d for further detailed acreage values.

		Portland Harbor, ME Transect				New England CAF Region			
		1947-1997 Historic Acres Gain/Loss	1947-1997 Historic Percent Gain/Loss	1986-1997 Recent Acres Gain/Loss	1986-1997 Recent Percent Gain/Loss	Historic 1947 to 2004 Estimated Acres Gain/Loss	Historic 1947 to 2004 Estimated Percent Gain/Loss	Recent 1992 to 2004 Estimated Acres Gain/Loss	Recent 1992 to 2004 Estimated Percent Gain/Loss
Wetland Habitats	***Wetlands Total[1]***	***-128.77***	***-5.42%***	***-198.60***	***-8.17%***	***-146,657 to -359,145***	***-16% to -38%***	***-114,757 to -298,732***	***-13% to -32%***
	Emergent Wetlands	0.89	0.20%	-126.10	-21.88%	-34,772 to -77,567	-13% to -28%	-23,015 to -56,258	-9% to -20%
	Woody Wetlands Total[2]	-15.57	-5.00%	-229.51	-43.80%	-103,833 to -269,956	-17% to -43%	-89,462 to -238,565	-15% to -38%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	-21.35	-18.79%	-136.77	-59.65%	no data	-10% to -15%	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	5.78	2.92%	-92.74	-31.47%	no data	-2% to -5%	no data	no data
	Natural (non-armored) Shoreline	-114.09	-7.07%	157.01	11.80%	-3,366 to -5,871	-10% to -17%	-2,280 to -3,909	-7% to -11%
Open Water Habitats	***Open Water Total[3]***	***0.00***	***0.00%***	***-280.44***	***-18.45%***	***-73,616 to -172,652***	***-10% to -22%***	***-57,612 to -108,023***	***-8% to -14%***
	Open Water	0.00	0.00%	1,137.55	2273.33%	no data	no data	no data	no data
	Aquatic Bed Total[4]	0.00	0.00%	-4.89	-8.63%	no data	-5% to -10%	no data	no data
	Aquatic Bed (undetermined)**	0.00	0.00%	-4.45	-10.10%	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	0.00	0.00%	-0.44	-3.51%	no data	-3% to -10%	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***911.37***	***44.19%***	***188.37***	***6.78%***	***211,173 to 309,808***	***30% to 45%***	***83,189 to 166,378***	***12% to 24%***
	Agriculture	***-731.01***	***-98.24%***	***0.22***	***0.98%***	***-214,331 to -332,432***	***-20% to -30%***	***40,825 to -40,825***	***4% to -4%***
	Other Upland	***-51.60***	***-1.19%***	***290.45***	***7.34%***	***0 to -570,577***	***0% to -5%***	***0 to 516,236***	***0% to 5%***

1 "Emergent Wetlands", "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", "Palustrine Forested Wetlands", and "Natural (non-armored) Shoreline" have been summarized in "Wetlands Total".

2 "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", and Palustrine Forested Wetlands" have summarized in "Woody Wetlands Total".

3 "Aquatic Beds", Palustrine Aquatic Beds", Estuarine Aquatic Beds", "Coral Reefs", "Oyster Reefs/Shell Bottom", "Hard Bottom" and "Soft Bottom" have been summarized in "Open Water Total".

4 "Aquatic Beds", "Palustrine Aquatic Beds", and "Estuarine Aquatic Beds" have been summarized in "Aquatic Bed Total".

* "Woody Wetlands (undetermined)" includes wetlands not specifically identified by system (palustrine, estuarine, etc.) and/or type of woody vegetation (shrub-scrub, forested, etc.).

** "Aquatic Bed (undetermined)" includes aquatic beds not specifically identified by system (palustrine, estuarine, etc.).

Section 5.0 Mid Atlantic CAF

Section 5.1 CAF Description

The Mid Atlantic Coastal Assessment Framework (CAF) region is approximately 29,548,100 acres in size, and includes parts of Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, and Virginia. NOAA has sub-divided the Mid Atlantic CAF into 33 Estuarine Drainage Areas and 10 different Coastal Drainage Areas. The northeastern portion of the CAF, from Massachusetts through New York, includes land areas that drain into Buzzards Bay, Narragansett Bay, Long Island Sound, and Raritan Bay through the extensive Hudson River system. Parts of the northeastern end of the CAF extend inland approximately 50 miles; however, around the Hudson River the CAF stretches nearly 150 miles inland. Ground elevations around Buzzards Bay, Narragansett Bay and Long Island Sound extend from sea level to approximately 100 meters above sea level as one moves inland, while elevations further from the coast in north central Connecticut reach a maximum of 400 meters above sea level. The elevation gradient across the Hudson River is relatively steep as the ground rises from sea level to 100 meters above sea level over an average distance of 7 miles. Maximum elevations in the Hudson River drainage basin are on the order of 1,000 meters above sea level in the Catskill and Berkshire Mountains. Wetland types range from sandy beaches along the coast, to freshwater tidal wetlands, to seasonally flooded wetlands and forested swamps along the streams at higher elevations.

The southern portion of the CAF from New Jersey through Virginia includes the Atlantic facing beaches and barrier islands of New Jersey, Delaware, and Maryland, as well as the extensive estuary systems associated with the Delaware and Chesapeake Bays. The southern part of the CAF extends inland anywhere from 25 to 150 miles. Elevations are much lower than the northern portion of the CAF, ranging from 0 to 30 meters above sea level over most of the Coastal Plain Province. Ground elevations are between 100 and 500 meters above sea level in the Piedmont Plateau Province along the western boundary of the CAF. Large expanses of estuarine wetlands are present within the southern portion of the CAF, including coastal and barrier beaches, salt marshes, and shallow inland ponds. Further inland near the boundary with the Piedmont Plateau, freshwater wetlands start to dominate in the form of small tributary streams, seasonally flood wetlands and forested swamps.

Just over 20% of the Mid Atlantic CAF is composed of densely populated regions, primarily in the large cities of Providence (Rhode Island), Bridgeport (Connecticut), New York (New York), Philadelphia (New Jersey), Baltimore (Maryland), Washington D.C., Richmond (Virginia), and Norfolk (Virginia). These urban areas account for a total of 5,916,370 acres, or 20.0% of the total CAF area. Population densities are highest in the urban corridor between New York City and Washington, D.C. Human population growth from 1990 to 2000 was slightly over 8%, increasing from an estimated 30,127,404 persons to 32,641,669 persons (ESRI, 2000 and ESRI, 2002). This growth has been highest in the Coastal Plain Province near the ocean and the estuaries, while growth in the

western portion of the CAF region has been nearly flat or negative. The percentage of federally owned land is relatively small in the Mid Atlantic CAF, accounting for 650,317 acres or 2.2% of the total area. The largest of these areas are owned by the Department of Defense, the US Fish and Wildlife Service, and the National Park Service.

Review of data from existing studies provides some insight as to the historical levels of wetland loss within the Mid Atlantic CAF. NOAA's National Marine Fisheries Service reports wetland losses through the 1980s for states in the Mid Atlantic CAF (NOAA, 2005). Of these, Connecticut, New York, and Maryland each lost 60% or more of their original wetland areas by the mid-1980s (74%, 60%, and 73% respectively). Wetland losses within Rhode Island, New Jersey, Delaware, and Virginia were significantly less at 37%, 46%, 54%, and 42%, respectively. The USDA has reported on wetland losses for the entire northeast region from Maine to Maryland for the more recent period between 1992 and 1997 (USDA, 2005a). These data show a 57,600 acre loss in palustrine and estuarine wetlands and a 15,400 acre gain, for a net wetland loss of 42,200 acres. Causes for the reduction in wetland areas were primarily development (67.2%), silviculture (16.3%), and agriculture (9.0%) (USDA, 2005b).

Section 5.2 Recent (1992) Land Cover Data Summary

Figure 5-01 shows the mapped target habitat groups and other land cover classes for the Mid Atlantic CAF region. The data was based on the 1992 USGS National Land Cover Dataset (NLCD).

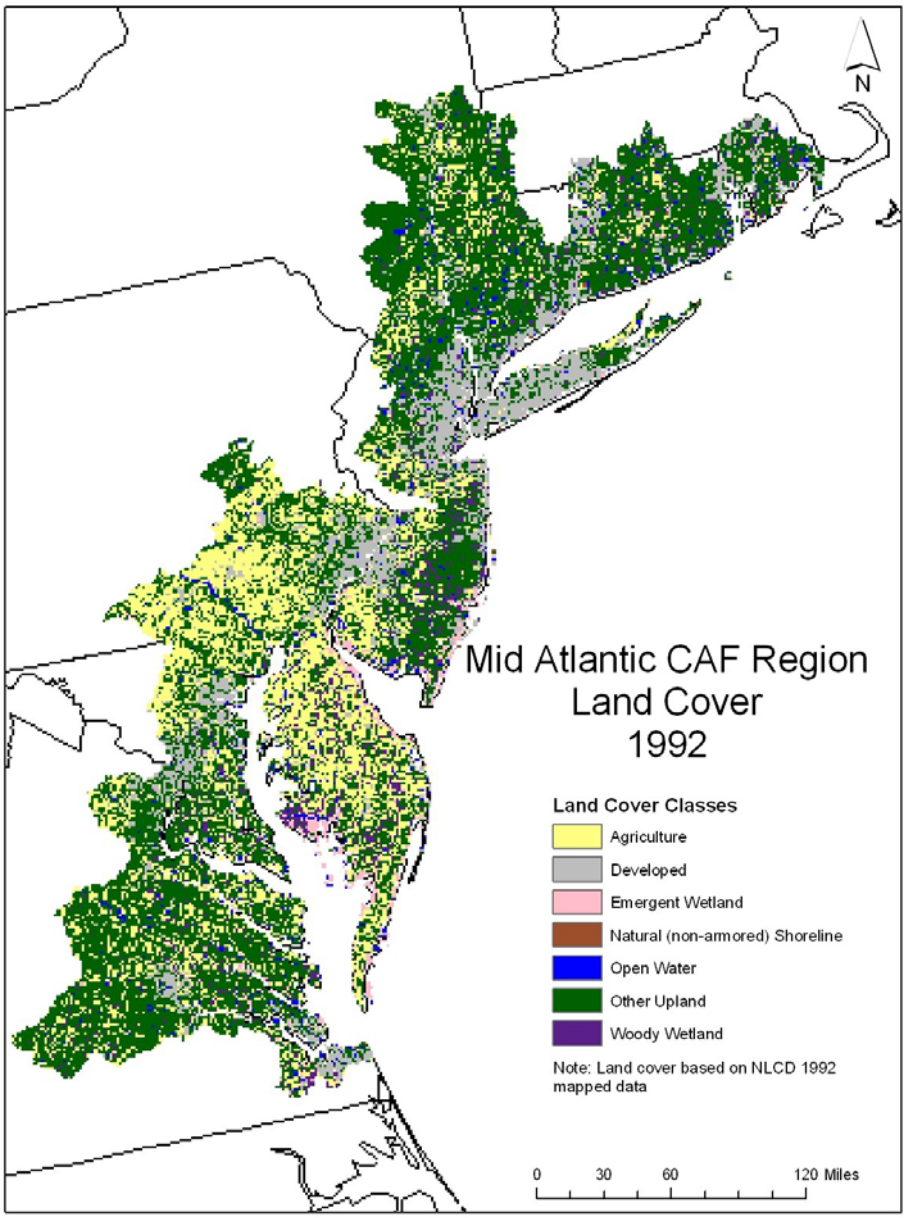


Figure 5-01. Mid Atlantic CAF Region land cover, 1992.

Of the total acreage within the Mid Atlantic CAF region, wetlands and open water habitats combined comprise approximately 10% of the area. Open water habitats alone account for only 2.4% of the total CAF area. Woody wetlands are far more prevalent than emergent wetlands, comprising nearly two-thirds of the wetland habitat class with a total of 1,403,948 acres. Emergent wetlands make up approximately 35% of the wetland

category and natural shorelines contribute only 1.5% to the wetland category. Overall, the 1992 NLCD for the Mid Atlantic CAF region shows a similar distribution of wetland and open water (10%) to other land cover (90%) areas as for the New England CAF.

Table 5-01. Total area of target habitat groups and other land cover classes within the Mid Atlantic CAF region (1992).

Mid Atlantic CAF Region - Total Area by Habitat Group and Other Land Cover Type	
	NLCD 1992 Acres
Wetlands Total[1]	***2,229,742.19***
Emergent Wetlands	791,986.61
Woody Wetlands Total[2]	1,403,948.29
Woody Wetlands (undetermined)*	1,403,948.29
Shrub-scrub Wetlands	0.00
Mangroves	0.00
Estuarine Forested Wetlands	0.00
Palustrine Forested Wetlands	0.00
Natural (non-armored) Shoreline	33,807.28
Open Water Total[3]	***696,276.63***
Open Water	696,276.63
Aquatic Bed Total[4]	0.00
Aquatic Bed (undetermined)**	0.00
Palustrine Aquatic Beds	0.00
Estuarine Aquatic Beds	0.00
Coral Reefs	0.00
Oyster Reefs/Shell Bottom	0.00
Hard Bottom	0.00
Soft Bottom	0.00
Developed	***4,090,337.43***
Agriculture	***7,124,562.99***
Other Upland	***15,223,588.92***
TOTAL	***29,364,508.14***

1 "Emergent Wetlands", "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", "Palustrine Forested Wetlands", and "Natural (non-armored) Shoreline" have been summarized in "Wetlands Total".

2 "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", and Palustrine Forested Wetlands" have summarized in "Woody Wetlands Total".

3 "Aquatic Beds", Palustrine Aquatic Beds", Estuarine Aquatic Beds", "Coral Reefs", "Oyster Reefs/Shell Bottom", "Hard Bottom" and "Soft Bottom" have been summarized in "Open Water Total".

4 "Aquatic Beds", "Palustrine Aquatic Beds", and "Estuarine Aquatic Beds" have been summarized in "Aquatic Bed Total".

* "Woody Wetlands (undetermined)" includes wetlands not specifically identified by system (palustrine, estuarine, etc.) and/or type of woody vegetation (shrub-scrub, forested, etc.).

** "Aquatic Bed (undetermined)" includes aquatic beds not specifically identified by system (palustrine, estuarine, etc.).

Note: Acreage totals are a rough estimate. Totals may not represent all of each CAF region due to clipping of raster datasets.

Section 5.3 Transect Analysis Results

Section 5.3.1 Block Island Sound, RI Transect

Transect Location

The location of the Block Island Sound, RI transect in the Mid Atlantic Coastal Assessment Framework (CAF) region is illustrated in Figure 5-02. The placement of the transect can be seen in more detail in Figure 5-03. The Block Island Sound transect is generally oriented parallel to the Rhode Island shoreline, stretching from Point Judith Pond in the east to Quonochontaug Pond in the west. The transect crosses a number of other coastal ponds, including Potter Pond, Trustom Pond, Green Hill Pond and Ninigret Pond. Most of these ponds are separated from Block Island Sound and the Atlantic Ocean by barrier beaches, with tidal exchange through structured and natural inlets. Quonochontaug Pond at the western end of the transect is a true coastal pond with no hydraulic connection to the Sound. The ponds are separated from each other by headland areas where glacial till and outwash deposits form low-lying coastal banks that directly abut coastal beaches. The transect contains the town of Charlestown, Rhode Island, as well as other heavily developed residential areas; however, the level of urban development characteristic of the Mid Atlantic CAF region between New York City and Washington, D.C. is not represented by the transect. Due to its orientation along the shoreline, the Block Island Sound transect does not capture any of the freshwater wetlands within the CAF region, and thus underestimates wetland changes that may be occurring in the brackish and freshwater areas of the Hudson River, and upper reaches of the Delaware and Chesapeake Bays. Aside from these differences, the Block Island Sound transect provides a good representation of the estuarine habitat conditions in the Mid Atlantic CAF that are influenced by saline conditions. A description of the Block Island Sound, Rhode Island transect using the condition variables listed in Section 1.2.3 is given below, along with a discussion of changes in habitat area as seen over two different time periods, recent (1992 to 1999) and historical (1939 to 1999).

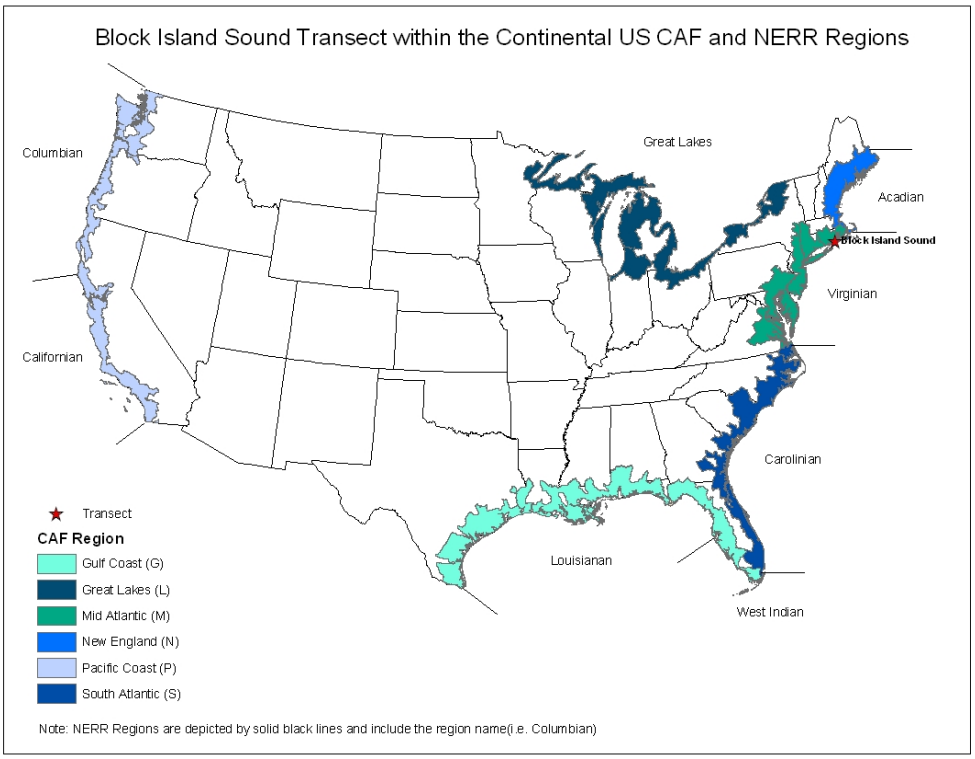


Figure 5-02. Location of the Block Island Sound, RI within the Mid-Atlantic CAF region.

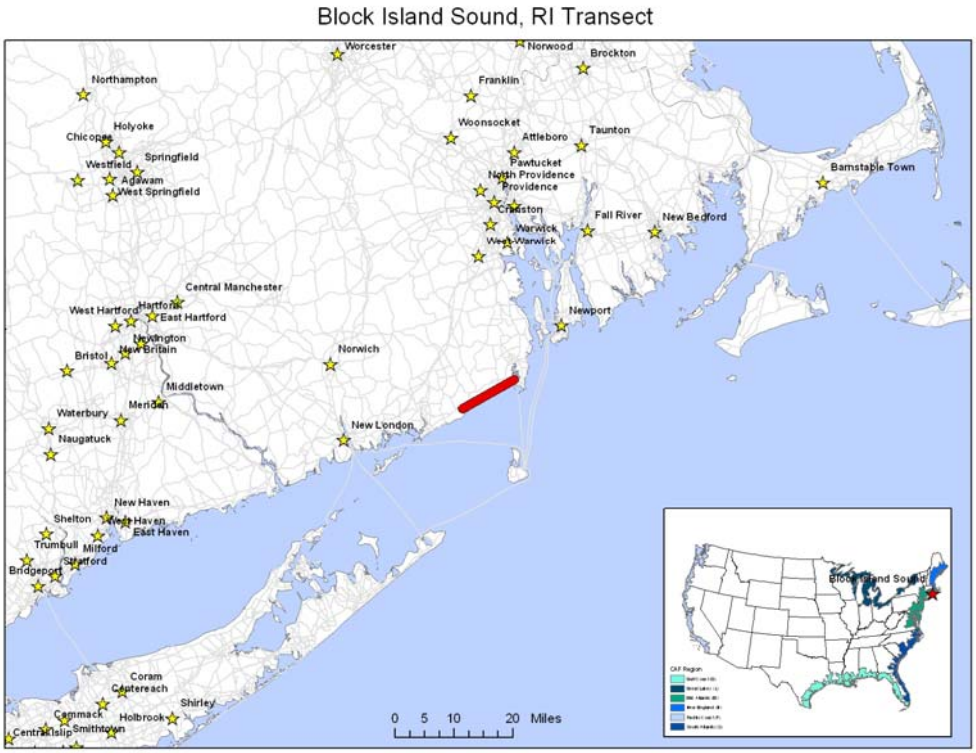


Figure 5-03. Block Island Sound, RI transect placement. Transect is mapped in red.

Transect Description

I. Distance to Coast
   a. The Block Island Sound transect is located along the coast line, and thus wetland status and trends observed within the transect will be representative of most coastal wetlands throughout the Mid Atlantic CAF.
   b. Due to its proximity to the coastal zone, the data derived from the Block Island Sound transect will not be representative of changes that have occurred within the palustrine wetlands of the CAF.
   c. Anthropogenic pressures on wetlands of the Block Island Sound transect are the result of coastal development primarily from suburban residential growth. These pressures are different, and generally of lower magnitude than those associated with urban landscapes which are prevalent throughout the central portion of the Mid Atlantic CAF.
   d. The wide boundaries of the CAF suggest that attempts to characterize the CAF with one or two transects that do not span the range of wetland types are apt to be both imprecise and inaccurate.

II. Salinity
   a. All of the Block Island Sound transect is located in an area of saline water with values ranging from 31 to 32 ppt.
   b. The Block Island Sound transect is not representative of brackish and freshwater conditions found at more inland locations with the Mid Atlantic CAF.

III. Topography/Elevation Range
   a. Elevation values throughout the transect range from sea level to 30 meters above sea level. This range is representative of conditions nearest the coastline, approximately 2 to 15 miles inland, for most of the CAF.
   b. Elevation ranges at the Block Island Sound transect are not representative of those found at more inland wetland or habitat locations, such as the Hudson River area where the elevation gradients are much steeper, and average elevations range from 200 to 400 meters above sea level.

IV. Proximity to City
   a. The Block Island Sound transect is located in an area of relatively heavy residential development; however, it is not classified as an urban area. Since urban areas make up just over 20.0% of the CAF region, development within the transect is likely similar to other near coastal regions of the CAF, with the exception of the large cities like Providence, New York, Baltimore, Washington D.C., and Norfolk.
   b. The population density within the transect is approximately 210 people per square mile. This is considerably less than the population densities for the urban belt between New York City and Washington, D.C. which range from around 3,700 to 26,500 people per square mile. On the other hand, the population density of the Block Island Sound transect is only slightly above the average of 181 people per square mile for the entire CAF. As such, wetland loss within the transect resulting from anthropogenic activities is similar to losses in most other areas of the CAF, with the exception of the larger urban areas.

c. Population growth in the Block Island Sound transect between 1990 and 2000 was on the order of 21.3%. This is considerably higher than the average population growth for the entire CAF region of 8.3% over the same time period. As a result, wetland loss within the transect caused by development pressures likely overestimates losses in the CAF as a whole, with the exception of the major urban cities.

V. Land Ownership

a. There are two federally owned properties within the Block Island Sound transect, managed as National Wildlife Refuges by the U.S. Fish and Wildlife Service. Together these protected areas comprise approximately 13% of the total transect area. The presence of these protected areas within the transect may underestimate the wetland loss in the larger CAF region.

VI. Dominant Land Uses

a. The largest percentage of land within the Block Island Sound transect is classified as water (approximately 24.0%). This includes the following coastal ponds: Point Judith Pond, Potter Pond, Trustom Pond, Green Hill Pond, Ninigret Pond, and Quonochontaug Pond.
b. Developed land comprises the next largest habitat category in the transect making up approximately 19% of the total area, following by agricultural (16.1%) and forest land (17.1%). Wetlands make up approximately 8.0% of the transect area, although this class may be under represented as a portion of the barrier beaches are not covered by the NLCD 1992 data.
c. As compared with land use throughout the Mid Atlantic CAF, the Block Island Sound transect shows a significantly higher percentage of water and wetland areas. Overall, throughout the CAF region the percentage of water areas is only 2.1%, as compared with the nearly 24.0% for the Block Island Sound transect. This is true primarily because the land cover data for the CAF does not include the extensive water areas of Long Island Sound, and Delaware and Chesapeake Bays. With these large water bodies included, the relative percent of water areas with the CAF would likely approach the 24.0% seen in the Block Island Sound transect.
d. The extent of urban or developed land within the Mid Atlantic CAF is considerably greater than represented by the Block Island Sound transect. This will likely result in an underestimate of wetland loss as a result of anthropogenic factors, when extrapolation the transect losses to the CAF region as a whole.
e. The Block Island Sound transect shows significantly less forest land than is represented by the entire CAF region. This should have little impact on estimates of wetland change.
f. Finally, the extent of agricultural land within the Mid Atlantic CAF is significantly greater than represented by the Block Island Sound transect. As such, wetland losses to agricultural conversion would be under estimated, when using the transect data to extrapolate values for the CAF region.

VII. Extent of Shoreline Armoring

a. Most of the shoreline areas within the Block Island Sound transect are natural (non-armored) sandy or marsh-lined shorelines.
b. While this shoreline type is characteristic of many of the open ocean facing coastline areas of Long Island, southern New Jersey, Delaware, and Maryland, it does not represent the high degree of armoring found in many of the more urban coastal areas. This will likely result in lower wetland losses for the Block Island Sound transect than are actually occurring within the Mid Atlantic CAF as a whole.

VIII. Shipping

a. Shipping within the Block Island Sound transect is basically non existent. Boat activity within this area is limited to small fishing vessels and recreational boating.
b. Shipping within other areas of the Mid Atlantic CAF is significant, especially in the major ports of New York City, Baltimore, and Norfolk. These areas are major ports of entry, serving as shipping and receiving sites for a variety of goods and services.
c. The absence of port and harbor shipping in the Block Island Sound transect likely results in lower rates of wetland loss from dredging as well as construction and/or maintenance of port facilities (e.g., docks, over water structures) than found elsewhere in the Mid Atlantic CAF. In addition, the degradation of estuarine habitats will be lower for the transect than for the CAF region as a whole, as water quality from shipping and upland runoff is likely not impacted as much at the Block Island Sound transect.

IX. Dredging.

a. Dredging activities have been conducted within Point Judith Pond since the early 1900s when a harbor of refuge was constructed by the state of Rhode Island and the US Army Corps of Engineers. Subsequently in the 1930s the state dredged an anchorage basin to provide a larger harbor area for fishing vessels. Since this time the entrance channel to Point Judith Pond has been maintained as a Federal Navigation Channel requiring periodic dredging. Potential impacts from this activity include removal of wetland resources during the actual dredging, as well as possible burial of valuable resources during disposal. Likely disposal sites are offshore, nearshore in harbor areas, nearshore upland fill, or remote upland sites. Adverse impacts to wetlands from dredging can also result from increased turbidity and changes in sediment substrata.
b. Major dredging projects are routinely conducted in many other coastal areas within the Mid Atlantic CAF region, ranging from the larger sites like Providence Harbor, New York Harbor, Newark, Norfolk, etc., to the smaller harbors and rivers where recreational boating is common. Additionally, routine maintenance dredging is conducted in the Delaware and Chesapeake Bay areas. As such, impacts from dredging on wetlands within the CAF region is likely under represented by changes observed in the Block Island Sound transect.

X. Major Natural Disasters

a. Hurricanes are the only natural disaster that affect the Block Island Sound transect. Although hurricane damages are much more common in the south-Atlantic US states, they can also impact the south facing shoreline of Rhode Island. Over the past 350 years, the state has been struck by 73 hurricanes, thirteen of which caused severe flooding and erosion. Wetland impacts from hurricanes include increased shoreline erosion from waves, as well as saltwater inundation and flooding.
b. As the frequency and severity of hurricanes generally increases from north to south through the Mid Atlantic CAF, associated wetland impacts also increase towards the south. As such, the hurricane related wetland loss observed in the Block Island Sound transect likely under estimates storm generated losses in the CAF region as a whole.

Recent Transect Maps

Figures 5-04 shows the 1997 Digital Orthophoto Quarter Quadrangles (DOQQs) of the Block Island Sound, RI transect. The DOQQs were used as a visual reference for interpreting recent land cover in the transect. Figure 5-05 and 5-06 depict the changes in wetland habitats and open water habitats from 1992 to 1999 respectively. The wetlands change map shows areas that changed from wetland to non-wetland classes and non-wetland to wetland classes. Similarly, the open water change map displays open water to non-open water classes and non-open water to open water classes. These maps are helpful in determining where wetlands and open water habitat changes occurred and which classes they changed between.

Figure 5-04. 2003/1997 DOQQ of Block Island Sound, RI transect.

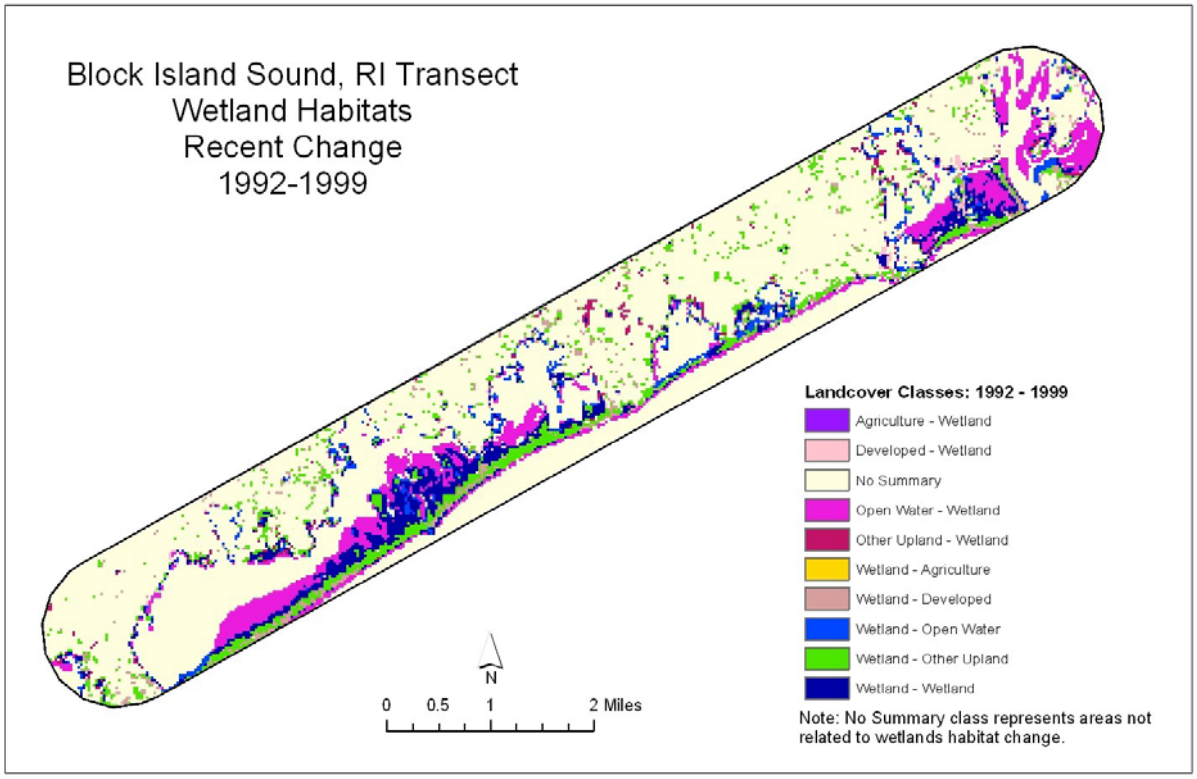


Figure 5-05. Change in wetland habitats from 1992-1999 for the Block Island Sound, RI transect.

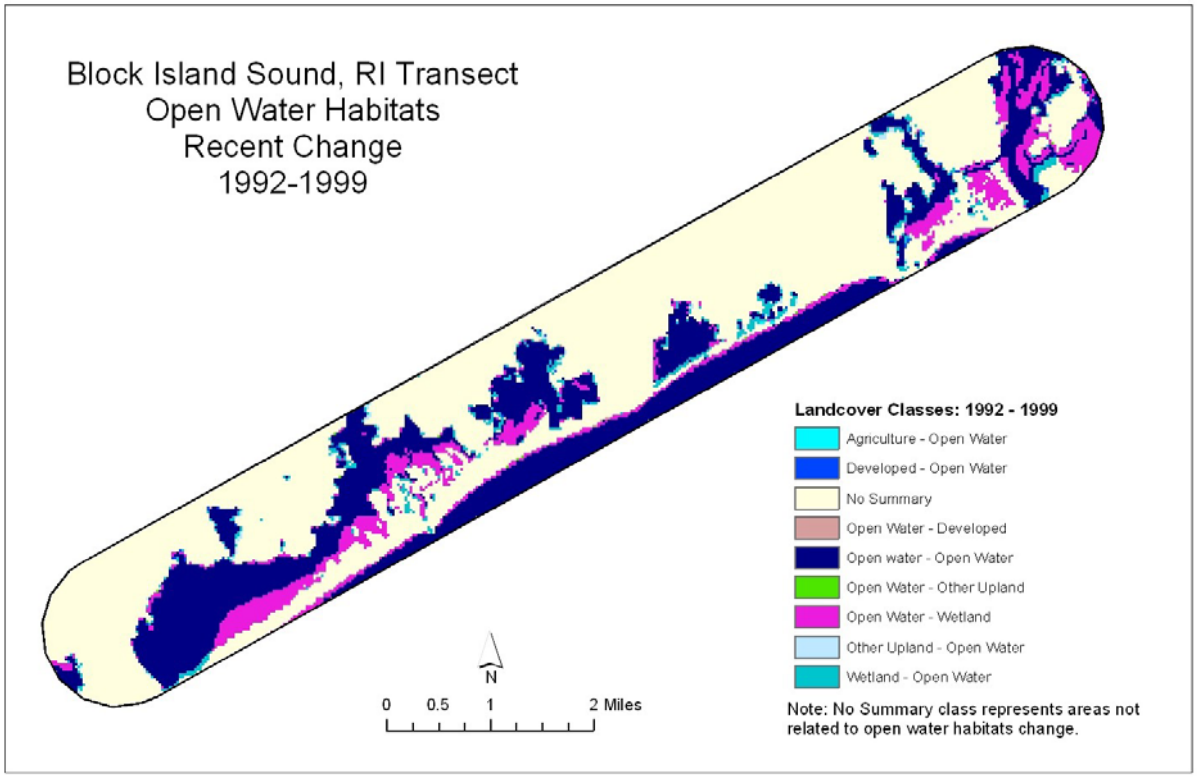


Figure 5-06. Change in open water habitats from 1992-1999 for the Block Island Sound, RI transect.

Recent (1992 – 1999) Change Tables

The datasets analyzed for this recent change included the NLCD 1992 land cover data as well as an overlay of National Wetlands Inventory (NWI) data from 1999 with C-CAP data from 1997. Overall, the Block Island Sound transect contains approximately 10,800 acres. Comparison between the 1992 and 1997/1999 datasets shows significant changes in a number of habitat groups (Table 5-02); however, close examination of the data indicates that many of these changes are anomalies resulting from differences in mapping resolution and/or use of different classification schemes. For example, areas of open water show a loss of nearly 96% between 1992 and 1997/1999, a finding that results largely from re-classification of the 1992 open water areas to soft bottom in 1997/1999. Similarly, gains of 100% for aquatic beds, oyster reefs, and soft bottom habitats are the result of a finer classification scheme to the sub-habitat level for the more recent dataset, and thus do not necessarily represent a loss in habitat area. When summarized into the broader open water total group, the data show an overall loss of open water habitat of approximately 577 acres, or -14.86% of the 1992 area. This summarized value likely provides a better estimate of the actual change; however, it may still over-estimate the loss, as many of the 1992 open water areas were erroneously classified as natural (non armored) shoreline in the 1997/1999 data.

Table 5-02. Acreage and percent change of land cover classes from 1992-1999. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

Block Island Sound, RI Transect - Dataset Acreage and Change by Land Cover Classes					
	NLCD92 Acres	**C-CAP97-NWI99 Acres**	**Change 92-99 Acres**	**Change 92-99 Percent**	**92-99 Gain/Loss**
Wetlands Total	***1,979.98***	***1,835.42***	***-144.56***	***-7.30%*** [a]	***loss***
Emergent Wetlands	614.48	550.20	-64.27	-10.46% [b]	loss
Woody Wetlands Total	799.29	182.36	-616.92	-77.18% [c]	loss
Woody Wetlands (undetermined)	799.29	0.00	-799.29	-100.00%	
Shrub-scrub Wetlands	0.00	62.94	62.94	100.00%	
Mangroves	0.00	0.00	0.00	0.00%	
Estuarine Forested Wetlands	0.00	0.00	0.00	0.00%	
Palustrine Forested Wetlands	0.00	119.43	119.43	100.00%	
Natural (non-armored) Shoreline	566.22	1,102.86	536.64	94.78% [d]	gain
Open Water Total	***3,881.68***	***3,305.01***	***-576.67***	***-14.86%*** [e]	***loss***
Open Water	3,881.68	169.91	-3,711.77	-95.62%	loss
Aquatic Bed Total	0.00	487.27	487.27	100.00%	
Aquatic Bed (undetermined)	0.00	27.35	27.35	100.00%	
Palustrine Aquatic Beds	0.00	0.00	0.00	0.00%	
Estuarine Aquatic Beds	0.00	459.91	459.91	100.00%	
Coral Reefs	0.00	0.00	0.00	0.00%	
Oyster Reefs/Shell Bottom	0.00	2.22	2.22	100.00%	

	NLCD92 Acres	C-CAP97-NWI99 Acres	Change 92-99 Acres	Change 92-99 Percent	92-99 Gain/Loss
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	0.00	2,645.61	2,645.61	100.00%	
Developed	***1,316.13***	***1,211.83***	***-104.30***	***-7.92%*** [c]	***loss***
Agriculture	***5.78***	***0.44***	***-5.34***	***-92.31%***	***loss***
Other Upland	***3,540.75***	***4,371.62***	***830.87***	***23.47%***	***gain***
TOTAL	***10,724.33***	***10,724.33***			

Note: The following footnotes indicate an actual total gain/loss of wetlands or open water habitats of at least/most the indicated amount. These numbers look strictly at change to development which is less likely to be misclassified.

[a] Wetlands total loss of at least 10.33% (204.61 acres)

[b] Emergent wetlands gain of at most 1.85% (11.34 acres)

[c] Woody wetlands total loss of at least 13.94% (111.42 acres)

[d] Natural (non-armored) shoreline loss of at least 18.46% (104.53 acres)

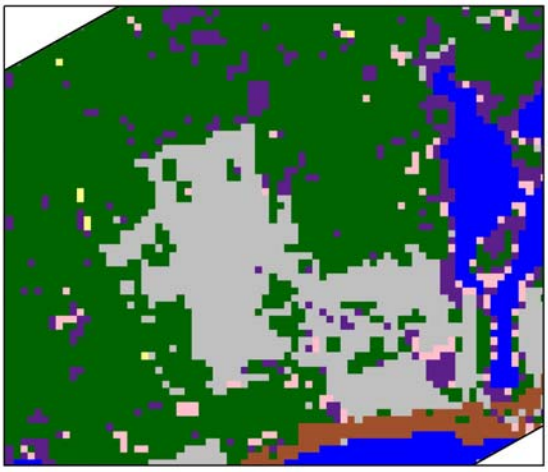
[e] Open water total gain of at most .40% (15.57 acres)

[f] Open water loss of at least 0% (3.11 acres)

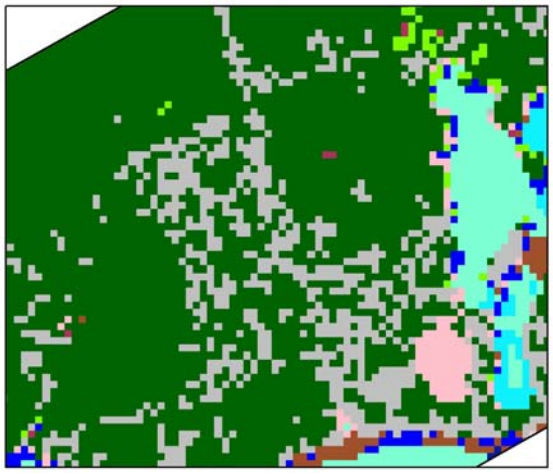
Table 5-02 also shows areas of overestimated change within the wetland classes such as a significant gain of 100% for shrub-scrub wetlands and palustrine forested wetlands, and 100% loss for woody wetlands (undetermined). As discussed previously, this gross overestimate is a result of the differences in classification schemes between the two datasets. The NLCD 1992 classification scheme lumped shrub-scrub and forested wetlands into woody wetlands, while the C-CAP/NWI classification scheme separated them out. In addition, natural (non-armored) shoreline areas show a gain of 536 acres or 94.78% of the original 1992 area. While this habitat group may have increased in area during this time period, an increase of nearly 95% is likely a gross overestimate and may be contributed to the C-CAP data incorrectly classifying shallow open water areas in the coastal ponds as natural shorelines. The 10.46% loss of emergent wetlands may also be overestimated. Most of the loss occurs along the inland side of the Ninigret and Green Hill Pond barriers, where large areas of emergent wetlands were classified as natural shoreline habitat in the C-CAP dataset. This resulted in a higher rate of loss for emergent wetlands than likely occurred. When summarized the data show an overall loss in wetland habitat of 144.5 acres, or 7.30% of the 1992 wetland area.

Finally, the recent 1992 to 1997/1999 time period shows a loss of developed land (7.92%) with a concurrent gain of other upland (23.47%). Given the high rate of population growth for this area (21.3%) during recent years, these findings are likely not accurate and the result of differences in resolution between the two datasets. For example, Figure 5-06 shows an urban neighborhood within the transect as depicted in the DOQQ, NLCD 1992, and NWI/C-CAP 1997/1999 datasets. The gray color in 5-06(b) and 5-06(c) represents the developed class. As can be seen, the C-CAP/NWI dataset shows more detail and pixelation whereas the NLCD classification is more generalized, possibly accounting for the acreage loss within the development class.

(a)



(b)



(c)

Figure 5-07. A neighborhood within the Block Island Sound, RI transect, as depicted in the DOQQ (a), NLCD 1992 (b), and C-CAP/NWI 1997 (c).

The potential causes for loss in wetland habitat can be further examined by looking at Table 5-03, which includes percent change in wetland and open water habitats due to conversion to development, agriculture, and/or other upland. These data show a net loss of 782.16 acres of wetland habitat to non-wet classes, or 39.42% of the original 1992 wetland area. Most of this loss can be attributed to conversion from wetland to other upland (29.13%) and developed land (10.31%) on the Ninigret Pond barrier beach. However, such a high loss of other upland between 1992 and 1997/1999 is unlikely,

whereas wetland losses to development on the barrier beach are likely accurate. Table 5-03 shows a relatively small gain of open water habitat from non-wet classes (1.57%).

Table 5-03. Change in Wetlands and Open Water Habitats due to Conversion to Development, Agriculture, or Other Upland Classes from 1992-1999.

Block Island Sound, RI Transect - Change in Wetlands and Open Water Habitats due to Conversion to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 92-99 Acres**	**Change 92-99 Percent**	**92-99 Gain/Loss**
Wetland Habitats	Developed, Agriculture, Other Upland	979.87		
Developed, Agriculture, Other Upland	Wetland Habitats	197.71		
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		-782.16	-39.42%	loss
Open Water Habitats	Developed, Agriculture, Other Upland	14.23		
Developed, Agriculture, Other Upland	Open Water Habitats	75.17		
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		60.94	1.57%	gain
Wetland Habitats	Other Upland	711.66		
Other Upland	Wetland Habitats	133.66		
Wetland Habitats Gain/Loss to Other Upland		-578.00	-29.13%	loss
Wetland Habitats	Agriculture	0.22		
Agriculture	Wetland Habitats	133.66		
Wetland Habitats Gain/Loss to Agriculture		133.44	6.73%	gain
Wetland Habitats	Developed	267.99		
Developed	Wetland Habitats	63.38		
Wetland Habitats Gain/Loss to Developed		-204.60	-10.31%	loss
Open Water Habitats	Other Upland	6.45		
Other Upland	Open Water Habitats	49.59		
Open Water Habitats Gain/Loss to Other Upland		43.14	1.11%	gain
Open Water Habitats	Agriculture	0.00		
Agriculture	Open Water Habitats	2.22		
Open Water Habitats Gain/Loss to Agriculture		2.22	0.06%	gain
Open Water Habitats	Developed	7.78		
Developed	Open Water Habitats	23.35		
Open Water Habitats Gain/Loss to Developed		15.57	0.40%	gain

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

A more detailed breakdown of changes in target habitat groups and other land cover classes between 1992 and 1997/1999 for the Block Island Sound transect can be seen in Table 5-04. This table shows the change in number of acres between the1992 and 1997/1999. Table 5-04 also shows the number of acres that remained unchanged during this time period. These data support the findings reported in Table 5-03, which indicate that conversion from wetland to developed and other upland made up the greatest losses in wetland area. However, as discussed previously, conversion from natural shoreline

and/or emergent wetland to other upland is likely an overestimate. Conversion from these wetland habitat classes to developed land is most likely accurate.

Table 5-04. Change matrix representing change in acres among target habitat groups and land cover classes in the transect from 1992 to 1999. Values in the gray shaded cells are acres of no change.

Block Island Sound, RI Transect Land Cover Change NLCD 1992 (early) to C-CAP 1997/NWI 1999 (late) (by acres)										
			1992							
			Wetland Habitats			Open Water Habitats	Non-Wet Land Cover			
			Emergent Wetlands	Woody Wetlands	Natural (Non-armored) Shoreline	Open Water	Developed	Agriculture	Other Upland	Acreage Totals for 1999 Classification
1999	Wetland Habitats	Emergent Wetlands	188.15	136.55	42.48	89.18	50.26	0.00	43.59	550.20
		Shrub-scrub Wetlands	25.35	11.56	8.01	5.78	1.11	0.00	11.12	62.94
		Palustrine Forested Wetlands	5.78	37.81	0.44	4.89	3.34	0.00	67.16	119.43
		Natural (Non-armored) Shoreline	145.67	35.58	71.83	828.64	8.67	0.67	11.79	1,102.86
	Open Water Habitats	Open Water	18.68	33.14	3.11	105.64	4.67	0.00	4.67	169.91
		Aquatic Bed	0.00	0.00	0.00	27.35	0.00	0.00	0.00	27.35
		Estuarine Aquatic Beds	18.68	16.01	3.34	411.88	2.89	0.00	7.12	459.91
		Oyster Reefs/Shell Bottom	0.00	0.00	0.00	2.22	0.00	0.00	0.00	2.22
		Soft Bottom	64.72	90.07	43.14	2,391.86	15.79	2.22	37.81	2,645.61
	Non-Wet Land Cover	Developed	38.92	115.87	113.20	7.78	598.46	0.22	337.37	1,211.83
		Agriculture	0.22	0.00	0.00	0.00	0.22	0.00	0.00	0.44
		Other Upland	108.31	322.69	280.66	6.45	630.71	2.67	3,020.12	4,371.62
		Acreage Totals for 1992 Classification	614.48	799.29	566.22	3,881.68	1,316.13	5.78	3,540.75	**10,724.33**

This table presents estimates of acreage by classification and the number of acres that changed classification between the two dates. The data shows the numbers of acres that have changed from the 1992 date to the 1999 date. The table reads down (1992/from) and to the left (1999/to).

Recent (1992 – 1999) Change Summary

Overall, the period between 1992 and 1997/1999 in the Block Island Sound transect saw a reduction in total wetland habitats, along with an increase in non-wet areas. The estimated loss in wetland area of 7.3% (Table 5-02) may represent a greater loss than actually occurred, as some wetland areas (i.e., natural shoreline and emergent wetlands) appear to be incorrectly classified as non-wetland in the 1997/1999 dataset. Despite this overestimate, conversion from wetland habitat to developed appears to be accurate. Insignificant changes in open water habitat were recorded during this time period.

Historical Transect Maps

The Block Island Sound transect is illustrated in Figures 5-08 through 5-10. The 1939 aerial photos presented in Figure 5-08 were used to classify land cover in the transect from the historic time period. Figures 5-09 and 5-10 depict the changes in wetland habitats and open water habitats from 1939 to 1999 respectively. The wetlands change map shows areas that changed from wetland to non-wetland classes and non-wetland to wetland classes. Similarly, the open water change map displays open water to non-open water classes and non-open water to open water classes. These maps are helpful in determining where wetlands and open water habitat changes occurred and which classes they changed between.

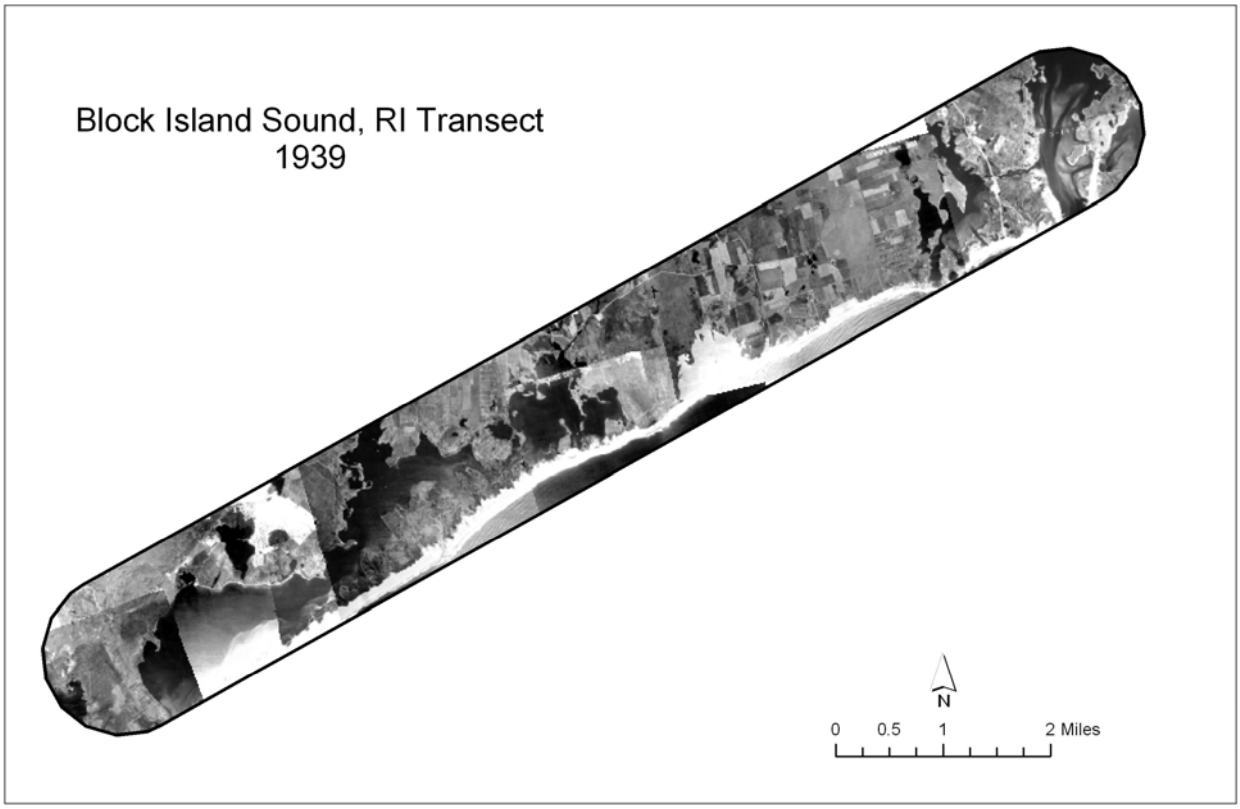


Figure 5-08.1939 Aerial photo of Block Island Sound, RI transect.

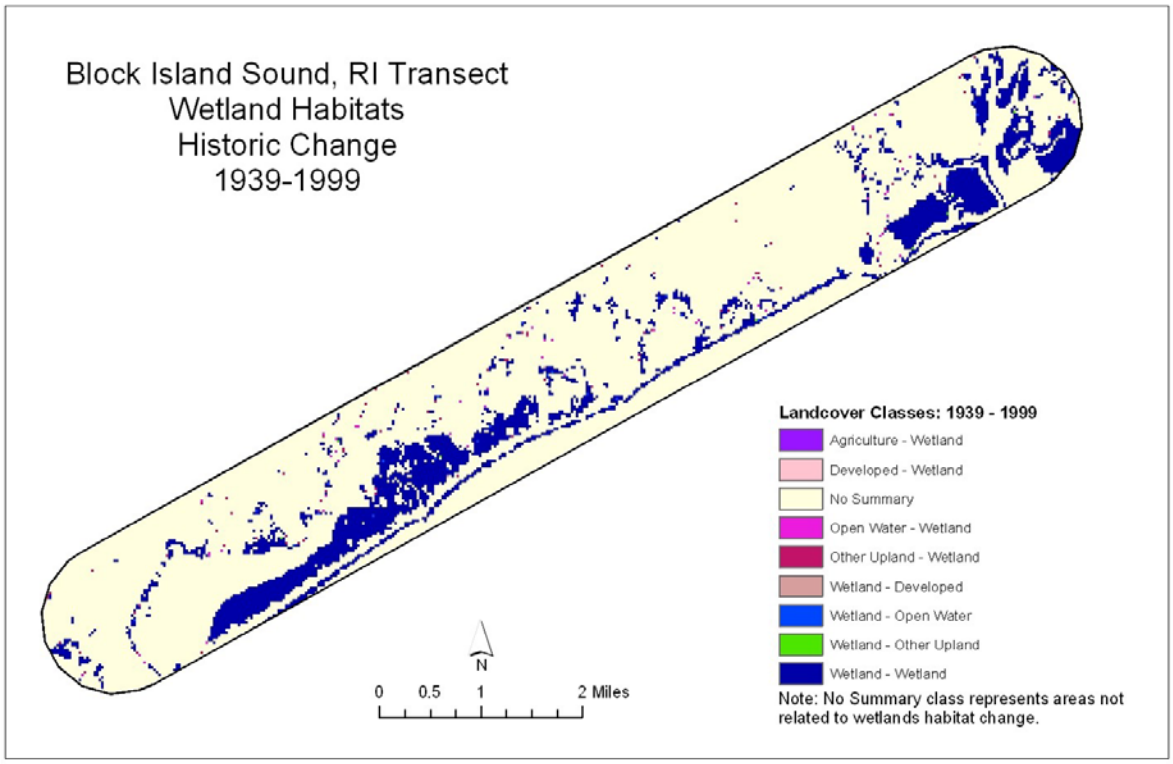


Figure 5-09. Wetland habitats change from 1939-1999, Block Island Sound, RI transect.

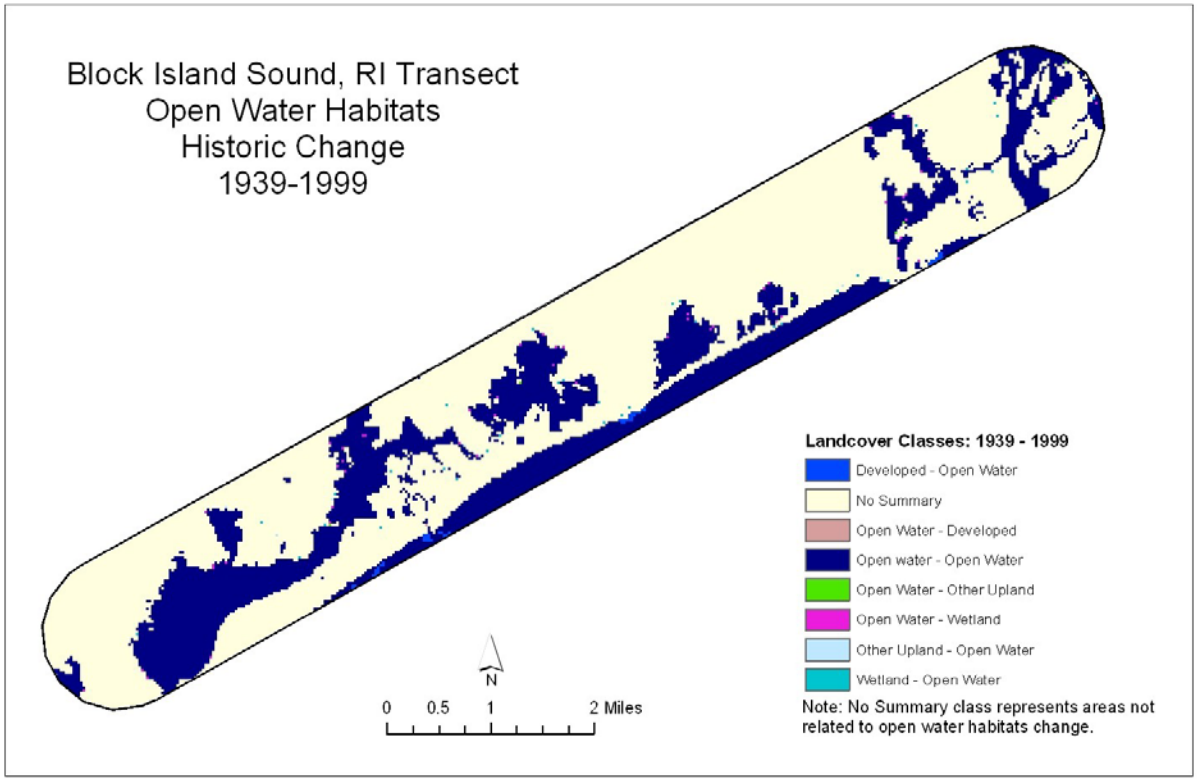


Figure 5-10.Open water habitats change from 1939-1999, Block Island Sound, RI transect.

Historical (1939-1999) Change Tables

Overall, there were few changes in the wetland habitat groups in the Block Island Sound transect for the historical time period between 1939 and 1999. The greatest amount of change occurred in other land cover classes (such as developed and agriculture). The data in Table 5-05 show a 907.20% gain in acres of developed land, from 120.5 to 1,214 acres. This increase in development occurred throughout the transect, both in the towns and villages on the mainland as well as along the barrier beaches. The data also show a reduction in agricultural land, losing nearly 99% of the original 340 acres. The majority of this agricultural conversion took place on the mainland between Charlestown and Point Judith Pond and in the area west of Charlestown where the local airport was constructed. Wetlands showed an overall gain from 1,809 to 1,848 acres, resulting in an increase of 2.15%. Woody wetlands and palustrine forested wetlands showed the largest increases: 12.01% and 16.45%, respectively. This increase in woody-type wetlands may be a natural progression of wetlands, or it may be an artifact of the data resolution.

Table 5-05. Acreage and percent change of land cover classes from 1939-1999. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

Block Island Sound, RI Transect - Dataset Acreage and Change by Land Cover Classes					
	HIST39 Acres	C-CAP97-NWI99 Acres	Change 39-99 Acres	Change 39-99 Percent	39-99 Gain/Loss
Wetlands Total	***1,809.85***	***1,848.77***	***38.92***	***2.15%***[a]	***gain***
Emergent Wetlands	536.86	551.98	15.12	2.82%[b]	gain
Woody Wetlands Total	163.02	182.59	19.57	12.01%[c]	gain
Woody Wetlands (undetermined)	0.00	0.00	0.00	0.00%	
Shrub-scrub Wetlands	60.27	62.94	2.67	4.43%[d]	gain
Mangroves	0.00	0.00	0.00	0.00%	
Estuarine Forested Wetlands	0.00	0.00	0.00	0.00%	
Palustrine Forested Wetlands	102.75	119.65	16.90	16.45%[e]	gain
Natural (non-armored) Shoreline	1,109.97	1,114.20	4.23	0.38%[f]	loss
Open Water Total	***3,388.19***	***3,381.51***	***-6.67***	***-0.20%***[g]	***loss***
Open Water	144.11	171.02	26.91	18.67%[h]	gain
Aquatic Bed Total	496.16	492.16	-4.00	-0.81%[i]	loss
Aquatic Bed (undetermined)	32.25	32.25	0.00	0.00%	
Palustrine Aquatic Beds	0.00	0.00	0.00	0.00%	
Estuarine Aquatic Beds	463.92	459.91	-4.00	-0.86%[j]	loss
Coral Reefs	0.00	0.00	0.00	0.00%	
Oyster Reefs/Shell Bottom	2.22	2.22	0.00	0.00%	
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	2,745.69	2,716.11	-29.58	-1.08%[k]	loss
Developed	***120.54***	***1,214.05***	***1,093.52***	***907.20%***	***gain***
Agriculture	***340.71***	***0.44***	***-340.26***	***-99.87%***	***loss***
Other Upland	***5,166.23***	***4,380.73***	***-785.50***	***-15.20%***	***loss***
TOTAL	***10,825.51***	***10,825.51***			

Note: The following footnotes indicate an actual total gain/loss of wetlands or open water habitats of at least/most the indicated amount. These numbers look strictly at change to development which is less likely to be misclassified.

[a] Wetlands total loss of at least .15% (2.67 acres)
[b] Emergent wetlands loss of at least .42% (2.23 acres)
[c] Woody wetlands total of 0% (0 acres)
[d] Shrub-scrub wetlands loss of at least .37% (0.22 acres)
[e] Palustrine forested wetlands gain of at most .21% (0.22 acres)
[f] Natural (non-armored) shoreline loss of at least .02% (0.44 acres)
[g] Open water total loss of at least .07% (2.22 acres)
[h] Open water loss of at least .15% (0.22 acres)
[i] Aquatic bed total loss of at least .04% (0.22 acres)
[j] Estuarine aquatic beds loss of at least .05% (0.22 acres)
[k] Soft bottom loss of at least .06% (1.78 acres)

The potential causes for alterations in wetland habitat within the transect can be further examined by looking more specifically at percent change in wetland and open water habitats due to conversion to development, agriculture, and/or other upland (Table 5-06).These data show a net gain of 31.8 acres of wetland habitat from 1939 to 1999 due to conversion between developed, agriculture, and other upland. This change translates to a gain of 1.76% from the original 1,809 acres. Nearly all of this change can be attributed to conversion between other upland and the wetland classes (1.89%). The data in Table 5-06 also show negligible change between open water and non-wet classes over the historical time period.

Table 5-06. Change in Wetlands and Open Water Habitats due to Conversion to Development, Agriculture, or Other Upland Classes from 1939-1999.

Block Island Sound, RI Transect - Change in Wetlands and Open Water Habitats due to Conversion to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 39-99 Acres**	**Change 39-99 Percent**	**39-99 Gain/Loss**
Wetland Habitats	Developed, Agriculture, Other Upland	6.67		
Developed, Agriculture, Other Upland	Wetland Habitats	38.47		
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		31.80	1.76%	gain
Open Water Habitats	Developed, Agriculture, Other Upland	5.78		
Developed, Agriculture, Other Upland	Open Water Habitats	6.23		
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		0.44	0.01%	gain
Wetland Habitats	Other Upland	2.89		
Other Upland	Wetland Habitats	37.14		
Wetland Habitats Gain/Loss to Other Upland		34.25	1.89%	gain
Wetland Habitats	Agriculture	0.00		
Agriculture	Wetland Habitats	0.22		
Wetland Habitats Gain/Loss to Agriculture		0.22	0.01%	gain
Wetland Habitats	Developed	3.78		
Developed	Wetland Habitats	1.11		
Wetland Habitats Gain/Loss to Developed		-2.67	-0.15%	loss
Open Water Habitats	Other Upland	3.34		

From	To	Change 39-99 Acres	Change 39-99 Percent	39-99 Gain/Loss
Other Upland	Open Water Habitats	6.00		
Open Water Habitats Gain/Loss to Other Upland		2.67	0.08%	gain
Open Water Habitats	Agriculture	0.00		
Agriculture	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Agriculture		0.00	0.00%	
Open Water Habitats	Developed	2.45		
Developed	Open Water Habitats	0.22		
Open Water Habitats Gain/Loss to Developed		-2.22	-0.07%	loss

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

A more detailed breakdown of changes in target habitat groups and other land cover classes between 1939 and 1999 for the Block Island Sound transect are presented in Table 5-07. This table shows the change in number of acres for each target habitat group and land cover type in the transect between 1939 and 1999. The table also shows the number of acres that remained unchanged over this time period. These data support the findings reported in Table 5-06, which indicate that the greatest amount of change occurred between other upland and developed land. Specifically, 1,029 acres of other upland from 1939 were converted to developed land. Other notable changes include 280 acres of agricultural land that were converted to other upland.

Historical (1939 – 1999) Change Summary

Overall, there was very little change in wetland habitat between 1939 and 1999 in the Block Island Sound transect. There were, however, significant changes in the developed and agriculture land cover types. Population growth in the area led to an increase in developed lands, primarily at the expense of other upland. Additionally, there was a significant loss in agricultural lands. Despite the dramatic growth and development, there was very little direct loss of wetland and open water habitats to accommodate this development.

Table 5-07. Change matrix representing change in acres among target habitat groups and other land cover classes in the transect from 1939 to 1999. Values in the gray shaded cells are acres of no change.

Block Island Sound, RI Land Cover Change Aerial Photos 1939 to C-CAP 1997/NWI 1999 (by acres)

		1939												
		Wetland Habitats				Open Water Habitats					Non-Wet Land Cover			
		Emergent Wetlands	Shrub-scrub Wetlands	Palustrine Forested Wetlands	Natural Non-armored) Shoreline	Open Water	Aquatic Bed	Estuarine Aquatic Beds	Oyster Reefs/Shell Bottom	Soft Bottom	Developed	Agriculture	Other Upland	Acreage Totals for 1999 Classification
1999 Wetland Habitats	Emergent Wetlands	523.07	0.00	0.44	4.23	1.11	0.00	1.11	0.00	6.45	0.22	0.00	15.35	551.98
1999 Wetland Habitats	Shrub-scrub Wetlands	0.00	58.71	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.22	3.56	62.94
1999 Wetland Habitats	Palustrine Forested Wetlands	1.33	0.67	100.97	0.44	0.44	0.00	0.67	0.00	2.67	0.22	0.00	12.23	119.65
1999 Wetland Habitats	Natural (Non-armored) Shoreline	4.00	0.00	0.22	1,095.74	1.33	0.00	1.33	0.00	4.89	0.67	0.00	6.00	1,114.20
1999 Open Water Habitats	Open Water	4.00	0.44	0.89	5.34	140.33	0.00	2.00	0.00	12.01	0.22	0.00	5.78	171.02
1999 Open Water Habitats	Aquatic Bed	0.00	0.00	0.00	0.00	0.00	32.25	0.00	0.00	0.00	0.00	0.00	0.00	32.25
1999 Open Water Habitats	Estuarine Aquatic Beds	0.00	0.00	0.00	1.11	0.00	0.00	458.13	0.00	0.67	0.00	0.00	0.00	459.91
1999 Open Water Habitats	Oyster Reefs/Shell Bottom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.22	0.00	0.00	0.00	0.00	2.22
1999 Open Water Habitats	Soft Bottom	0.67	0.00	0.00	0.89	0.00	0.00	0.22	0.00	2,714.11	0.00	0.00	0.22	2,716.11
1999 Non-Wet Land Cover	Developed	2.45	0.22	0.00	1.11	0.44	0.00	0.22	0.00	1.78	118.54	59.82	1,029.47	1,214.05
1999 Non-Wet Land Cover	Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.44
1999 Non-Wet Land Cover	Other Upland	1.33	0.22	0.22	1.11	0.44	0.00	0.22	0.00	2.67	0.67	280.22	4,093.62	4,380.73
	Acreage Totals for 1939 Classification	536.86	60.27	102.75	1,109.97	144.11	32.25	463.92	2.22	2,745.69	120.54	340.71	5,166.23	**10,825.51**

This table presents estimates of acreage by classification and the number of acres that changed classification between the two dates. The data shows the numbers of acres that have changed from the 1939 date to the 1999 date. The table reads down (1939/from) and to the left (1999/to).

Section 5.4 CAF Change Summary (1939 – 2004)

A summary of estimated habitat and other land cover change within the Mid Atlantic Coastal Assessment Framework (CAF) region for the period 1939 to 2004 is shown in Table 5-08. The table shows actual measured acres lost and gained for the Block Island Sound transect for both the historical and recent time periods. In addition, the percent of acres lost and gained for the transect are also shown. These specific transect data were considered in conjunction with regional information regarding the CAF, to develop estimates for habitat and other land cover change within the CAF as a whole.

In general, computed values for wetland change from the Block Island Sound transect for the historical time period provided little guidance in developing estimates of wetland change for the CAF as a whole. While the transect level data showed small percentage gains in the most of the wetland habitats, estimates given for the CAF show overall wetland loss. This is primarily due to the extent of urban or developed land with the Mid Atlantic CAF, which is considerably greater than that represented by the Block Island Sound transect, resulting in an underestimate of wetland loss at the transect level. More specifically, CAF losses ranging from 17 to 21% were estimated for emergent wetlands for the historical time period, with a high portion of 11 to 14% of these losses estimated for the more recent time period. The increase in the loss is the result of a rise in the rate of development over the last 10 to 15 years. Changes in woody wetlands for the historical period were estimated to be 17 to 52%, with a clear increase in loss during the more recent time period in which to 15 to 32% of the overall loss occurred. Once again, the increased loss is the result of greater development, both near the coast and inland, where woody wetlands are more prevalent. Little data were available for the shrub-scrub wetland category, and as a result the transect level data were assumed to also apply to the CAF with changes of -5 to 5%. Losses in natural (non-armored) shoreline for the CAF region were estimated to be 17 to 24% for the historical time period of which 11 to 16% was lost during the recent time period.

Changes in open water habitat for the Mid Atlantic CAF region were estimated to be higher than the Block Island Sound transect for the historical time period, and roughly equal to the transect data for the more recent time period. As such, losses for the total open water habitat were estimated to range from 12 to 22% for the historical period and 10 to 16% for the more recent time period. Higher losses for the CAF region as a whole can be attributed to heavy port and harbor development in the urban areas of the CAF as opposed to the much less developed nature of the Block Island Sound transect. The reduction in open water losses between the historic time period and the more recent time period is the result of a reduced rate of port and harbor development during the last 10 or so years, as well as an increased regulatory environment that places stricter controls on wetland losses. Although no transect data were available for the habitat groups of estuarine aquatic beds or oyster reefs/shell bottoms, rough estimated losses ranging from 0 to 10% over the historical period were given based on regional trends. These habitat groups, especially the oyster reefs/shell bottoms, make up a much smaller percentage of the overall open water habitat that smaller loss estimates are warranted.

For the other land cover classes (non-wetland or open-water habitats), changes seen in the Block Island Sound transect were generally not considered to be representative of the CAF as a whole. As such, other land cover values estimated for the Mid Atlantic CAF were based primarily on relative comparisons with adjacent CAF regions and information presented in the CAF description. Historic increases in developed land over the period 1939 to 2004 were estimated to be 35 to 50%, while over the more recent time period from 1992 to 2004 the increase in developed land was only 18 to 30%. The ranges given for both of these time periods represent a higher degree of development in the Mid Atlantic CAF than in the New England CAF. Agricultural losses in the Mid Atlantic CAF were estimated to be 25 to 35% for the historical time period, and 4 to 16 % for the more recent time period. Both of these estimates are considerably less than the values found for the Block Island Sound transect. This is primarily due to the loss of most of the agricultural land within the Block Island Sound transect over the time period studied, while a significant amount of agricultural land has been maintained over the years within the CAF region as a whole. Finally, close correlation between the transect data and the CAF region was estimated for changes in other upland.

Table 5-08. Estimated target habitat group and land cover change from 1939-2004 for the Mid Atlantic CAF region based on local expert analysis of recent and historic change. Estimated acreages were calculated using estimated percent change in conjunction with the NLCD 1992 acres for each target habitat group and land cover type (Table 5-01). Also see Appendix C, Tables 13-04e – 04f for further detailed acreage values.

		Block Island Sound, RI Transect				Mid Atlantic CAF Region			
		1939-1999 Historic Acres Gain/Loss	1939-1999 Historic Percent Gain/Loss	1992-1999 Recent Acres Gain/Loss	1992-1999 Recent Percent Gain/Loss	Historic 1939 to 2004 Estimated Acres Gain/Loss	Historic 1939 to 2004 Estimated Percent Gain/Loss	Recent 1992 to 2004 Estimated Acres Gain/Loss	Recent 1992 to 2004 Estimated Percent Gain/Loss
Wetland Habitats	***Wetlands Total[1]***	***38.92***	***2.15%***	***-144.56***	***-7.30%***	***-393,264 to -1,117,792***	***-17% to -42%***	***-309,688 to -686,125***	***-13% to -26%***
	Emergent Wetlands	15.12	2.82%	-64.27	-10.46%	-142,748 to -178,949	-17% to -21%	-95,038 to -118,798	-11% to -14%
	Woody Wetlands Total[2]	19.57	12.01%	-616.92	-77.18%	-244,422 to -912,566	-17% to -52%	-210,592 to -561,579	-15% to -32%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	2.67	4.43%	no data	no data	no data	5% to -5%	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	16.90	16.45%	no data	no data	no data	-10% to -20%	no data	no data
	Natural (non-armored) Shoreline	4.23	0.38%	536.64	94.78%	-6,093 to -8,861	-17% to -24%	-4,057 to -5,747	-11% to -16%
Open Water Habitats	***Open Water Total[3]***	***-6.67***	***-0.20%***	***-576.67***	***-14.86%***	***-85,452 to -163,000***	***-12% to -22%***	***-69,628 to -118,367***	***-10% to -16%***
	Open Water	26.91	18.67%	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total[4]	-4.00	-0.81%	no data	no data	no data	no data	no data	no data
	Aquatic Bed (undetermined)**	0.00	0.00%	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	-4.00	-0.86%	no data	no data	no data	0% to -10%	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	0% to -5%	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	-29.58	-1.08%	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***1,093.52***	***907.20%***	***-104.30***	***-7.92%***	***1,219,527 to 1,704,307***	***35% to 50%***	***613,551 to 1,022,584***	***18% to 30%***
	Agriculture	***-340.26***	***-99.87%***	***-5.34***	***-92.31%***	***-2,256,112 to -3,069,043***	***-25% to -35%***	***-356,228 to -1,424,913***	***-4% to -16%***
	Other Upland	***-785.50***	***-15.20%***	***830.87***	***23.47%***	***-1,691,510 to -4,186,487***	***-10% to -20%***	***0 to 1,522,359***	***0% to 7%***

1 "Emergent Wetlands", "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", "Palustrine Forested Wetlands", and "Natural (non-armored) Shoreline" have been summarized in "Wetlands Total".

2 "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", and Palustrine Forested Wetlands" have summarized in "Woody Wetlands Total".

3 "Aquatic Beds", Palustrine Aquatic Beds", Estuarine Aquatic Beds", "Coral Reefs", "Oyster Reefs/Shell Bottom", "Hard Bottom" and "Soft Bottom" have been summarized in "Open Water Total".

4 "Aquatic Beds", "Palustrine Aquatic Beds", and "Estuarine Aquatic Beds" have been summarized in "Aquatic Bed Total".

* "Woody Wetlands (undetermined)" includes wetlands not specifically identified by system (palustrine, estuarine, etc.) and/or type of woody vegetation (shrub-scrub, forested, etc.).

** "Aquatic Bed (undetermined)" includes aquatic beds not specifically identified by system (palustrine, estuarine, etc.).

Section 6.0 South Atlantic CAF

Section 6.1 CAF Description

The South Atlantic CAF Region is approximately 34,917,430 acres in size, and includes areas within Virginia, North Carolina, South Carolina, Georgia, and the Atlantic coast of Florida. The South Atlantic CAF has been sub-divided into 22 Estuarine Drainage Areas by NOAA, as well as 18 additional Coastal Drainage Areas. The upper portion of the CAF in North Carolina contains an extensive barrier beach system in the Outer Banks that protects the two large shallow water estuaries of Albemarle and Pamlico Sound. Towards the southern end of the Outer Banks at Cape Hatteras, the extensive open water estuaries give way to the smaller coastal estuaries and river mouth systems of the Onslow Bay region. Two of the larger basins in the Onslow Bay area drain the New River and the Cape Fear River. Further to the south in Long Bay, which spans the North and South Carolina border, the coastal area contains many mainland beaches, with few salt marsh wetlands. The prevalence of barrier beach systems with extensive marsh plains begins to increase towards the southern end of Long Bay, especially at the mouth of the large Winyah Bay drainage basin, which forms the confluence of 4 major river systems. Further to the south in South Carolina and Georgia, the shoreline is dominated by numerous river mouth systems and smaller estuaries. The abundance of sediment from the rivers form many barrier beaches that are wide and short, being separated by frequent tidal inlets. The large tide range in lower South Carolina and Georgia has caused the formation of extensive salt marsh plains and tidal flats. Continuing to the south, along the Atlantic Ocean side of Florida, the barrier beaches begin to lengthen as the number of river systems decline. Additionally, the occurrence of salt marsh is reduced, while the karst topography, reefs and mangrove swamps increases.

On average, the South Atlantic CAF region extends inland approximately 30 to 50 miles, except in the larger drainage basins of Winyah Bay and the Cape Fear River where the CAF extends inland as far as 120 miles. Elevations within the South Atlantic CAF are relatively low, ranging from sea level to 30 meters above sea level over most of the region. In the western most portion of the CAF, where the largest drainage basins extend inland a great distance, ground elevations reach a maximum of 200 meters above sea level. The morphology and extent of coastal and estuarine wetlands varies throughout the South Atlantic CAF, primarily as a function of fluvial influence and tide range. As the tide range and number of river systems increases, the extent of emergent wetlands, barrier beaches, and tidal flats also increases. Where the sediment supply is more limited and the tidal range is lower, salt marsh plains are less common and the estuary systems are generally smaller.

Approximately 11.19% of the South Atlantic CAF is composed of densely populated regions, primarily in the larger cities of Wilmington, Charleston, Savannah, Jacksonville, and Miami. These urban areas account for a total of 2,179,574 acres, or 6.24% of the total CAF area. Human population growth from 1990 to 2000 has been around 16.0%, increasing from 7,494,417 persons to 8,738,684 persons (ESRI, 2000 and ESRI, 2002). The percentage of federally owned land is higher than most other regions of the U.S.,

accounting for approximately 2,848,490 acres, or 8.16% of the total area. The largest of these areas are owned by the National Forest Service (NFS) and the US Fish and Wildlife Service as National Wildlife Refuges.

Review of data from existing studies provides some insight as to the historical level of wetland loss within the South Atlantic CAF. NOAA's National Marine Fisheries Service reports on wetland loss through the 1980s within the South Atlantic CAF states (NOAA, 2005). This report indicates that North Carolina lost approximately 50% of its estimated original wetlands base by the mid 1980s, while South Carolina and Georgia lost 27% and 23%, respectively. NOAA reports approximately 46% of original wetlands lost in Florida by the mid-1980s; however, over half of this loss likely falls in the Gulf Coast CAF region. For the period 1992 to 1997, the US Department of Agriculture (USDA) reports a 216,900 acre loss in palustrine and estuarine wetlands and a 110,500 acre gain for the entire southeast region (includes Atlantic and Gulf Coast areas; USDA, 2005a). Causes for these wetland losses were assigned to the following activities: development (58%), agriculture (19.4%), silviculture (12.5 %), and miscellaneous (10.1%). These USDA estimates likely overestimate wetland losses in the South Atlantic CAF region alone, as the area considered by the USDA included a much larger portion of the southeast, where development and agriculture are more prevalent.

Section 6.2 Recent (1992) Land Cover Data Summary

Figure 6-01 shows the mapped target habitat groups and other land cover classes for the South Atlantic CAF region. The data was based on the 1992 USGS National Land Cover Dataset (NLCD).

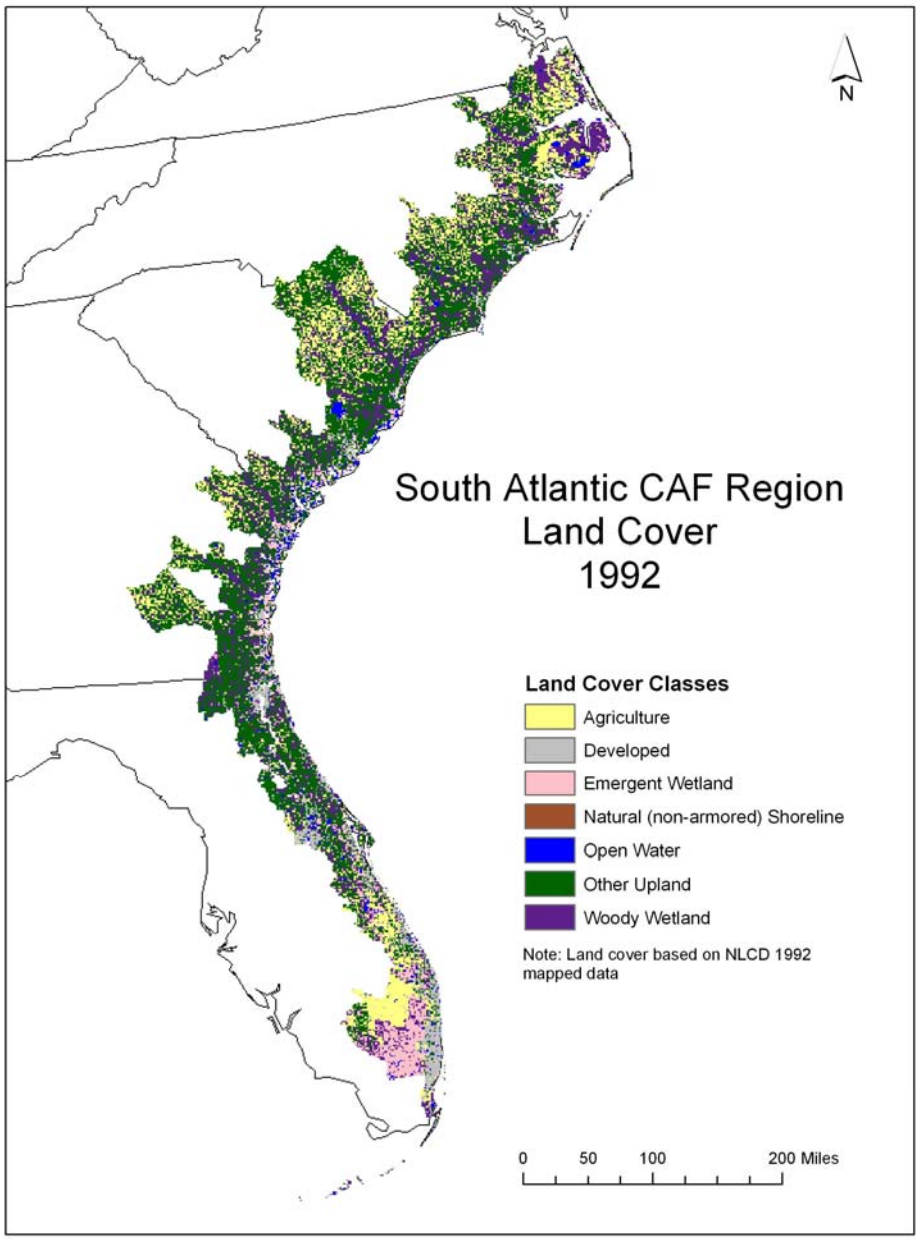


Figure 6-01. South Atlantic CAF Region land cover classes, 1992.

Rough estimates of total area of land cover, based on the 1992 NLCD classification, are presented in Table 6-01. Of the total acreage within the South Atlantic CAF region, wetlands make up approximately 29.5%, while open water makes up only 3.0% of the total area. All other non-wet areas make up the remaining 67.3% of the CAF area.

Within the wetlands category, woody wetlands and emergent wetlands make up the largest areas, followed by natural (non-armored) shorelines. Woody wetlands comprise nearly 75% of the total wetlands, with emergent wetlands and natural shorelines making up the remaining 23.8% and 0.7%, respectively. Of the non-wet areas, other upland makes up the largest area with 13,980,140 acres. Agricultural lands make up the next largest area with 7,358,758 acres, while the developed class makes up the smallest area with 1,938,685 acres. Overall, the 1992 NLCD dataset for the South Atlantic CAF region shows a higher percentage of wetland areas (29.5%) than the Mid Atlantic and New England CAF regions, which both show an approximately 10% wetland coverage .

Table 6-01. Total area of target habitat groups and other land cover classes within the South Atlantic CAF region (1992).

South Atlantic CAF Region - Total Area by Habitat Groups and Other Land Cover Classes	
	NLCD92 Acres
Wetlands Total[1]	***10,191,168.08***
Emergent Wetlands	2,435,483.40
Woody Wetlands Total[2]	7,683,938.11
Woody Wetlands (undetermined)*	7,683,938.11
Shrub-scrub Wetlands	0.00
Mangroves	0.00
Estuarine Forested Wetlands	0.00
Palustrine Forested Wetlands	0.00
Natural (non-armored) Shoreline	71,746.57
Open Water Total[3]	***1,076,134.09***
Open Water	1,076,134.09
Aquatic Bed Total[4]	0.00
Aquatic Bed (undetermined)**	0.00
Palustrine Aquatic Beds	0.00
Estuarine Aquatic Beds	0.00
Coral Reefs	0.00
Oyster Reefs/Shell Bottom	0.00
Hard Bottom	0.00
Soft Bottom	0.00
Developed	***1,938,685.94***
Agriculture	***7,358,758.56***
Other Upland	***13,980,140.60***
TOTAL	***34,544,887.27***

1 "Emergent Wetlands", "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", "Palustrine Forested Wetlands", and "Natural (non-armored) Shoreline" have been summarized in "Wetlands Total".

2 "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", and Palustrine Forested Wetlands" have summarized in "Woody Wetlands Total".

3 "Aquatic Beds", Palustrine Aquatic Beds", Estuarine Aquatic Beds", "Coral Reefs", "Oyster Reefs/Shell Bottom", "Hard Bottom" and "Soft Bottom" have been summarized in "Open Water Total".

4 "Aquatic Beds", "Palustrine Aquatic Beds", and "Estuarine Aquatic Beds" have been summarized in "Aquatic Bed Total".

* "Woody Wetlands (undetermined)" includes wetlands not specifically identified by system (palustrine, estuarine, etc.) and/or type of woody vegetation (shrub-scrub, forested, etc.). ** "Aquatic Bed (undetermined)" includes aquatic beds not specifically identified by system (palustrine, estuarine, etc.).
Note: Acreage totals are a rough estimate. Totals may not represent all of each CAF region due to clipping of raster datasets.

Section 6.3 Transect Analysis Results

Section 6.3.1 Pamlico Sound, NC Transect

Transect Location

The location of the Pamlico Sound, NC transect in the Mid-Atlantic CAF region is illustrated in Figure 6-02. The placement of the transect can be seen in more detail in Figure 6-03. The Pamlico Sound transect is generally located at the southern end of the Outer Banks near Cape Lookout. The transect itself is located on the mainland and stretches in an east-west orientation from Harkers Island in Core Sound, through Beaufort, and across to Morehead City, North Carolina. The transect crosses portions of the mainland that likely used to be the former shoreline before the more seaward barrier islands formed. Additionally, the transect includes extensive sand bars and submerged shoal formations, as well as natural and dredged estuarine channels. Many of the shallow portions of the estuary contain large areas of submerged aquatic vegetation. Additionally, the transect includes a portion of the Inter Coastal Waterway, near the town of Beaufort, as well as the fishing harbor at Morehead City. Development within Morehead City, Beaufort, and a portion of Harkers Island is relatively heavy; however the size of these urban centers is considerably smaller than the other major cities within the Mid Atlantic CAF. Due to its orientation along the mainland shoreline, the Pamlico Sound transect does not cover any of the offshore barrier islands and associated habitats. As such, wetland losses resulting from barrier island recession and overwash, which occurs extensively throughout coastal portions of the CAF, are not represented by this transect. Additionally, the Pamlico Sound transect does not contain the large expanse of salt marsh that is seen in the central portion of the South Atlantic CAF, and as such will likely under-estimate the loss of this valuable wetland resource. Aside from these differences, the Pamlico Sound transect provides a good representation of the estuarine habitat conditions in the South Atlantic CAF that are influenced by saline conditions. A description of the Pamlico Sound, North Carolina transect using the condition variables listed in Section 3.1 is given below, along with a discussion of changes in habitat area as seen over two different time periods, recent (1991 to 1997) and historical (1953 to 1997).

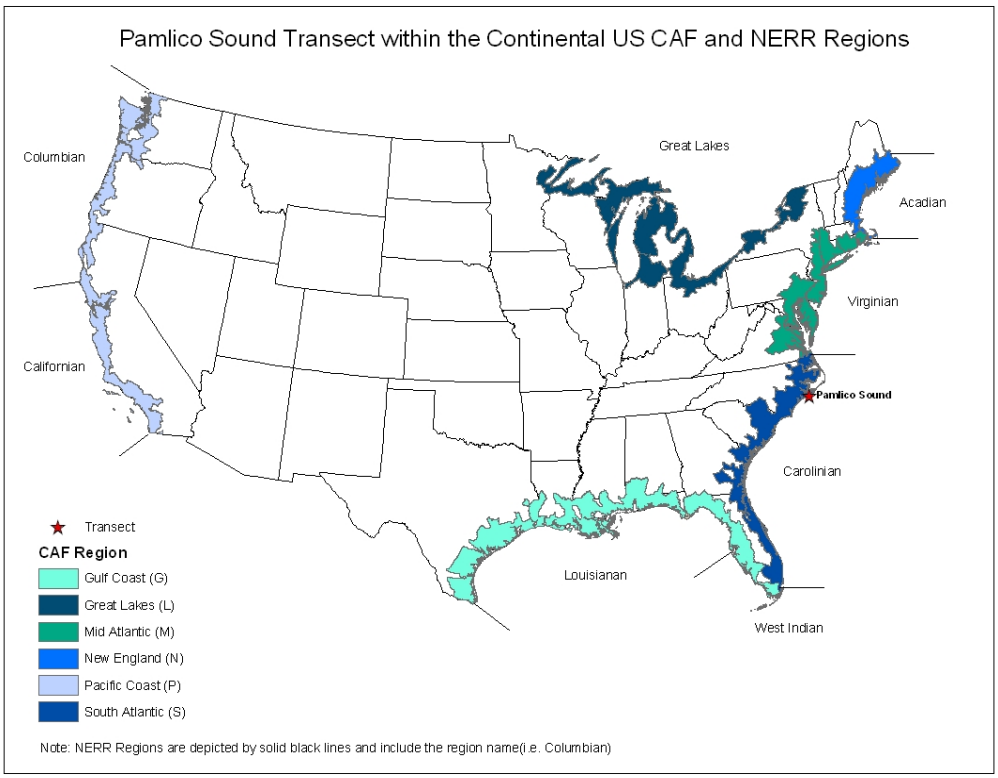


Figure 6-02. Location of Pamlico Sound, NC transect within the South Atlantic CAF region.

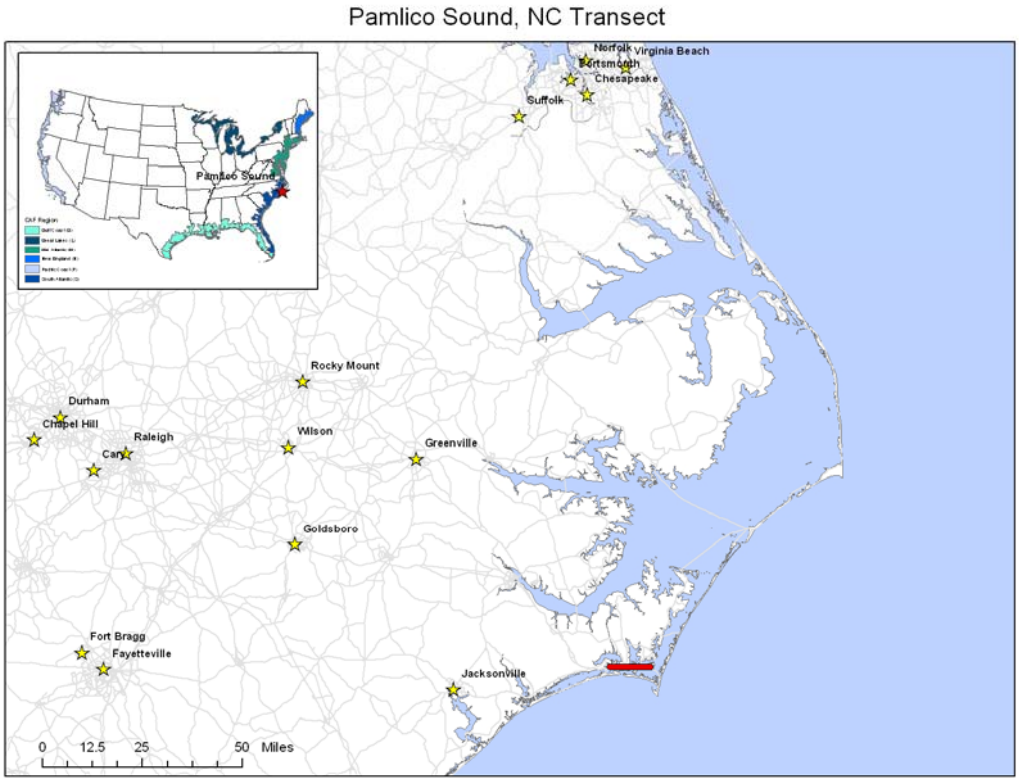


Figure 6-03. Pamlico Sound, NC transect placement.

Transect Description

I. Distance to Coast
   a. The Pamlico Sound transect is located along the mainland coastline, behind the Bogue Sound barrier islands. As such, it is approximately 1.5 to 2.0 miles from the coast and wetland status and trends observed within the transect will be representative of most coastal wetlands throughout the South Atlantic CAF.
   b. Due to its proximity to the coastal zone, the data derived from the Pamlico Sound transect will not be representative of changes that have occurred within the palustrine wetlands of the CAF.
   c. The wide boundaries of the CAF, and the dramatically different wetland extent throughout the CAF, both suggest that attempts to characterize the CAF with one or two transects that do not span the range of wetland types are apt to be both imprecise and inaccurate.
   d. The wide boundaries of the CAF, and the dramatically different wetland extent throughout the CAF, both suggest that attempts to characterize the CAF with one or two transects that do not span the range of wetland types are apt to be both imprecise and inaccurate.

II. Salinity
   a. Most of the Pamlico Sound transect is located in an area of saline water with values ranging from 31 to 34 ppt. The only exception is the brackish water zone near Moorehead Harbor, where freshwater from the Newport River mixes with the saline ocean water.
   b. Because of it near coastal location, the Pamlico Sound transect is not representative of freshwater conditions found at more inland locations with the South Atlantic CAF.

III. Topography/Elevation Range
   a. Elevation values throughout the transect are extremely low, ranging from sea level to 10 meters above sea level. This range is representative of conditions nearest the coastline to approximately 30 miles inland for most of the CAF.
   b. Elevation ranges at the Pamlico Sound transect are not representative of those found at more inland wetland or habitat locations, such as the upper reaches of the fluvial drainage basins where the elevation gradients are steeper, and average elevations range from 30 to 200 meters above sea level.

IV. Proximity to City
   a. The Pamlico Sound transect covers areas that are heavily developed, primarily for residential use; however, two small urban areas also existing within the transect. Although the transect does not adequately represent changes occurring in the larger metropolitan areas of Wilmington, Charleston, Savannah, Jacksonville, and Miami, it likely provides a good representation of the CAF region as a whole.
   b. The population density within the transect is approximately 777 people per square mile. This is significantly greater that the average population

density of 160 people per square mile for the entire CAF. As such, overall wetland losses due to anthropogenic causes such as development will likely be greater for the transect than for the CAF as a whole.

c. Population growth in the Pamlico Sound transect between 1990 and 2000 was on the order of 11.8%. This is somewhat lower than the average population growth for the entire CAF region of 16.0% over the same time period. As a result, the recent rate of wetland loss within the transect resulting from development pressures may be lower than for the CAF region as a whole.

V. Land Ownership

a. There are no federally owned properties within the Pamlico Sound transect, as much of the land area is owned by private or municipal interests. This will likely result in greater wetland loss for the transect than for the CAF region, as federal land preservation measures are not active in the transect.

VI. Dominant Land Uses

a. The largest percentage of land within the Pamlico Sound transect is classified as wetland or open water (approximately 42.0%). This includes areas within Core and Bogue Sound, Morehead City harbor, as well as sub aerial shoals and marsh areas.

b. Urban or built-up land also comprises a large portion of the Pamlico Sound transect, accounting for approximately 39.8% of the entire transect. This includes the mainland areas of Morehead City and Beaufort, as well as the southwestern portion of Harkers Island which are all developed primarily for residential use.

c. Forest lands make up 6.2% of the Pamlico Sound transect while the remaining land areas are occupied by barren or agricultural lands at 8.1% and 2.9%, respectively.

d. As compared with land use throughout the South Atlantic CAF, the Pamlico Sound transect shows a significantly higher percentage of urban or built-up land. Overall, throughout the CAF region the percentage of urban or built-up land is only 3.6%, as compared with the nearly 40.0% for the Pamlico Sound transect. This likely will cause wetland loss in the transect as caused by development to be much greater than actually exists with the CAF region.

e. On the other hand, the percentage of wetlands within the transect closely approximates the aerial extent of wetlands within the CAF. For both the small scale and large scale areas, wetlands make up anywhere from 27% to 42% of the total area.

f. Agricultural lands make up a much larger percentage of the South Atlantic CAF (approximately 25%) than seen in the Pamlico Sound transect (only 2.9%). As a result, the wetland loss to agricultural conversion values for the transect will likely under represent what is happening over the entire CAF region.

g. Finally, the extent of forest land within the South Atlantic CAF is significantly greater than represented by the Pamlico Sound transect. This should have little impact on the wetland loss values.

VII. Extent of Shoreline Armoring

a. Most of the shoreline areas within the Pamlico Sound transect are natural (non-armored) sandy or marsh-lined shorelines. The primary exception occurs within the Morehead City harbor where much of the shoreline has been developed with bulkheads and other harbor facilities.
b. Overall, the degree of shoreline armoring found within the Pamlico Sound transect closely approximates the extent of armoring found elsewhere in the South Atlantic CAF region.

VIII. Shipping

a. Shipping within the Pamlico Sound transect is confined exclusively to the Morehead City harbor area. The harbor serves as a moderate sized port exporting primarily phosphate, military, and metal goods, while importing sulfur, scrap metal, rubber, and asphalt.
b. Other significant shipping sites within the South Atlantic CAF include Wilmington, Charleston, Savannah, Jacksonville, and Miami. These areas are major ports of entry, serving as shipping and receiving sites for a variety of goods and services.

IX. Dredging.

a. Dredging activities have been conducted within the Pamlico Sound transect for port and harbor maintenance at Morehead City harbor, as well as other subsidiary dredged channels that allow fishing vessels and recreational craft to reach the port of Beaufort. Additionally, dredging within the Intracoastal Waterway near Beaufort takes place. Much of this dredging is ongoing, requiring periodic maintenance in order to provide the necessary deep and shallow draft channels.
b. Potential impacts from dredging include removal of wetland resources during the actual dredging, as well as possible burial of valuable resources during disposal. The most common disposal sites are either in water areas through sidecast dredging, or lowlands immediately adjacent to the channel areas. In some cases, wetland areas have been created as the result of dredge spoil placement.
c. Major dredging projects are also routinely conducted in many other of the port areas within the South Atlantic CAF region, including Wilmington, Charleston, Savannah, Jacksonville, and Miami. In addition, many of the smaller harbors and rivers, as well as the Intracoastal Waterway, are routinely dredged for recreational boat usage.
d. In general, the extent and frequency of dredging within the Pamlico Sound transect provides a good representation of dredging within the rest of the South Atlantic CAF.

X. Major Natural Disasters

a. Hurricanes are the only natural disaster that affect the Pamlico Sound transect. Since 1876 this area has experienced approximately 22 major

hurricanes, most of which caused major flooding and severe beach erosion.

b. The frequency of hurricanes in the Pamlico Sound transect closely approximates the frequency in most other areas of the CAF. On average hurricanes strike the Cape Hatteras area every 2.53 years, increasing to every 2.79 years in Miami, and every 3.08 years in Jacksonville. As such, the hurricane related wetland loss observed in the Pamlico Sound transect will be similar to the storm generated losses in the CAF region as a whole.

Recent Transect Maps

Figures 6-04 shows 1990's Digital Orthophoto Quarter Quadrangles (DOQQs) of the Pamlico Sound, NC transect. The DOQQs were used as a visual reference for interpreting recent land cover.

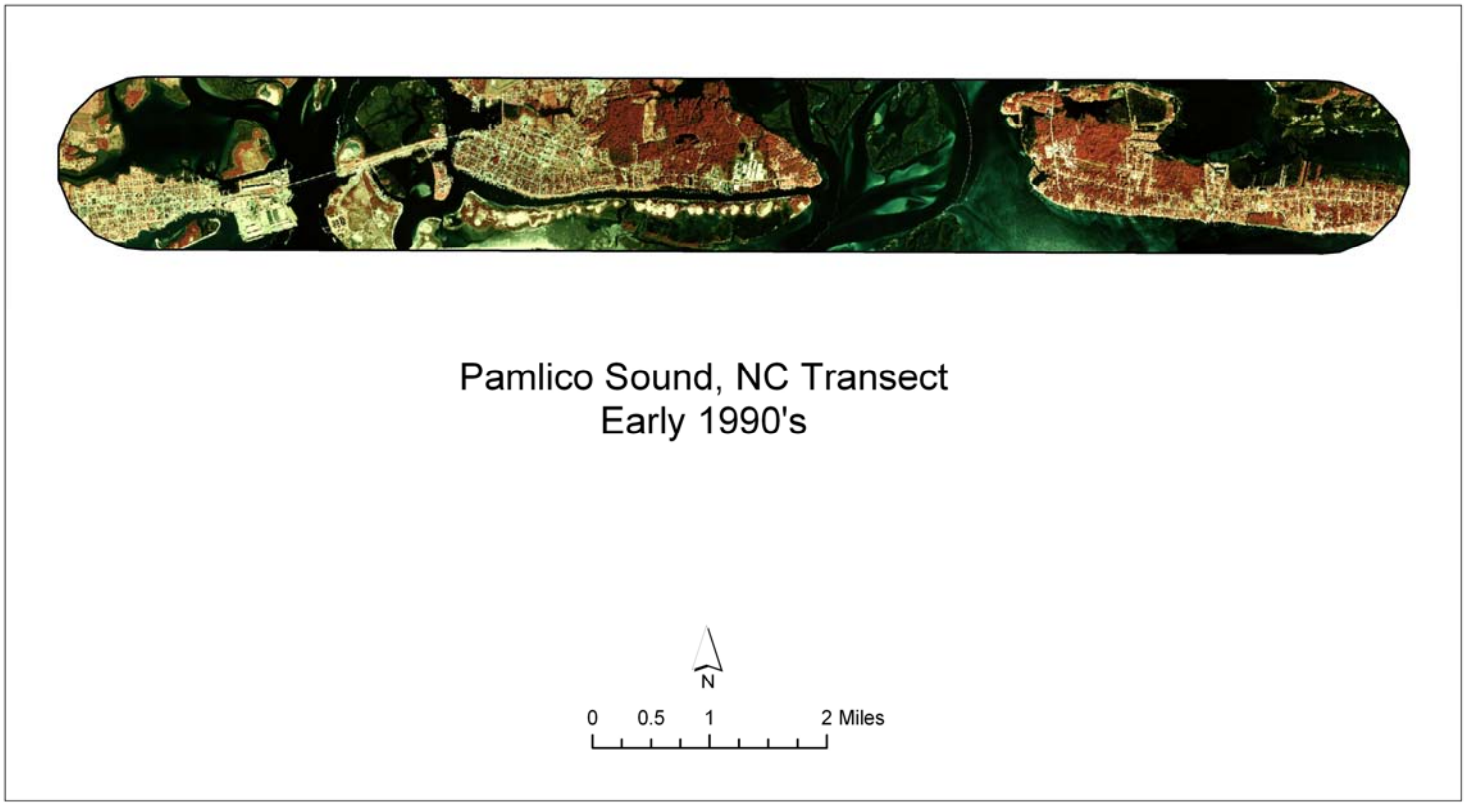


Figure 6-04. 1990's DOQQ of Pamlico Sound, NC transect.

Figure 6-05 and 6-06 depict the changes in wetland habitats and open water habitats from 1991 to 1997 respectively. The wetlands change map shows areas that changed from wetland to non-wetland classes and non-wetland to wetland classes. Similarly, the open water change map displays open water to non-open water classes and non-open water to open-water classes. These maps are helpful in determining where wetlands and open water habitat changes occurred and which classes they changed between.

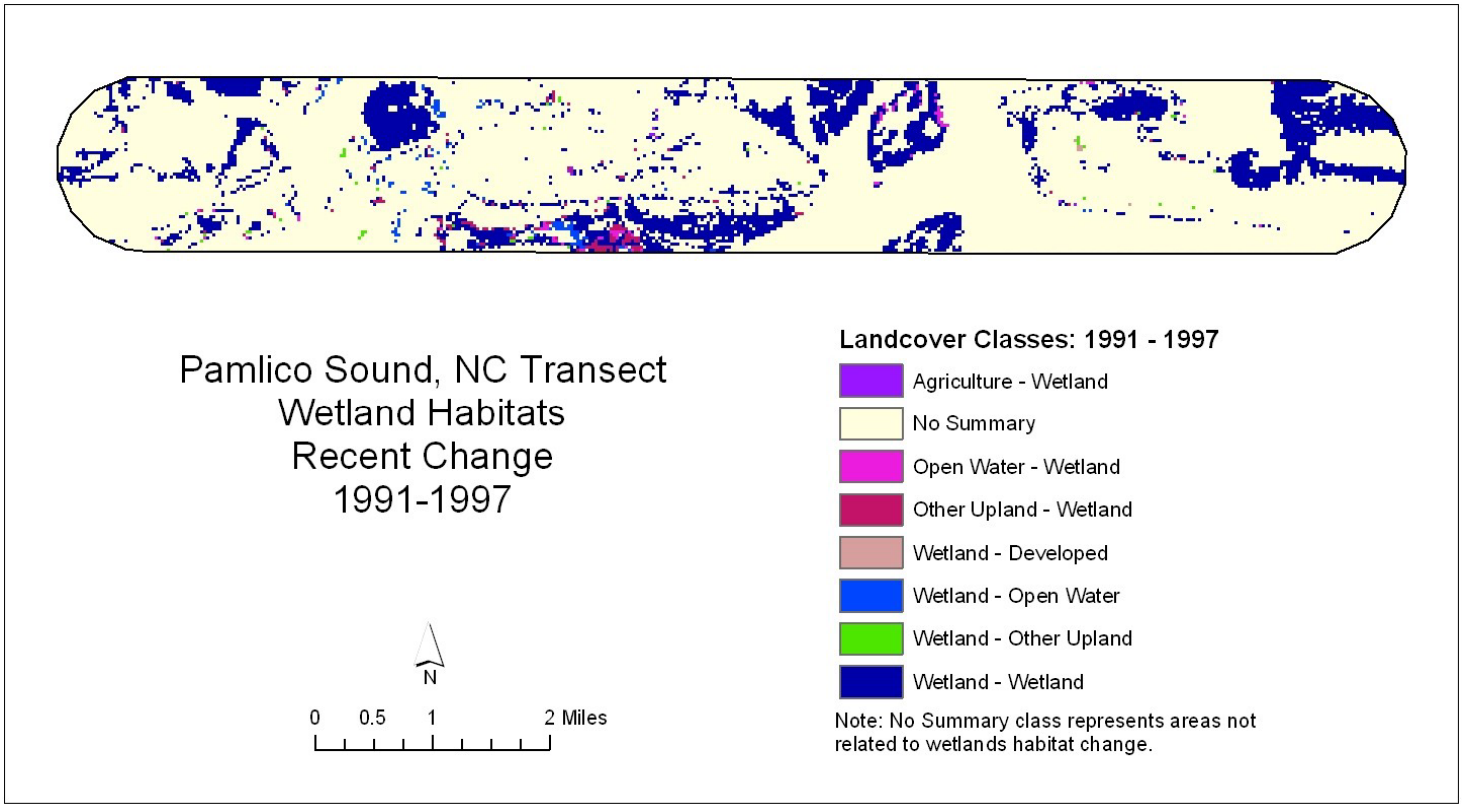


Figure 6-05. Wetland habitats change from 1991-1997, Pamlico Sound, NC transect.

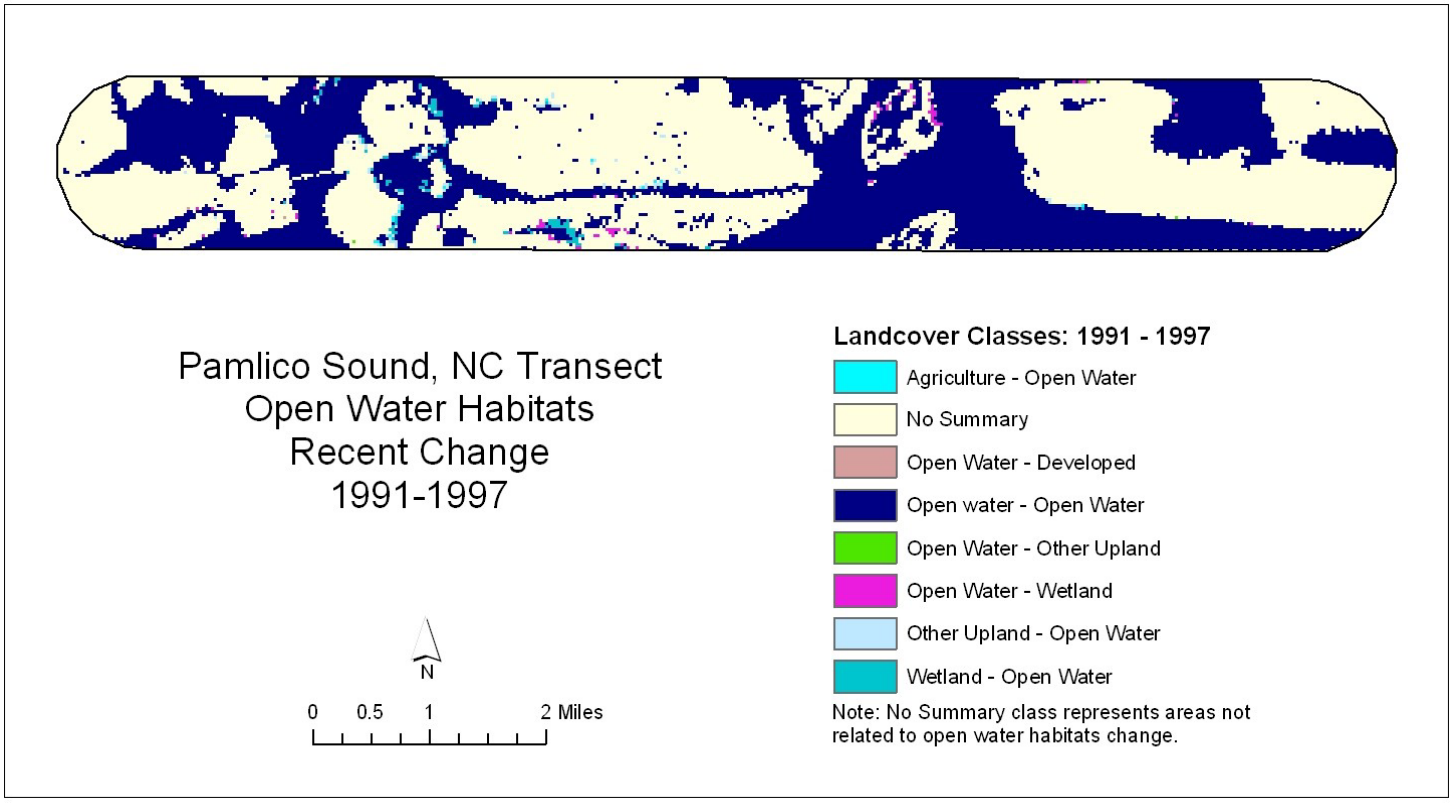


Figure 6-06. Open water habitats change from 1991-1997, Pamlico Sound, NC transect.

Recent (1991 – 1997) Change Tables

The datasets analyzed for this recent change included two C-CAP datasets from 1991 and 1997. Overall, the Pamlico Sound transect contains approximately 10,750 acres. The data in Table 6-02 show that in general very little change occurred to wetland and open water habitats over the recent six-year period between 1991 and 1997. Within the wetland habitats, palustrine forested wetlands lost a little over 42% of their 1991 acreage, while shrub-scrub wetlands gained an almost equal area amounting to 38.2%. In total, woody wetlands are shown to have decreased in size by approximately 30.6%. Natural (non-armored) shorelines saw an increase of 66 acres, or 25.6% of the 1991 area, while emergent wetlands only decreased by 0.8%. The increase in natural shoreline occurred primarily in the area to the south of the Intracoastal Waterway where dredge spoils are routinely placed during maintenance of the waterway. Overall, wetlands showed an increase of 1.86% over the six-year period studied.

Minimal changes are also shown in Table 6-02 for open water habitat categories. Overall, these habitats increased in size by approximately 1.35%, a change that likely falls within the error of the analysis. Note that aquatic beds were only classified in the 1991 dataset and not in the 1997 dataset. Some of the greatest change was seen in developed and agricultural lands, where an 8.8% gain is shown for developed land, and a 57.7% loss is shown for agricultural lands. Most of the increase in development occurred on Harkers Island, while the loss in cultivated land occurred nearly evenly throughout the mainland portions of the transect. The 8.8% gain in developed land closely corresponds with the average population growth for the Pamlico Sound transect.

Table 6-02. Acreage and percent change of land cover classes from 1991-1997. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

Pamlico Sound, NC Transect - Dataset Acreage and Change by Land Cover Classes					
	C-CAP91 Acres	**C-CAP97 Acres**	**Change 91-97 Acres**	**Change 91-97 Percent**	**91-97 Gain/Loss**
Wetlands Total	***1,983.76***	***2,020.68***	***36.92***	***1.86%***[a]	***gain***
Emergent Wetlands	1,671.52	1,657.73	-13.79	-0.82%[b]	loss
Woody Wetlands Total	52.26	36.25	-16.01	-30.64%[c]	loss
Woody Wetlands (undetermined)	0.00	0.00	0.00	0.00%	
Shrub-scrub Wetlands	7.56	10.45	2.89	38.24%[d]	gain
Mangroves	0.00	0.00	0.00	0.00%	
Estuarine Forested Wetlands	0.00	0.00	0.00	0.00%	
Palustrine Forested Wetlands	44.70	25.80	-18.90	-42.29%[e]	loss
Natural (non-armored) Shoreline	259.98	326.70	66.72	25.66%[f]	gain
Open Water Total	***4,570.44***	***4,632.04***	***61.60***	***1.35%***[g]	***gain***
Open Water	4,485.93	4,632.04	146.11	3.26%	gain
Aquatic Bed Total	84.51	0.00	NA	NA	
Aquatic Bed (undetermined)	84.51	0.00	NA	NA	

	C-CAP91 Acres	C-CAP97 Acres	Change 91-97 Acres	Change 91-97 Percent	91-97 Gain/Loss
Palustrine Aquatic Beds	0.00	0.00	0.00	0.00%	
Estuarine Aquatic Beds	0.00	0.00	0.00	0.00%	
Coral Reefs	0.00	0.00	0.00	0.00%	
Oyster Reefs/Shell Bottom	0.00	0.00	0.00	0.00%	
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	0.00	0.00	0.00	0.00%	
Developed	***1,365.28***	***1,485.82***	***120.54***	***8.83%***	***gain***
Agriculture	***108.31***	***45.81***	***-62.49***	***-57.70%***	***loss***
Other Upland	***2,723.67***	***2,567.10***	***-156.57***	***-5.75%***	***loss***
TOTAL	***10,751.46***	***10,751.46***			

Note: The following footnotes indicate an actual total gain/loss of wetlands or open water habitats of at least/most the indicated amount. These numbers look strictly at change to development which is less likely to be misclassified.

[a] Wetlands total loss of at least .11% (2.22 acres)

[b] Emergent wetlands loss of at least .01% (0.22 acres)

[c] Woody wetlands total loss of at least 3.83% (2 acres)

[d] Shrub-scrub wetlands loss/gain of 0% (0 acres)

[e] Palustrine forested wetlands loss of at least 4.47% (2 acres)

[f] Natural (non-armored) shoreline loss/gain of 0% (0 acres)

[g] Open water total loss of at least .01% (0.44 acres)

The potential causes for loss in wetland habitat can be further examined by looking at Table 6-03, which includes percentages of change in wetland and open water habitats due to conversion to development, agriculture, and/or other upland. These data show a net gain of 74.5 acres of non-wet classes to wetland habitat. This conversion translates to a gain of only 2.65% of the original 1991 wetland area. Most of this gain can be attributed to conversion from other upland to wetland (2.61%) around one of the dredge spoil islands in Morehead City harbor. Table 6-03 also shows a relatively small gain in open water habitat from non-wet classes (1.01%). This change is likely within the resolution of the data analysis, and the changes should be considered negligible. The primary losses seen in the recent time frame are due to development, where approximately 2.2 acres (0.11%) of emergent wetland were lost to development.

Table 6-03. Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes from 1991-1997.

Pamlico Sound Transect - Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 91-97 Acres**	**Change 91-97 Percent**	**91-97 Gain/Loss**
Wetland Habitats	Developed, Agriculture, Other Upland	22.02		
Developed, Agriculture, Other Upland	Wetland Habitats	74.50		
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		52.49	2.65%	gain
Open Water Habitats	Developed, Agriculture, Other Upland	1.78		
Developed, Agriculture, Other Upland	Open Water Habitats	47.81		

From	To	Change 91-97 Acres	Change 91-97 Percent	91-97 Gain/Loss
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		46.04	1.01%	gain
Wetland Habitats	Other Upland	19.79		
Other Upland	Wetland Habitats	71.61		
Wetland Habitats Gain/Loss to Other Upland		51.82	2.61%	gain
Wetland Habitats	Agriculture	0.00		
Agriculture	Wetland Habitats	2.89		
Wetland Habitats Gain/Loss to Agriculture		2.89	.15%	gain
Wetland Habitats	Developed	2.22		
Developed	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Developed		-2.22	-0.11%	loss
Open Water Habitats	Other Upland	1.33		
Other Upland	Open Water Habitats	41.37		
Open Water Habitats Gain/Loss to Other Upland		40.03	0.88%	gain
Open Water Habitats	Agriculture	0.00		
Agriculture	Open Water Habitats	6.45		
Open Water Habitats Gain/Loss to Agriculture		6.45	0.14%	gain
Open Water Habitats	Developed	0.44		
Developed	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Developed		-0.44	-0.01%	loss

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

A more detailed breakdown of changes in land cover classes between 1991 and 1997 for the Pamlico Sound transect can be seen in Table 6-04. This table shows the distribution and change in number of acres between 1991 and 1997. The table also shows the number of acres that remained unchanged over the recent six-year period. These data support the findings from Table 6-03, which indicate that the greatest changes in the transect occurred within the non-wet categories. For example, 112 acres of other upland were lost to development between 1991 and 1997, primarily in the Harkers Island area. Additionally, 63.6 acres of agriculture were lost to other upland. Among the wetland habitat types, the greatest changes were seen with emergent wetlands, where 37.36 acres were converted into open water, and 20.24 acres of were converted into natural (non-armored) shoreline. The next largest change in wetland habitat occurred to aquatic beds, which lost 65.83 acres to open water; however, as discussed previously this is primarily the result of classification differences between the two datasets. Overall however, very little loss of wetland habitat occurred within the Pamlico Sound transect over the period 1991 to 1997.

Recent (1991 – 1997) Change Summary

Overall, the six-year period between 1991 and 1997 for the Pamlico Sound transect saw very small gains in total wetland and open water habitats. These gains were less than 2% of the original 1991 acreages. The increases in wetland and open water habitats were primarily at the expense of other upland areas. The most significant changes in wetland acreage were seen in the natural (non-armored) shoreline and emergent wetland

categories. Within this group, the natural shoreline increased in area by 25.66% and the emergent wetland decreased by 0.82%. Most of these changes were the result of dredging and associated dredge spoil placement around the Intracoastal Waterway. The largest changes within the Pamlico Sound transect were seen in the non-wet classes. Within this category, an 8.8% gain was seen in developed land while agriculture lost 57.7%.

Table 6-04. Change matrix representing change in acres between land cover classes from 1991 to 1997. Values in the gray shaded cells are acres of no change.

Pamlico Sound, NC Land Cover Change C-CAP 1991/NOAA Benthic 1992 to C-CAP 1997 (by acres)												
			1991									
			Wetland Habitats				Open Water Habitats		Non-Wet Land Cover			
			Emergent Wetlands	Shrub-scrub Wetlands	Palustrine Forested Wetlands	Natural Non-armored) Shoreline	Open Water	Aquatic Bed	Developed	Agriculture	Other Upland	Acreage Totals for 1997 Classification
1997	Wetland Habitats	Emergent Wetlands	1,611.92	0.00	12.68	0.00	0.22	12.23	0.00	0.00	20.68	1,657.73
		Shrub-scrub Wetlands	0.00	5.12	0.22	0.00	0.00	0.00	0.00	0.44	4.67	10.45
		Palustrine Forested Wetlands	0.00	2.45	17.57	0.00	0.00	0.00	0.00	2.45	3.34	25.80
		Natural (Non-armored) Shoreline	20.24	0.00	0.44	237.30	19.79	6.00	0.00	0.00	42.92	326.70
	Open Water Habitats	Open Water	37.36	0.00	7.12	9.34	4,464.58	65.83	0.00	6.45	41.37	4,632.04
	Non-Wet Land Cover	Developed	0.22	0.00	2.00	0.00	0.44	0.00	1,365.28	5.12	112.75	1,485.82
		Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.25	15.57	45.81
		Other Upland	1.78	0.00	4.67	13.34	0.89	0.44	0.00	63.60	2,482.37	2,567.10
		Acreage Totals for 1991 Classification	1,671.52	7.56	44.70	259.98	4,485.93	84.51	1,365.28	108.31	2,723.67	**10,751.46**

This table presents estimates of acreage by classification and the number of acres that changed classification between the two dates. The data shows the numbers of acres that have changed from the 1991 date to the 1997 date. The table reads down (1991/from) then left (1997/to).

Historical Transect Maps

Figure 6-07 shows the 1953 aerial photos of the Pamlico Sound, NC transect. The 1953 aerial photography was used to classify land cover for the historic time period.

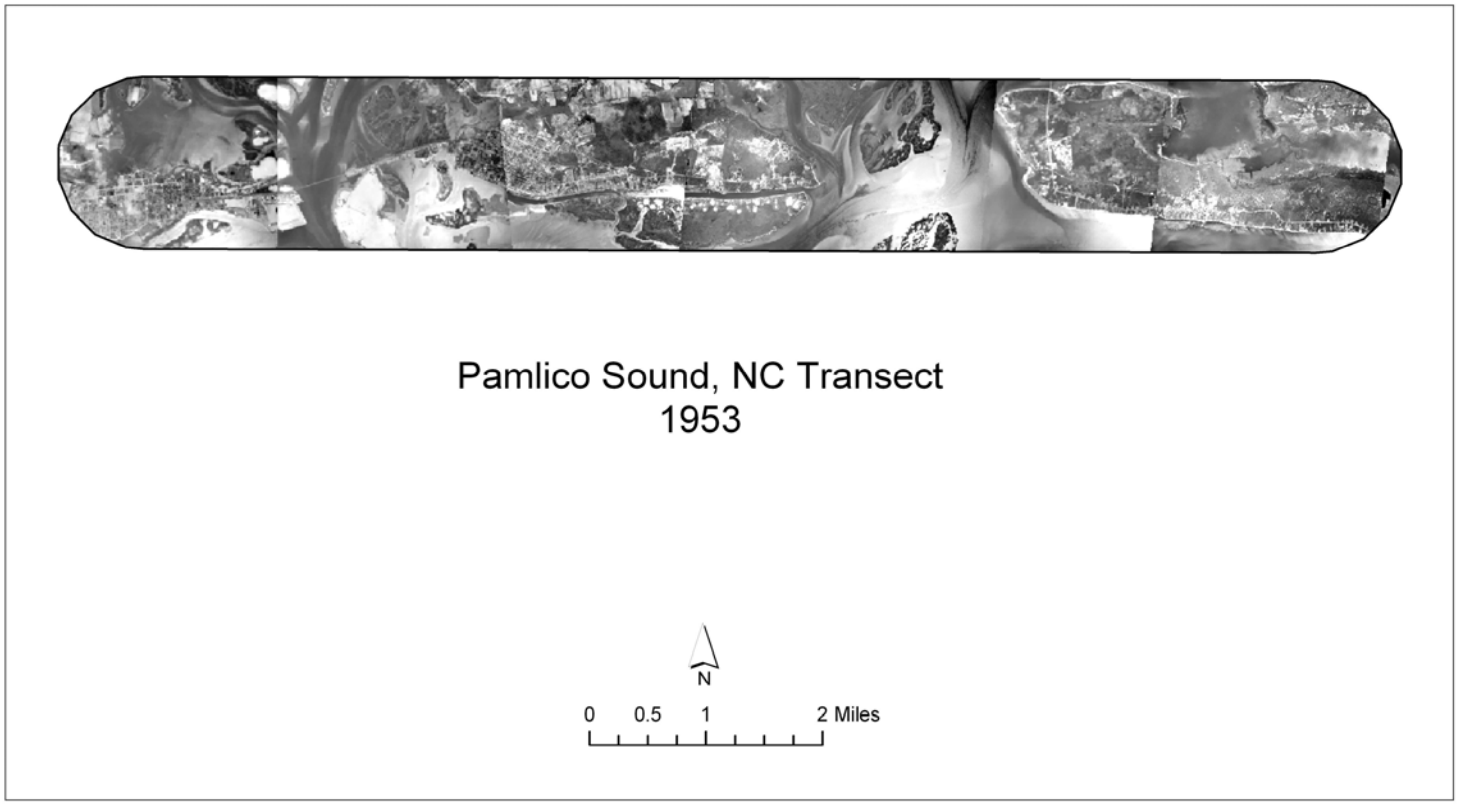


Figure 6-07. 1953 Aerial photos of Pamlico Sound, NC transect

Figures 6-08 and 6-09 depict the changes in wetland habitats and open water habitats from 1953 to 1997 respectively. The wetlands change map shows areas that changed from wetland to non-wetland classes and non-wetland to wetland classes. Similarly, the open water change map displays open water to non-open water classes and non-open water to open-water classes. These maps are helpful in determining where wetlands and open water habitat changes occurred and which classes they changed between.

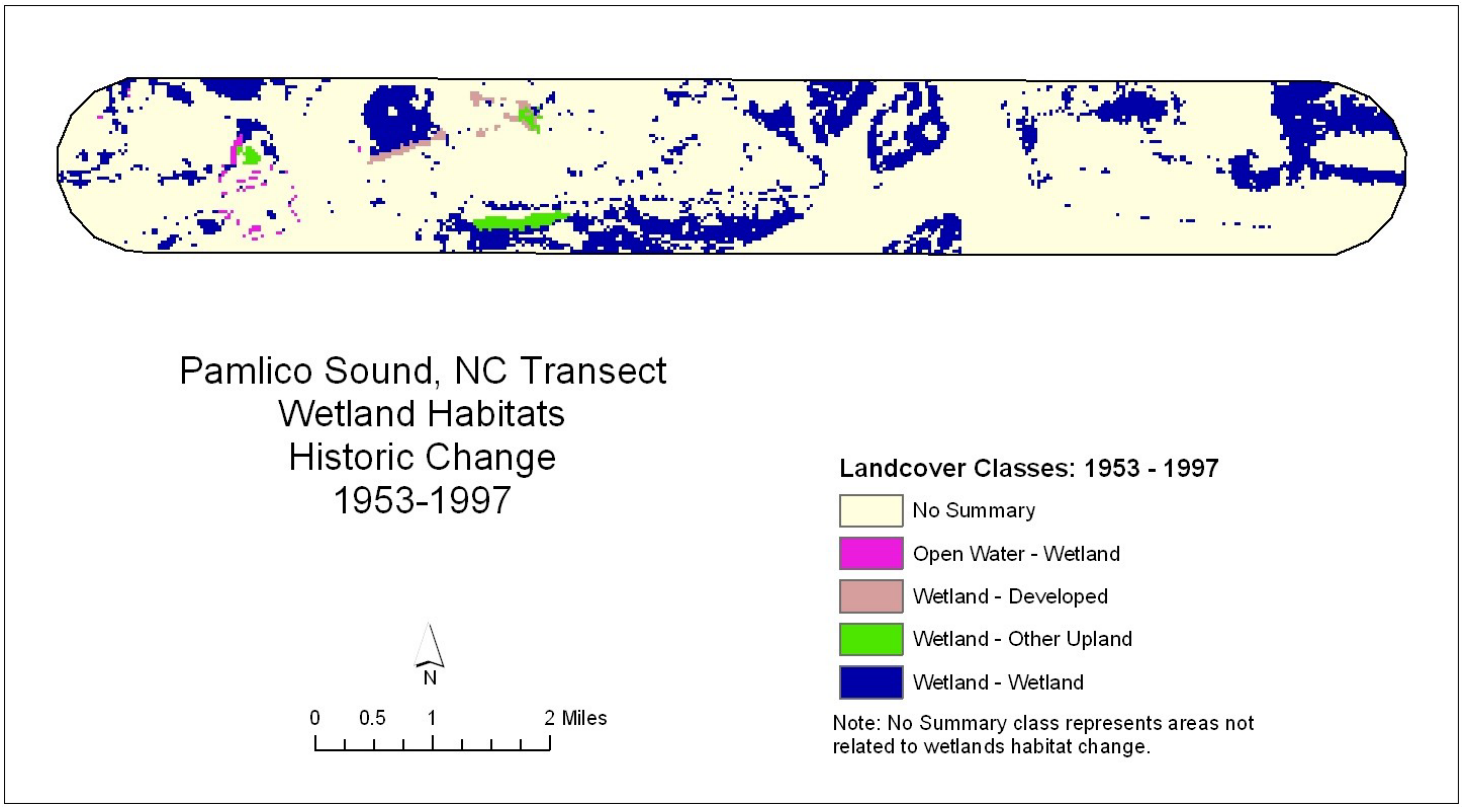


Figure 6-08. Wetland habitats change from 1953-1997, Pamlico Sound, NC transect.

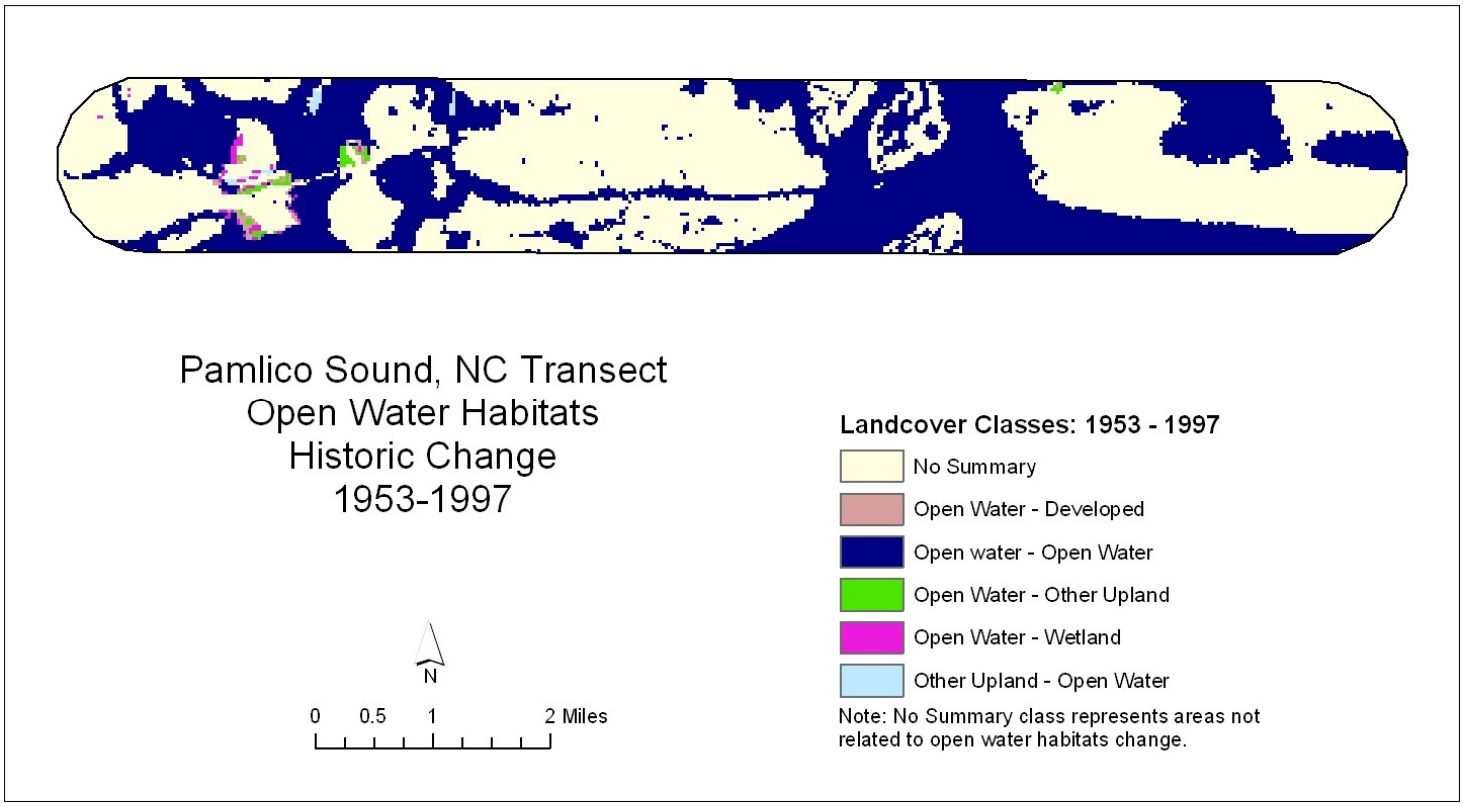


Figure 6-09. Open water habitats change from 1953-1997, Pamlico Sound, NC transect.

Historical (1953 – 1997) Change Tables

The datasets analyzed for this historical change included a set of black and white historical aerial photography from 1953, and the C-CAP dataset from 1997. The historical data are summarized for each of the land cover classes in Table 6-05. These data show losses for all land cover except palustrine forested wetlands and developed lands.

Within the wetland habitats, losses of 0.2% are shown for emergent wetlands, while greater losses of 62.03% and 20.75% are shown for shrub-scrub wetlands and natural (non-armored) shorelines, respectively. Most of these losses occurred near the entrance to Beaufort Harbor where the shrub-scrub wetlands were lost, and on the marsh islands south of the Intracoastal Waterway near the city of Beaufort where dredge spoils were placed to cover the natural shoreline areas. Even smaller losses of open water habitat are shown in Table 6-05, accounting for only 1.81% of the total open water habitat. Overall, the total wetland loss of 4.25% of the original 1953 acreage provides a good representation for the historical Pamlico Sound transect.

By far, the greatest changes in the Pamlico Sound transect occurred within non-wet classes. Developed lands increased in areal extent by 60.93%, while agricultural lands were reduced by 85.04%. Other upland also decreased by 6.19% of the original 1953 acreage. Development increased sharply within Morehead City, Beaufort, and Harkers Island. Losses in agricultural lands occurred primarily to the north of Beaufort and west of Morehead City harbor.

Table 6-05. Acreage and percent change of land cover classes from 1953-1997. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

Pamlico Sound, NC Transect - Dataset Acreage and Change by Land Cover Classes					
	HIST53 Acres	C-CAP97 Acres	Change 53-97 Acres	Change 53-97 Percent	53-97 Gain/Loss
Wetlands Total	***2,050.26***	***1,963.08***	***-87.18***	***-4.25%***[a]	***loss***
Emergent Wetlands	1,660.62	1,657.29	-3.34	-0.20%[b]	loss
Woody Wetlands Total	36.03	25.58	-10.45	-29.01%[c]	loss
Woody Wetlands (undetermined)	0.00	0.00	0.00	0.00%	
Shrub-scrub Wetlands	17.57	6.67	-10.90	-62.03%[d]	loss
Mangroves	0.00	0.00	0.00	0.00%	
Estuarine Forested Wetlands	0.00	0.00	0.00	0.00%	
Palustrine Forested Wetlands	18.46	18.90	0.44	2.41%[e]	gain
Natural (non-armored) Shoreline	353.61	280.22	-73.39	-20.75%[f]	loss
Open Water Total	***4,743.24***	***4,657.39***	***-85.84***	***-1.81%***[g]	***loss***
Open Water	4,743.24	4,657.39	-85.84	-1.81%	loss
Aquatic Bed Total	0.00	0.00	0.00	0.00%	
Aquatic Bed (undetermined)	0.00	0.00	0.00	0.00%	
Palustrine Aquatic Beds	0.00	0.00	0.00	0.00%	
Estuarine Aquatic Beds	0.00	0.00	0.00	0.00%	
Coral Reefs	0.00	0.00	0.00	0.00%	

	HIST53 Acres	C-CAP97 Acres	Change 53-97 Acres	Change 53-97 Percent	53-97 Gain/Loss
Oyster Reefs/Shell Bottom	0.00	0.00	0.00	0.00%	
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	0.00	0.00	0.00	0.00%	
Developed	***927.83***	***1,493.16***	***565.33***	***60.93%***	***gain***
Agriculture	***258.65***	***38.70***	***-219.95***	***-85.04%***	***loss***
Other Upland	***2,782.83***	***2,610.47***	***-172.36***	***-6.19%***	***loss***
TOTAL	***10,762.80***	***10,762.80***			

Note: The following footnotes indicate an actual total gain/loss of wetlands or open water habitats of at least/most the indicated amount. These numbers look strictly at change to development which is less likely to be misclassified.

[a] Wetlands total loss of at least 2.49% (51.15 acres)

[b] Emergent wetlands loss of at least 1.46% (24.24 acres)

[c] Woody wetlands total loss of at least 30.25% (10.9 acres)

[d] Shrub-scrub wetlands loss of at least 62.04% (10.9 acres)

[e] Palustrine forested wetlands loss/gain of 0% (0 acres)

[f] Natural (non-armored) shoreline loss of at least 4.53% (16.01 acres)

[g] Open water total loss of at least .68% (32.25 acres)

The potential causes for alterations in wetland habitat can be further examined by looking at Table 6-06, which includes percentages of change in wetland and open water habitats due to conversion to development, agriculture, and/or other upland. These data show a net loss of 124.7 acres of wetland habitat between 1953 and 1997, resulting from conversion between wetland and non-wet classes. This change translates to a loss of 6.09% of the original 1953 wetland area. The losses can be attributed nearly equally to conversion from wetland to developed land (2.48%) and other upland (3.59%). No loss of wetland areas to agricultural lands are shown in Table 6-06. The data show negligible change between open water and non-wet classes over the historical time period, on the order of 1.02%. Most of this change is seen as conversion from open water to developed land (0.68%)

Table 6-06. Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes from 1953-1997.

Pamlico Sound Transect - Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 53-97 Acres**	**Change 53-97 Percentage**	**53-97 Gain/Loss**
Wetland Habitats	Developed, Agriculture, Other Upland	124.76		
Developed, Agriculture, Other Upland	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		-124.76	-6.09%	loss
Open Water Habitats	Developed, Agriculture, Other Upland	73.17		
Developed, Agriculture, Other Upland	Open Water Habitats	24.91		
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		-48.26	-1.02%	loss
Wetland Habitats	Other Upland	73.61		
Other Upland	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Other Upland		-73.61	-3.59%	loss
Wetland Habitats	Agriculture	0.00		

From	To	Change 53-97 Acres	Change 53-97 Percentage	53-97 Gain/Loss
Agriculture	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Agriculture		0.00	0.00%	
Wetland Habitats	Developed	51.15		
Developed	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Developed		-51.15	-2.49%	loss
Open Water Habitats	Other Upland	40.92		
Other Upland	Open Water Habitats	24.91		
Open Water Habitats Gain/Loss to Other Upland		-16.01	-0.34%	loss
Open Water Habitats	Agriculture	0.00		
Agriculture	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Agriculture		0.00	0.00%	
Open Water Habitats	Developed	32.25		
Developed	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Developed		-32.25	-0.68%	loss

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

A more detailed breakdown of changes in land cover classes between 1953 and 1997 for the Pamlico Sound transect can be seen in Table 6-07. This table shows the distribution and change in number of acres between the 1953 and 1997. The table also shows the number of acres that remained unchanged over the recent 44-year period. These data support the findings from Table 6-06, which indicate that most of the loss in wetland habitat is due to conversion to developed or other upland. A total of 124 acres of wetlands were lost to these non-wet classes. The data also show some shifting of open water habitat to the wetland class, for a total of 37 acres, along with a loss of 73 acres of open water to the non-wet classes. As described above, the most significant changes within the Pamlico Sound transect occurred within the non-wet classes, where over 100 acres of agricultural land and 381 acres of other upland were lost to development.

Historical (1953 – 1997) Change Summary

Overall, the 44-year period between 1953 and 1997 saw a moderate loss of wetland habitat coupled with a significant increase in non-wet classes for the Pamlico Sound transect. Population growth and development in the area contributed to the loss in wetlands as well as the increase in non-wet classes. Other factors include the continued use of dredge spoil islands adjacent to the Intracoastal Waterway and Morehead City harbor, which have increased in size and become stabilized with vegetation over the years.

Table 6-07. Change matrix representing change in acres between land cover classes from 1953 to 1997. Values in the gray shaded cells are acres of no change.

Pamlico Sound Land Cover Change Aerial Photos 1953 to C-CAP 1997 (by acres)											
			1953								
			Wetland Habitats				Open Water Habitats	Non-Wet Habitats			
			Emergent Wetlands	Shrub-scrub Wetlands	Palustrine Forested Wetlands	Natural Non-armored) Shoreline	Open Water	Developed	Agriculture	Other Upland	Acreage Totals for 1997 Classification
1997	Wetland Habitats	Emergent Wetlands	1,636.38	0.00	0.00	0.00	20.91	0.00	0.00	0.00	1,657.29
		Shrub-scrub Wetlands	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00	6.67
		Palustrine Forested Wetlands	0.00	0.00	18.46	0.00	0.44	0.00	0.00	0.00	18.90
		Natural (Non-armored) Shoreline	0.00	0.00	0.00	263.98	16.23	0.00	0.00	0.00	280.22
	Open Water Habitats	Open Water	0.00	0.00	0.00	0.00	4,632.49	0.00	0.00	24.91	4,657.39
	Non-Wet Land Cover	Developed	24.24	10.90	0.00	16.01	32.25	927.83	100.97	380.96	1,493.16
		Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	38.70	0.00	38.70
		Other Upland	0.00	0.00	0.00	73.61	40.92	0.00	118.98	2,376.96	2,610.47
		Acreage Totals for 1953 Classification	1,660.62	17.57	18.46	353.61	4,743.24	927.83	258.65	2,782.83	**10,762.80**

This table presents estimates of acreage by classification and the number of acres that changed classification between the two dates. The data shows the numbers of acres that have changed from the 1953 date to the 1997 date. The table reads down (1953/from) and to the left (1997/to).

Section 6.4 CAF Change Summary (1953 – 2004)

A summary of estimated habitat and other land cover change within the South Atlantic CAF region for the period 1953 to 2004 is shown in Table 6-08. The table shows actual measured acres lost and gained for the Pamlico Sound transect for both the historical and recent time periods. In addition, the percent of acres lost and gained for the transect are also shown. These specific transect data were used in conjunction with regional information regarding the CAF, to develop estimates for change within the CAF as a whole.

Computed values for change within the Pamlico Sound transect provide a rough basis for estimating change within the much larger CAF region. This is true for both the historical and recent time periods examined. Overall, most target habitat groups and other land cover classes were reduced in areal extent; the only exceptions were palustrine forested wetlands and developed areas. Within the wetlands habitats, emergent wetlands were estimated to decrease by 8 to 11% over the historical time period, and by 5 to 10% over the more recent 1992 to 2004 time period. Both of these ranges are considerably higher than computed for the Pamlico Sound transect, primarily because of the greater extent of emergent wetlands in the CAF region as a whole. The rate of loss for emergent wetlands was estimated to decline over the recent time period, a result of increased regulatory controls designed to protect these fragile wetlands. Losses in total woody wetlands for the historical time period was estimated to be 7 to 21%, with 5 to 14% lost during the recent time period. These losses are assumed to be the result of development pressures in older growth areas on barrier islands as well as further inland where woody wetlands are prevalent. Losses in shrub-scrub wetlands were assumed to be close to woody wetlands loss as a whole, at 5 to 15% for the historical time period. There was little basis for comparison between the Pamlico Sound transect and the CAF for the palustrine forested wetlands. Finally, losses in natural (non armored) shoreline for the CAF were determined to align rather closely with the historic data produced from the CAF, at 10 to 28% for the historic time period, with 5 to 18% lost from 1992 to 2004.

Changes in open water habitat for the South Atlantic CAF region were estimated to be slightly higher than the Pamlico Sound transect for both the historical and recent time periods. As such, losses for total open water habitats were estimated to range from 0 to 7% historically while 0 to 5% was estimated lost recently. Higher losses for the CAF region as a whole can be attributed to continued development pressures throughout the CAF region, especially in the near coast areas where the cumulative effects of private development have resulted in wetland loss.

For the non-wet land cover classes, changes seen in the Pamlico Sound transect were generally considered to be representative of the CAF as a whole. Historic increases in developed land over the period 1953 to 2004 were estimated to be between 30 and 45%, while over the more recent time period from 1992 to 2004 the increase in developed land was only 17 to 24%. The ranges given for both of these time periods represent a higher degree of development in the South Atlantic CAF than in the New England or Mid Atlantic CAF regions. These estimates for the CAF also reflect a greater level of

development than found within the Pamlico Sound transect. Agricultural losses in the South Atlantic CAF were estimated to be 20 to 35% for the historical time period, and 9 to 16% for the more recent time period. Both of these estimates are considerably less than the values found for the Pamlico Sound transect. This is primarily due to the loss of most of the agricultural land within the Pamlico Sound transect over the time period studied, while a significant amount of agricultural land has been maintained over the years within the CAF region as a whole. Finally, close correlation between the transect data and the CAF region was estimated for changes in other upland, with a loss estimate of 5 to 10%.

Table 6-08. Estimated target habitat group and other land cover change from 1953-2004 for the South Atlantic CAF region based on local expert analysis of recent and historic habitat change of the Pamlico Sound, NC transect. The estimated acreages were calculated using NLCD 1992 as listed in Table 6-01. Also see Appendix C, Tables 13-04g – 04h for further detailed acreage values.

		Pamlico Sound, NC Transect				South Atlantic CAF Region			
		1953-1997 Historic Acres Gain/Loss	1953-1997 Historic Percent Gain/Loss	1991-1997 Recent Acres Gain/Loss	1991-1997 Recent Percent Gain/Loss	Historic 1953 to 2004 Estimated Acres Gain/Loss	Historic 1953 to 2004 Estimated Percent Gain/Loss	Recent 1992 to 2004 Estimated Acres Gain/Loss	Recent 1992 to 2004 Estimated Percent Gain/Loss
Wetland Habitats	***Wetlands Total[1]***	***-87.18***	***-4.25%***	***36.92***	***1.86%***	***-841,879 to -2,059,666***	***-8% to -19%***	***-509,558 to -1,410,488***	***-5% to -13%***
	Emergent Wetlands	-3.34	-0.20%	-13.79	-0.82%	-201,192 to -270,913	-8% to -11%	-121,774 to -243,548	-5% to -10%
	Woody Wetlands Total[2]	-10.45	-29.01%	-16.01	-30.64%	-549,443 to -1,736,181	-7% to -21%	-384,197 to -1,152,591	-5% to -14%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	-10.90	-62.03%	2.89	38.24%	no data	-5% to -15%	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	0.44	2.41%	-18.90	-42.29%	no data	5% to -5%	no data	no data
	Natural (non-armored) Shoreline	-73.39	-20.75%	66.72	25.66%	-7,573 to -22,321	-10% to -28%	-3,587 to -14,349	-5% to -18%
Open Water Habitats	***Open Water Total[3]***	***-85.84***	***-1.81%***	***61.60***	***1.35%***	***0 to -76,949***	***0% to -7%***	***0 to -53,807***	***0% to -5%***
	Open Water	-85.84	-1.81%	146.11	3.26%	no data	no data	no data	no data
	Aquatic Bed Total[4]	no data	no data	no data	no data	no data	0% to -3%	no data	no data
	Aquatic Bed (undetermined)**	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***565.33***	***60.93%***	***120.54***	***8.83%***	***514,497 to 721,993***	***30% to 45%***	***290,803 to 387,737***	***17% to 24%***
	Agriculture	***-219.95***	***-85.04%***	***-62.49***	***-57.70%***	***-1,655,721 to -3,169,927***	***-20% to -35%***	***-735,876 to -1,471,752***	***-9% to -16%***
	Other Upland	***-172.36***	***-6.19%***	***-156.57***	***-5.75%***	***-713,723 to -1,429,081***	***-5% to -10%***	***-419,404 to -1,118,411***	***-3% to -8%***

1 "Emergent Wetlands", "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", "Palustrine Forested Wetlands", and "Natural (non-armored) Shoreline" have been summarized in "Wetlands Total".

2 "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", and Palustrine Forested Wetlands" have summarized in "Woody Wetlands Total".

3 "Aquatic Beds", Palustrine Aquatic Beds", Estuarine Aquatic Beds", "Coral Reefs", "Oyster Reefs/Shell Bottom", "Hard Bottom" and "Soft Bottom" have been summarized in "Open Water Total".

4 "Aquatic Beds", "Palustrine Aquatic Beds", and "Estuarine Aquatic Beds" have been summarized in "Aquatic Bed Total".

* "Woody Wetlands (undetermined)" includes wetlands not specifically identified by system (palustrine, estuarine, etc.) and/or type of woody vegetation (shrub-scrub, forested, etc.).

** "Aquatic Bed (undetermined)" includes aquatic beds not specifically identified by system (palustrine, estuarine, etc.).

Section 7.0 Gulf Coast CAF

Section 7.1 CAF Description

The Gulf Coast Coastal Assessment Framework (CAF) Region is approximately 59,044,718 acres in size, and includes areas within the west coast of Florida, Georgia, Alabama, Mississippi, Louisiana, and Texas. The Gulf Coast CAF has been sub-divided into 38 Estuarine Drainage Areas and 35 additional Coastal Drainage Areas by NOAA. The western portion of the CAF, along the Gulf coast of Florida, extends from the coastal zone inland to include the Big Cypress Swamp and the Everglades. This portion of the CAF also includes the many barrier beaches and coastal marshlands that line the west coast of Florida, as well as the low hills and lakes of the Florida Uplands. The CAF in the western part of Florida extends inland on average 50 miles, and reaches maximum elevations of 330 feet above sea level. Wetland types are varied, ranging from sandy barrier beaches along the coast, to forested freshwater habitats on stream flood plains. The western part of the Gulf Coast CAF, from Pensacola Bay to Brownsville, Texas, is dominated by a number of large scale river basins and coastal estuary systems. The CAF boundaries extend from the coastal zone inland, and include the major features of Pensacola Bay, Mobile Bay, lower Mississippi River, Sabine River, Galveston Bay, Brazos River and Matagorda Bay. This western portion of the CAF extends inland further than in western Florida, ranging from 100 miles wide to over 150 miles wide in the Mississippi River area. Most of the CAF is relatively low lying, ranging in elevation from sea level to 100 feet above sea level. The highest elevations of approximately 800 feet above sea level are found in the upper reaches of the Laguna Madre drainage basins near south Texas. Wetland types range from sandy beaches along the coast, to extensive salt marsh areas, to alluvial flood plains and freshwater swamps, to forested wetlands.

Approximately 9.4% of the Gulf Coast CAF is composed of densely populated regions, primarily in the larger cities of Fort Myers (Florida), Tampa/St. Petersburg (Florida), Tallahassee (Florida), Mobile (Alabama), New Orleans (Louisiana), Baton Rouge (Louisiana), Houston/Galveston (Texas), and Corpus Christi (Texas). These urban areas account for a total of 2,976,189 acres, or 5.0% of the total CAF area. Human population growth from 1990 to 2000 has been nearly 21%, increasing from 10,053,540 persons to 12,186,868 persons (ESRI, 2000 and ESRI, 2002). The percentage of federally owned land is relatively small in the Gulf Coast CAF, accounting for 4,034,567 acres or 6.8% of the total area. The largest of these areas are national forests operated by the US Forest Service and National Wildlife Refuges operated by the US Fish and Wildlife Service.

Review of data from existing studies provides some insight as to the historical level of wetland loss within the Gulf Coast CAF. NOAA's National Marine Fisheries Service reports on wetland loss through the 1980s within the Gulf Coast CAF states (NOAA, 2005). This report indicates that Florida had lost approximately 46% of its estimated original wetlands acreage by the 1980s, while Alabama and Mississippi had lost 50% and 59%, respectively. For Louisiana, NOAA reports a loss of between 16,000 and 22,000 acres per year, and Texas is reported to have lost nearly one-half of its original wetlands acreage by the 1980s. For the period 1992 to 1997, the US Department of Agriculture

(USDA) reports a loss of 84,100 acres of palustrine and estuarine wetlands and a 78,400 acre gain for the south central US states of Texas and Louisiana (USDA, 2005a). Causes for these wetland losses were assigned to the following activities: development (59.3%), agriculture (21.8%), miscellaneous (14.4%), and silviculture (11.9%) (USDA, 2005b). Considerably higher losses are reported by the USDA for the southeast region, where 216,900 acres of palustrine and estuarine wetlands were lost over the period from 1992 to 1997. These values certainly overestimate the amount of wetlands lost in the southeast CAF states, since the USDA southeast region includes more than just the Gulf coast states.

Section 7.2 Recent (1992) Land Cover Data Summary

Figure 7-01 shows the mapped target habitat groups and other land cover classes for the Gulf Coast CAF region. The data was based on the 1992 USGS National Land Cover Dataset (NLCD).

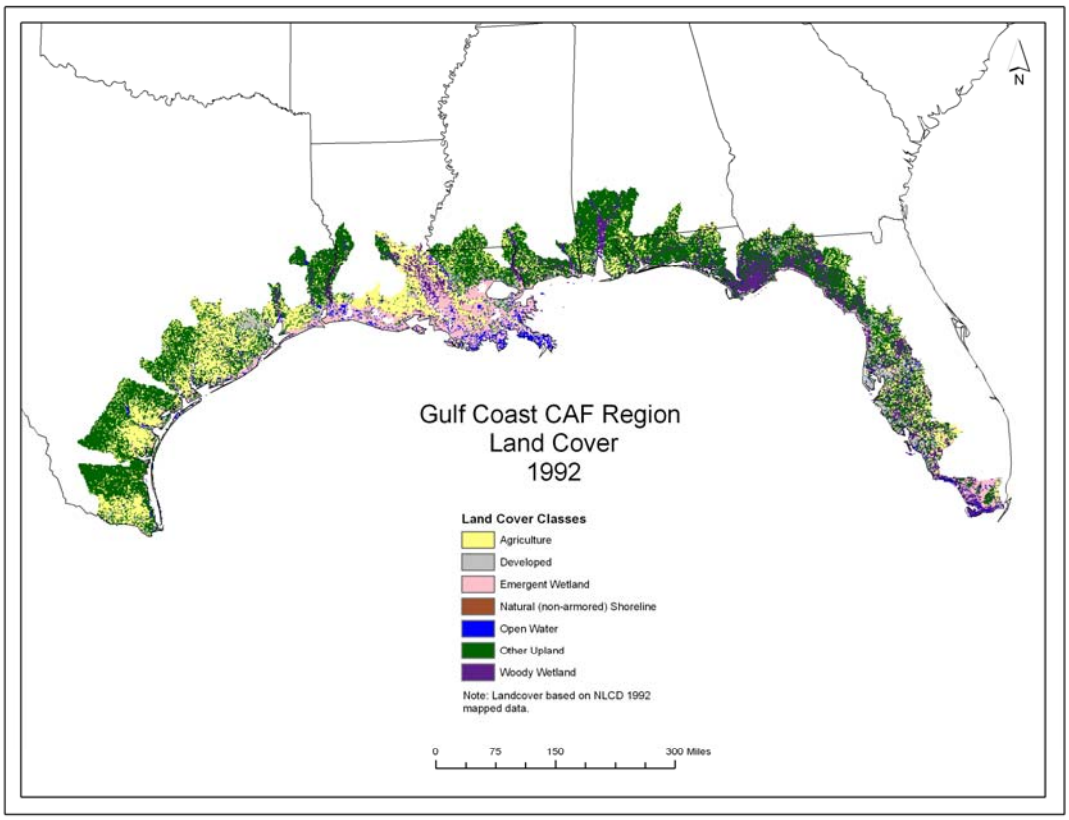


Figure 7-01. Gulf Coast CAF Region land cover classes, 1992.

Rough estimates of total area of land cover, based on the 1992 NLCD classification, are presented in Table 7-01.According to the NLCD 1992 classifications, the Gulf Coast CAF region is comprised of 57,264,539 acres. Of this land area, the greatest percentage is classified as other upland (44.6%), while agricultural lands and wetlands make up almost equal percentages of 24.4% and 22.4%. The wetlands areas are split nearly equally between emergent wetlands and woody wetlands, with a very small percentage

falling within the natural (non-armored) shoreline habitat. Open water habitats and developed lands comprise only 3.9% and 4.5% of the total CAF area, respectively.

Table 7-01. Total area of target habitat groups and other land cover classes within the Gulf Coast CAF region (1992).

Gulf Coast CAF Region - Total Area by Habitat Group and Other Land Cover Classes	
	NLCD92 Acres
Wetlands Total[1]	***14,001,983.52***
Emergent Wetlands	6,853,460.46
Woody Wetlands Total[2]	6,960,168.74
Woody Wetlands (undetermined)*	6,960,168.74
Shrub-scrub Wetlands	0.00
Mangroves	0.00
Estuarine Forested Wetlands	0.00
Palustrine Forested Wetlands	0.00
Natural (non-armored) Shoreline	188,354.32
Open Water Total[3]	***2,192,978.67***
Open Water	2,192,978.67
Aquatic Bed Total[4]	0.00
Aquatic Bed (undetermined)**	0.00
Palustrine Aquatic Beds	0.00
Estuarine Aquatic Beds	0.00
Coral Reefs	0.00
Oyster Reefs/Shell Bottom	0.00
Hard Bottom	0.00
Soft Bottom	0.00
Developed	***2,807,880.35***
Agriculture	***14,356,064.87***
Other Upland	***25,861,562.53***
TOTAL	***59,220,469.95***

1 "Emergent Wetlands", "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", "Palustrine Forested Wetlands", and "Natural (non-armored) Shoreline" have been summarized in "Wetlands Total".

2 "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", and Palustrine Forested Wetlands" have summarized in "Woody Wetlands Total".

3 "Aquatic Beds", Palustrine Aquatic Beds", Estuarine Aquatic Beds", "Coral Reefs", "Oyster Reefs/Shell Bottom", "Hard Bottom" and "Soft Bottom" have been summarized in "Open Water Total".

4 "Aquatic Beds", "Palustrine Aquatic Beds", and "Estuarine Aquatic Beds" have been summarized in "Aquatic Bed Total".

* "Woody Wetlands (undetermined)" includes wetlands not specifically identified by system (palustrine, estuarine, etc.) and/or type of woody vegetation (shrub-scrub, forested, etc.).

** "Aquatic Bed (undetermined)" includes aquatic beds not specifically identified by system (palustrine, estuarine, etc.).

Note: Acreage totals are a rough estimate. Totals may not represent all of each CAF region due to clipping of raster datasets (not all of each CAF region could be clipped due to high amount of small island polygons).

Section 7.3 Transect Analysis Results

Section 7.3.1 Tampa Bay, FL Transect

Transect Location

The location of the Tampa Bay, FL transect in the Gulf Coast CAF region is illustrated in Figure 7-02. The placement of the transect within the confines of Tampa Bay can be seen in more detail in Figure 7-03.

Located on the east side of Tampa Bay in what is considered the Middle Bay, the transect is in the most undeveloped portion of the bay ecosystem and as a result may not represent typical changes and wetland conversions changes for this area. It is located in a highly urbanized bay system, and, as a result, degraded water quality and human activity and encroachment has affected the area, although much of the transect wetland habitat remains relatively intact. Much of the transect is now included in the Cockroach Bay State Aquatic Preserve and other wetlands are publicly owned (e.g. E.G. Simmons County Park).

It may, however, be more representative of the western Gulf of Mexico (Florida to Mississippi) as a whole as it reflects the patchwork of intensive coastal development (e.g. Tarpon Springs south to Ft. Myers, the westernmost Florida Panhandle Coast, Mobile, AL, and Biloxi, MS) mixed with long stretches of relatively undisturbed coast (e.g. Everglades National Park, Florida Big Bend area, and much of the Panhandle coast) Forested wetlands on the coast are more heavily represented here than further to the north as mangroves in the Tampa Bay area are approaching the northern limit of their distribution. To the north along the west Florida coast tidal salt marshes become more dominant and form the majority of the wetland habitats (along with seagrasses) in the northeastern Gulf. To the south from Tampa Bay to the south edge of Everglades National Park and Florida Bay, mangrove wetlands are the dominant coastal wetland habitat.

There are diverse wetland plant communities in the transect including shallow water seagrasses offshore and in the larger bays, tidal mangroves, a drainage system from the freshwater wetland interior here (Little Manatee River in the center of the transect), estuarine conditions and plant communities at the river mouth, and salt marshes and salt pans composed of halophytic plants landward of the mangroves.

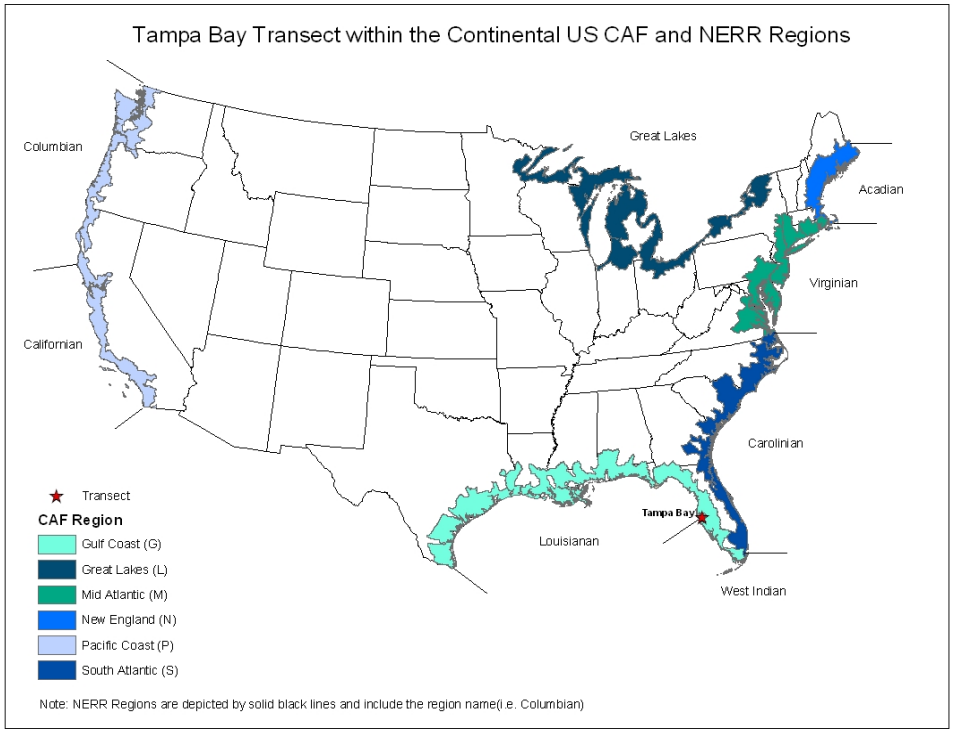


Figure 7-02. Location of the Tampa Bay, FL transect within the Gulf Coast CAF region.

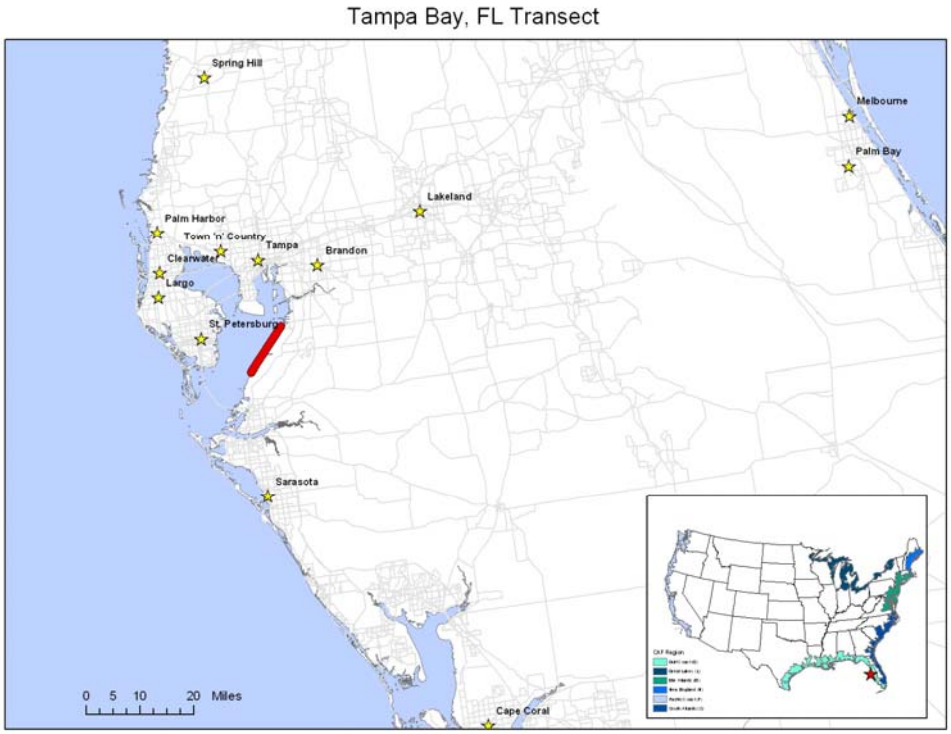


Figure 7-03. Tampa Bay, FL transect placement. Transect is mapped in red.

Transect Description

I. Distance to Coast

a. The transect is located in the Middle Tampa Bay region with habitats and water quality associated with and reflecting the tidal processes of the eastern Gulf of Mexico. The transect is in an area where the physical and chemical gradients between the upper (north) and lower Bay are pronounced.
b. The daily tidal range is low, typically less than a foot with diurnal tides. Circulation is good but tidal and wind generated circulation and flushing depends on location.
c. Water quality is influenced by discharges in the more heavily developed portions of the Bay and wind and tidally driven circulation.
d. The transect is on the Bay shoreline and extends offshore across shallow flats of unconsolidated, sometime vegetated, sediments into deeper water of the Bay. The transect extends approximately 0.5 to 1.2 miles inland of the open Bay shoreline, entirely within the tidal and estuarine portion of the Bay system.
e. Located on an open water west facing shoreline of the Bay with about 5-8 miles of fetch across waters to 20-30 feet deep, shoreline features of the transect include low barrier islands formed by coastal current and other physical forces and processes at work, and shallow protected bays and creeks lined with mangroves.
f. The drainage of creeks and rivers from the interior create estuarine conditions that vary with the seasons and strength of rain events. Mangroves make up the bulk of the forested wetland near the river mouth while other shrubs and trees occur along the shoreline up river above the transect.

II. Salinity
a. The open water areas and shallow bays and lagoons are marine in nature with salinities typically above 30 ppt, with some seasonal variation. At the mouth of Little Manatee Creek in the center of the transect, salinities typically range from about 20-30 ppt as a result of low salinity and freshwater discharge from the river and its interior drainage basin - also varying seasonally with Florida's wet and dry season cycle.

III. Topography/Elevation Range
a. Most wetlands in the Tampa Bay transect exist within a few feet of mean sea level in a physical setting typical of marine coastal wetlands along the Gulf coast. Offshore, open water depths range from a few feet deep across the shallow nearshore flats to about 10 feet deep further offshore.
b. The tidal creeks and bays may include tidal channels that range from 5 to 10 feet deep bordered by shallow seagrass flats, often with red mangroves encroaching into the water from the shoreline. Black mangrove wetlands rarely are found below the mean high water line in Gulf coast wetlands.
c. Dredged channels and marine basins associated with the few large developed sites in the transect may vary in depth, depending on when they were dredged and if fill to create nearby development sites in wetlands or open water was needed. They likely range from about 5 to 20 feet deep.

IV. Proximity to City

a. Urban development has been a major cause of wetland and other habitat loss in the Tampa Bay region, as it has on other portions of the central Florida Gulf coast. Overall, the percentage of the transect that can be considered urban is low, with two major centers of development, one a residential/commercial development mostly created by dredge and fill and the other a community park also created in the coastal zones by early large scale dredge and fill. Otherwise, the transect is mostly undeveloped with rock pit excavation landward of the wetland zone to the south and canal dredging in the central and north areas.
b. As is often true, development here followed and tracked development of the Port of Tampa and other marine facilities on the Bay. Both St. Petersburg on the west side of the bay and the City of Tampa on the east filled and developed much of their respective coastal wetland habitat during the early to mid 1950s. The east side of the Middle Bay escaped much of the habitat loss during this period of intense development and as a result large tracts of tidal wetland habitat persist, along with offshore seagrasses lost from much of the Bay decades ago due to deterioration of water quality associated with discharges from sewage treatment plants and uncontrolled stormwater runoff from urban areas.
c. Improvements in water quality since about 1980 have resulted in improved habitat conditions in much of the bay, including recovery of some seagrass habitats.
d. Growth pressures persist in the Bay region but a combination of public ownership of much remaining tidal wetland habitat, local, state and federal wetland regulations, and wetland restoration have greatly reduced the rate of loss and in some areas resulted in an increase in wetland habitat, even with increasing population around the Bay.

V. Land Ownership
a. Submerged lands (to the mean high water line in most locations) within the transect are owned and managed by the State of Florida as Trustees for its citizens. As red mangroves can exist below the mean high water line some mangrove habitats are also owned by the State.
b. A considerable amount of the tidal wetland habitat within the transect is owned either by the County as part of a Community Park (central) or by the State as part of the Cockroach Bay State Aquatic Preserve in the south.
c. The remainder (50%) of the wetland habitats within the transect are privately owned.

VI. Dominant Land Uses
a. Land use and human activity within the Tampa Bay transect varies from none along the coast other than the two heavily developed sites at E.G. Simmons Community Park and Apollo Beach to low intensity agriculture landward of the wetland zone in the south.
b. Natural habitats make up much of the transect - especially along the shorelines.
c. Some industrial activity in the form of large rock pits exist in the south.

d. Cockroach Bay is a protected area but includes a filled causeway to the shoreline with an increasingly popular boat ramp.

VII. Extent of Shoreline Armoring

a. Armored shorelines exist on most artificial shorelines in the two large developed sites in the transect (central and north) but rather than directly eliminating wetland habitats this armoring precludes the revegetation of filled shorelines by wetland plants. In many cases they exist to retain fill placed through the dredging and filling process that created these areas.
b. Little armoring exists in the river and creek drainages within the transect or in the shallow tidal creeks and bays.
c. Roads and causeways that pass through tidal wetlands may be armored or may have revegetated with mangroves on the slope into the adjoining waterbody.

VIII. Shipping

a. Tampa Bay includes several major ports and the Army Corps of Engineers maintains a dredged navigation channel through the center of the Bay extending to the heavily developed northern portion of the Bay. Spoil islands have been created in the Bay offshore and north of the transect.
b. Dredged channels and the intense large vessel activity (including cruise ships) that now exists in Tampa Bay (thousands of vessel passages each year) affect water quality and the health and productivity of nearshore shallow water and shoreline wetland communities. Resuspended sediment, increased turbidity, discharges, shoreline erosion, and the risk of spills are factors that affect the Bay region in the area of the transect. Smaller dredged channels for use by recreational vessels associated with E.G. Simmons Community Park and the Apollo Beach area affect water quality in similar ways.
c. Prop dredging and scarring of shallow water seagrass habitat by recreational and commercial fishing vessels is also a very real problem in Florida's Gulf Coast resulting in loss and degradation of substantial areas of aquatic vegetation, including in the transect. The three County Tampa Bay region has 111,000 registered boats. The scale and resolution of the map coverages used in the current assessment preclude identification of these small but serious impacts and losses.

IX. Dredging

a. As noted above, the two major developed upland sites in the transect were created almost entirely by dredging and filling at the expense of shoreline wetland habitats and open water (including seagrasses). The alteration of nearshore tidal and wind generated current patterns are obvious based on a review of the transect imagery. Use of these channels by large and increasing numbers of recreational vessels degrades water quality, erodes shorelines (some artificial) and disrupts use of nearshore wetland and shallow water habitats by fish and wildlife.
b. The main navigation channel through the Bay was deepened originally by dredging and is maintained on a routine basis through a process that adds dredge spoil to spoil islands in the Bay (often to create wetland habitat)

and through use of offshore disposal sites. Use of the channel by large vessels (tankers, freighters, cargo ships, cruise ships) offshore of the transect in the center of the Bay results in resuspended bottom sediment and increased water turbidity. This use will continue and likely increase and routine maintenance dredging will continue.

X. Major Natural Disasters
   a. In the Southeast and Gulf Coasts hurricanes regularly reshape barrier islands, coastal channels, shallow water habitats, and wetlands. Recent hurricanes that included bisection and cutting of new channels through Gulf barrier islands south of Tampa Bay are indicative of the massive physical and shaping forces at work in natural systems exposed to hurricanes.
   b. Storm surge from advancing hurricanes can erode and reshape shorelines while winds of Category 3 and above hurricanes can strip all leaves from coastal vegetation leaving it prone to mortality. This is especially true of red mangroves that are known not to tolerate total defoliation. Massive red mangrove forests south of Miami and on the southwest coast of Florida have been lost in recent years to large hurricanes.

Recent Transect Maps

Figures 7-04 shows the 2004 Digital Orthophoto Quarter Quadrangles (DOQQs) of the Tampa Bay, FL transect. The DOQQs were used as a visual reference for interpreting land cover changes and represent current conditions. They clearly show the important shallow water habitats, including seagrass, immediately offshore. Wetland and shallow water habitats lost to development, and wetlands converted to open water by dredging (canals, channels, basins, etc.) in the central and north portion of the transect are easily identified as are other large scale conversions in the area (i.e. agriculture lands behind the wetland fringe to rock pits in the south).

Figure 7-04. 2004 DOQQ of Tampa Bay, FL transect.

Figure 7-05 and 7-06 reflects the changes in wetland habitats and open water habitats from 1982 to 1992 respectively. The wetlands change map shows areas that changed from wetland to non-wetland classes and non-wetland to wetland classes. Similarly, the open water change map displays open water to non-open water classes and non-open water to open water classes. These maps are helpful in determining where wetlands and open water habitat changes occurred and which classes they changed between.

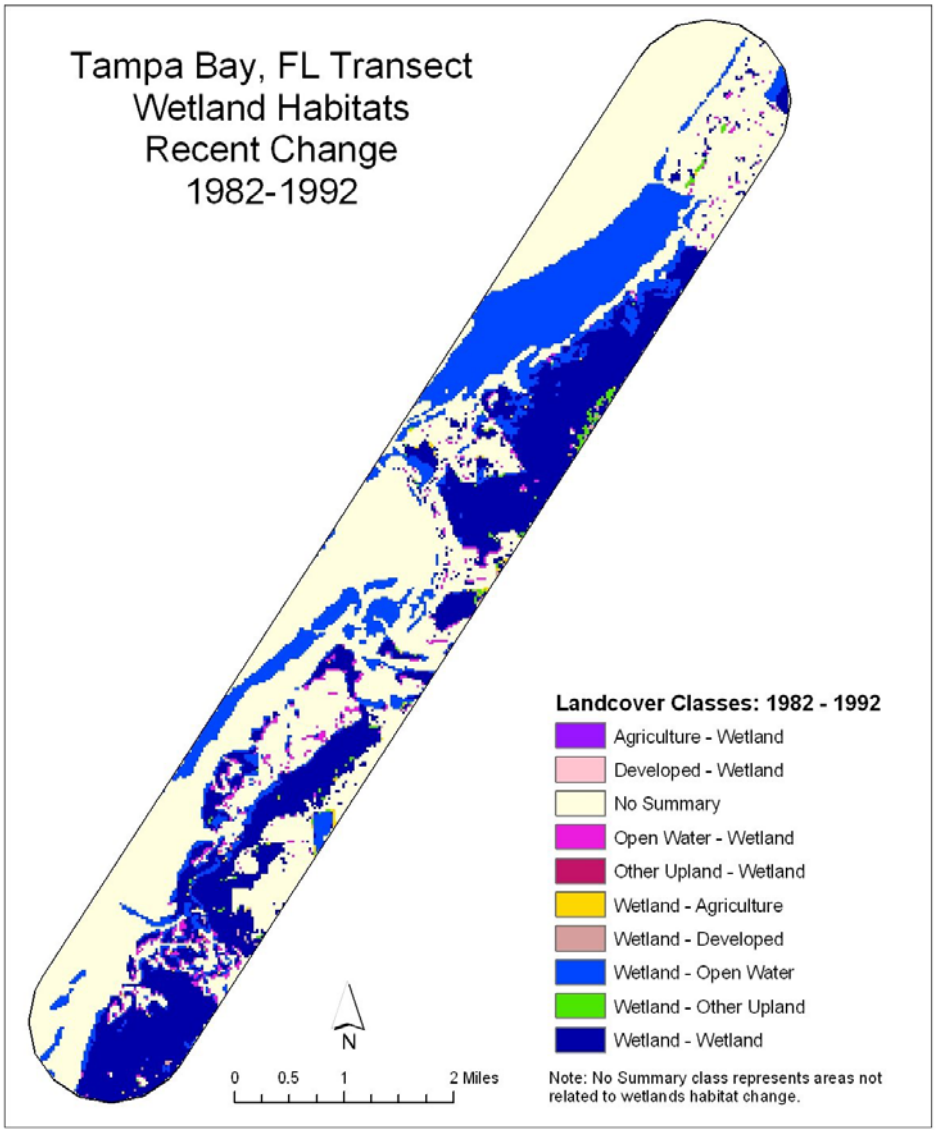


Figure 7-05. Wetland habitats change from 1982-1992, Tampa Bay, FL transect.

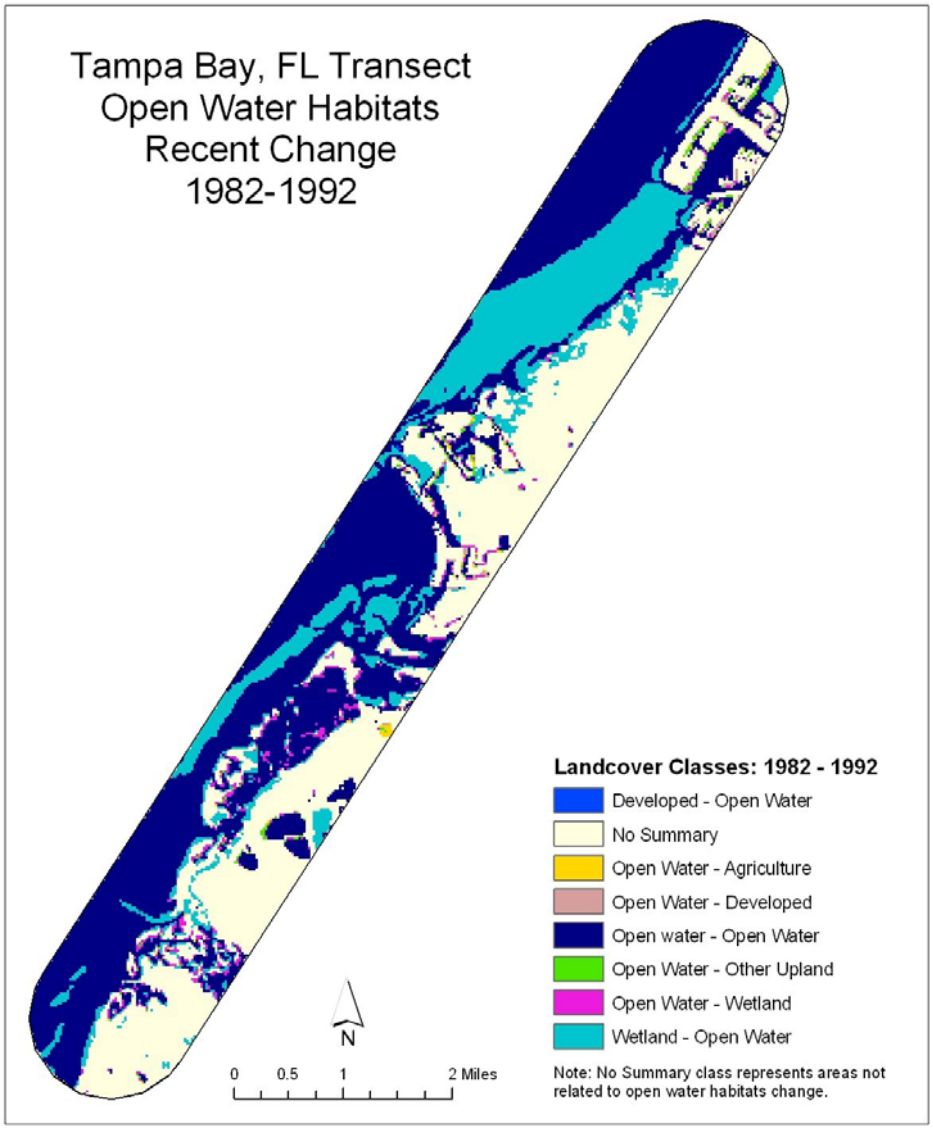


Figure 7-06. Open water habitats change from 1982-1992, Tampa Bay, FL transect.

Recent (1982 – 1992) Change Tables

As a result of using NWI data from 1982 as the early date of change, several classes of woody wetlands were captured that were not differentiated in the NLCD 1992 dataset, namely mangroves which are encompassed within the woody wetlands target habitat group for NLCD 1992. And, a seagrass mapping dataset for the period 1987 to 1999 was incorporated into the NLCD 1992 dataset from another source to try to provide more detail for aquatic beds in the transect.

Due to the scale and resolution of the imagery used, and the different classification schemes, it is only reasonably possible to compare woody wetlands as a unit during this time period. Lumping all classes from the two sets of map data reveals that about 96 acres (about 3%-4%) were lost during the period, a reasonable estimate for this period. However, the increase in emergent wetlands is not supported by a review of the imagery,

and the scattered locations of these gains in wetlands suggest they are misidentified. During this period of increasing wetland regulation and acknowledgment of wetland values in this region, little loss of emergent wetlands probably occurred compared to previous decades, and no large areas of conversion are known. The use of the term "natural (non-armored) shoreline" is treated very differently between the two datasets.

The extent of true open water areas (those below the mean high water line) probably changed little during this period and a major difference in the open water class schemes between the two datasets is apparent in Table 7-02. Although historically there has been major loss of seagrasses in Tampa Bay (and probably in the transect area) due to water quality degradation, with some recent recovery, the loss reflected in Table 7-02 is not supported by a review of the imagery and is a direct result of very different schemes used for mapping of offshore area in 1982 and 1992. Many different class schemes have been used for seagrass (aquatic bed) mapping with the inclusion of low levels of patchy seagrasses in some schemes, a difference that can result in major variations in acreage trends. It appears that the 1982 NWI mapping took a broad view of the extent of submerged vegetation (possibly including macroalgae) whereas the additional dataset included in the 1992 data likely was more exact in mapping the extent of more easily identifiable seagrass habitat. And the NWI scheme led to the identification of soft bottom (unvegetated) habitats in 1982 whereas the 1992 mapping combined all into an open water category.

Table 7-02. Acreage and percent change of land cover classes from 1982-1992. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

Tampa Bay, FL Transect - Dataset Acreage and Change by Land Cover Classes					
	NWI82 Acres	**NLCD92 Acres**	**Change 82-92 Acres**	**Change 82-92 Percent**	**82-92 Gain/Loss**
Wetlands Total	***4,684.08***	***2,858.00***	***-1,826.08***	***-38.98%*** [a]	***loss***
Emergent Wetlands	57.82	219.06	161.24	278.85% [b]	gain
Woody Wetlands Total	2,699.87	2,603.35	-96.52	-3.57% [c]	loss
Woody Wetlands (undetermined)	66.05	2,603.35	2,537.30	3841.41%	gain
Shrub-scrub Wetlands	34.03	0.00	-34.03	-100.00%	
Mangroves	2,505.95	0.00	-2,505.95	-100.00%	
Estuarine Forested Wetlands	14.46	0.00	-14.46	-100.00%	
Palustrine Forested Wetlands	79.39	0.00	-79.39	-100.00%	
Natural (non-armored) Shoreline	1,926.38	35.58	-1,890.80	-98.15% [d]	loss
Open Water Total	***5,211.16***	***6,782.15***	***1,571.00***	***30.15%*** [e]	***gain***
Open Water	191.04	5,913.26	5,722.22	2995.34%	gain
Aquatic Bed Total	1,834.98	868.90	-966.08	-52.65% [f]	loss
Aquatic Bed (undetermined)	0.67	868.90	868.23	130133.33%	
Palustrine Aquatic Beds	0.00	0.00	0.00	0.00%	
Estuarine Aquatic Beds	1,834.31	0.00	NA	NA	
Coral Reefs	0.00	0.00	0.00	0.00%	
Oyster Reefs/Shell Bottom	0.00	0.00	0.00	0.00%	

	NWI82 Acres	NLCD92 Acres	Change 82-92 Acres	Change 82-92 Percent	82-92 Gain/Loss
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	3,185.14	0.00	NA	NA	
Developed	***287.11***	***360.72***	***73.61***	***25.64%***	***gain***
Agriculture	***254.42***	***315.58***	***61.16***	***24.04%***	***gain***
Other Upland	***310.91***	***431.22***	***120.32***	***38.70%***	***gain***
TOTAL	***10,747.68***	***10,747.68***			

Note: The following footnotes indicate an actual total gain/loss of wetlands or open water habitats of at least/most the indicated amount. These numbers look strictly at change to development which is less likely to be misclassified.

[a] Wetlands total loss of at least .42% (19.56 acres)

[b] Emergent wetlands loss of at least 3.84% (2.22 acres)

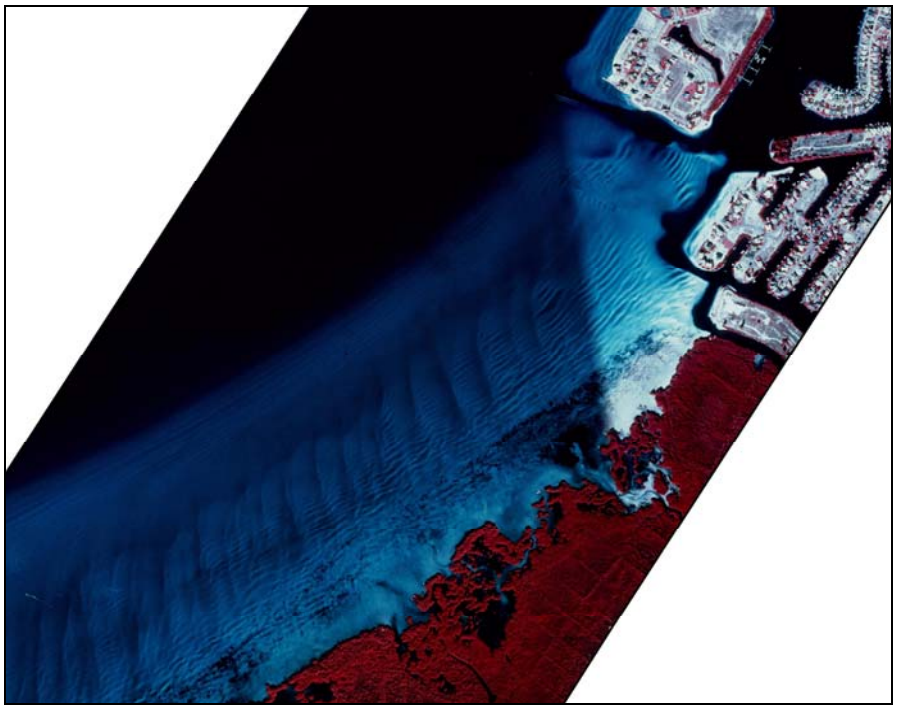
[c] Woody wetlands total loss of at least .31% (8.24 acres)

[d] Natural (non-armored) shoreline loss of at least .47% (9.12 acres)

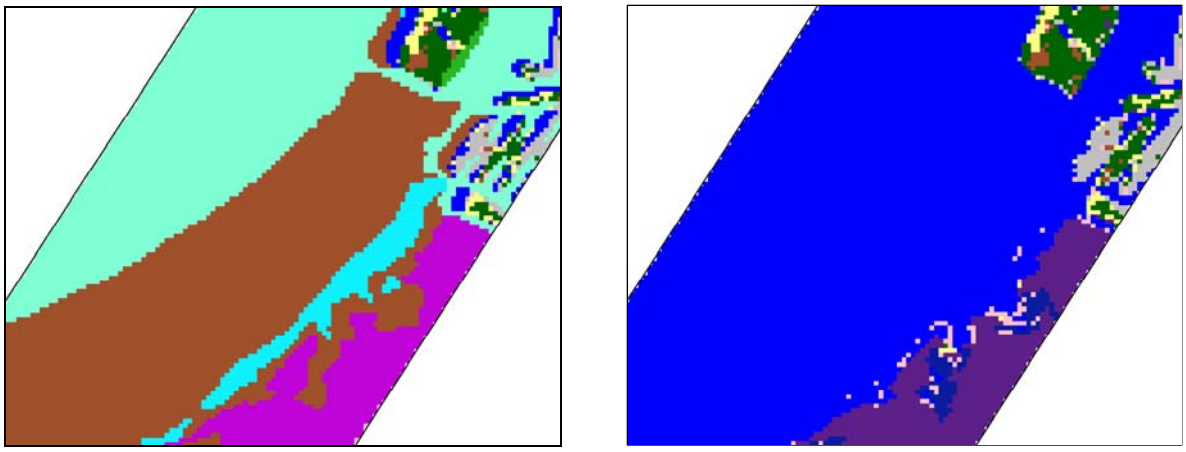
[e] Open water total loss of at least 1.04% (54.04 acres)

[f] Aquatic bed total loss/gain of 0% (0 acres)

The high gain in open water from natural shoreline is likely simply due to a difference in dataset classification, single date imagery for NLCD 1992, and the finer details available in mapping to polygon versus raster datasets. Figure 7-07 shows an example area in which open water from 1992 was mapped as natural shoreline in 1982 NWI data. The brown in Figure 7-07b shows natural shoreline in NWI 1982, while the dark blue of NLCD 1992 shows open water in Figure 7-07c.When excluding the effects that open water and natural shoreline had on each other and determining change based solely on development, natural shoreline actually only has a loss of 9 acres (.46%) and open water shows a 1% loss (54 acres).



(a)



(b) (c)

Figure 7-07. An area of open water as seen in the 2004 DOQQs (a) and mapped in the NWI 1982 (b) and NLCD 1992 (c).

Developed, agricultural, and other uplands would be expected to have increased during the decade but on a much smaller scale than indicated. Considering the level of regulatory oversight during the period and the probable mapping errors noted below, the increase would only be roughly 10% - 20% of that indicated in Table 7-02. An example of improperly attributing wetland conversion to agriculture development appears along the northeastern border of the transect in Figure 7-05 where the wetland conversion to agriculture land portrayed is actually an error confusing open salt marsh habitat on the landward edge of forested wetland (mangroves) with converted land. Otherwise, the very small areas of land converted to various upland categories are probably misidentified polygons.

Table 7-03 also suggests that the overall loss of wetlands proceeded at a relatively slow pace from 1982 to 1992, at a rate of approximately 0.2% per year. All wetlands only lost 19 acres (.42%) to development. With higher resolution imagery and mapping this loss might be determined to have been offset by wetland restoration work in the area of the transect and the expansion of mangroves into shallow open water areas. Figure 7-05 reflects scattered areas of open water conversion to wetlands that are probably a function of higher resolution in the 1992 mapping including smaller mangrove sites but also may represent increasing extent of small mangrove islands.

Table 7-03. Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes from 1982-1992.

Tampa Bay, FL Transect - Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 82-92 Acres**	**Change 82-92 Percent**	**82-92 Gain/Loss**
Wetland Habitats	Developed, Agriculture, Other Upland	101.19		
Developed, Agriculture, Other Upland	Wetland Habitats	0.00		

From	To	Change 82-92 Acres	Change 82-92 Percent	82-92 Gain/Loss
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		-101.19	-2.16%	loss
Open Water Habitats	Developed, Agriculture, Other Upland	153.90		
Developed, Agriculture, Other Upland	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		-153.90	-2.95%	loss
Wetland Habitats	Other Upland	54.04		
Other Upland	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Other Upland		-54.04	-1.15%	loss
Wetland Habitats	Agriculture	27.58		
Agriculture	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Agriculture		-27.58	-0.59%	loss
Wetland Habitats	Developed	19.57		
Developed	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Developed		-19.57	-0.42%	loss
Open Water Habitats	Other Upland	66.27		
Other Upland	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Other Upland		-66.27	-1.27%	loss
Open Water Habitats	Agriculture	33.58		
Agriculture	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Agriculture		-33.58	-0.64%	loss
Open Water Habitats	Developed	54.04		
Developed	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Developed		-54.04	-1.04%	loss

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

In summary, the loss of approximately 3%-4% of woody wetlands from 1982 to 1992 (about 0.3% to 0.4% annually) is the portion of Table 7-02 that most accurately reflects conditions there, based on the mapping datasets made available. The wetland conversion to the three non-wet classes reflected in Table 7-03 represents the variety of types of conversion that has taken place in rapidly developing coastal areas of west Florida, but due to the relatively low level of development activity in this region of Tampa Bay, the numbers are low and if anything, may overstate even this low level of conversion.

Recent (1982 - 1992) Change Summary

The 10-year period between 1982 and 1992 for the Tampa Bay Transect saw a small loss in total open water habitats. The large gain in open water habitat in the data is the result of the difference in classification schemes being compared, as is the increase in natural shoreline. Little change in the extent of open water would be expected although minor conversion to non-wet classes during the period might have occurred and some expansion of mangroves into open water may have taken place as well. The sizeable increases in non-wet classes at the expense of wetlands and open water are probably the lack of detail in mapping, and different methods and schemes used.

Table 7-04. Change matrix representing change in acres between land cover classes from 1982 to 1992. Values in the gray shaded cells are acres of no change.

Tampa Bay, FL Transect Land Cover Change NWI 1982 to NLCD 1992/Seagrass Mapping (by acres)

			1982														
			Wetland Habitats							Open Water Habitats				Non-Wet Land Cover			
			Emergent Wetlands	Woody Wetlands	Shrub-scrub Wetlands	Mangroves	Estuarine Forested Wetlands	Palustrine Forested Wetlands	Natural Non-armored) Shoreline	Open Water	Aquatic Bed	Estuarine Aquatic Beds	Soft Bottom	Developed	Agriculture	Other Upland	Acreage Totals for 1992 Classification
1992	Wetland Habitats	Emergent Wetlands	48.70	0.00	0.44	30.25	0.22	4.00	39.81	0.00	0.00	59.60	36.03	0.00	0.00	0.00	219.06
		Woody Wetlands	3.78	66.05	31.14	2,253.53	4.89	72.06	71.17	0.00	0.00	62.72	38.03	0.00	0.00	0.00	2,603.35
		Natural (Non-armored) Shoreline	0.00	0.00	0.00	0.00	0.44	0.00	30.91	0.00	0.00	0.00	4.23	0.00	0.00	0.00	35.58
	Open Water Habitats	Open Water	2.67	0.00	0.00	137.00	0.67	0.00	1,646.61	191.04	0.00	1,007.23	2,928.05	0.00	0.00	0.00	5,913.26
		Aquatic Bed	0.00	0.00	0.00	48.04	0.00	0.00	90.51	0.00	0.67	694.09	35.58	0.00	0.00	0.00	868.90
	Non-Wet Land Cover	Developed	2.22	0.00	1.11	6.67	0.22	0.22	9.12	0.00	0.00	0.00	54.04	287.11	0.00	0.00	360.72
		Agriculture	0.22	0.00	0.44	11.79	0.67	0.67	13.79	0.00	0.00	4.67	28.91	0.00	254.42	0.00	315.58
		Other Upland	0.22	0.00	0.89	18.68	7.34	2.45	24.46	0.00	0.00	6.00	60.27	0.00	0.00	310.91	431.22
		Acreage Totals for 1982 Classification	57.82	66.05	34.03	2,505.95	14.46	79.39	1,926.38	191.04	0.67	1,834.31	3,185.14	287.11	254.42	310.91	**10,747.68**

This table presents estimates of acreage by classification and the number of acres that changed classification between the two dates. The data shows the numbers of acres that have changed from the 1982 date to the 1992 date. The table reads down (1982/from) and to the left (1992/to).

Historical Transect Maps

Figure 7-08 shows a mosaic of the 1957 aerial photos of the Tampa Bay, FL transect. The 1957 aerial photography was used to classify land cover for the historic time period.

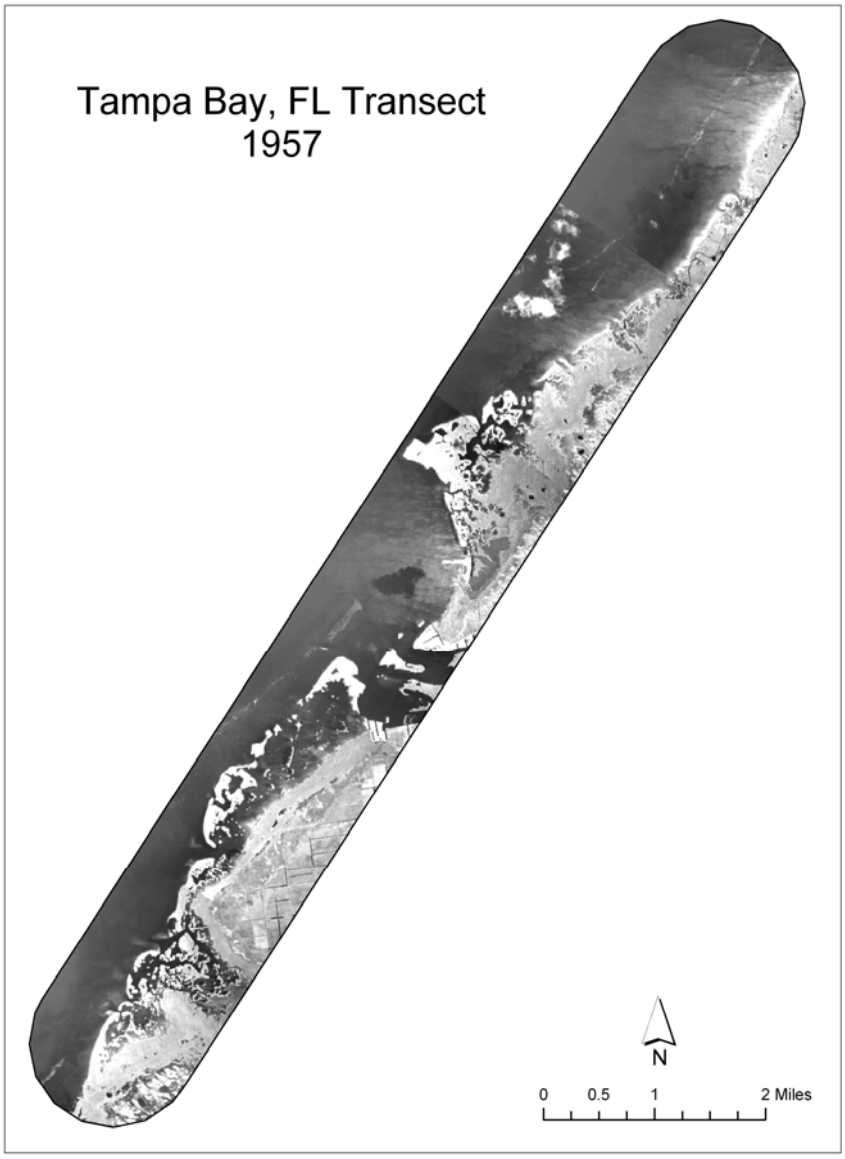


Figure 7-08. 1957 aerial photos of Tampa Bay, FL transect.

Figures 7-09 and 7-10 depict the changes in wetland habitats and open water habitats from 1957 to 1992 respectively. The wetlands change map shows areas that changed from wetland to non-wetland classes and non-wetland to wetland classes. Similarly, the open water change map displays open water to non-open water classes and non-open water to open-water classes. These maps are helpful in determining where wetlands and open water habitat changes occurred and which classes they changed between.

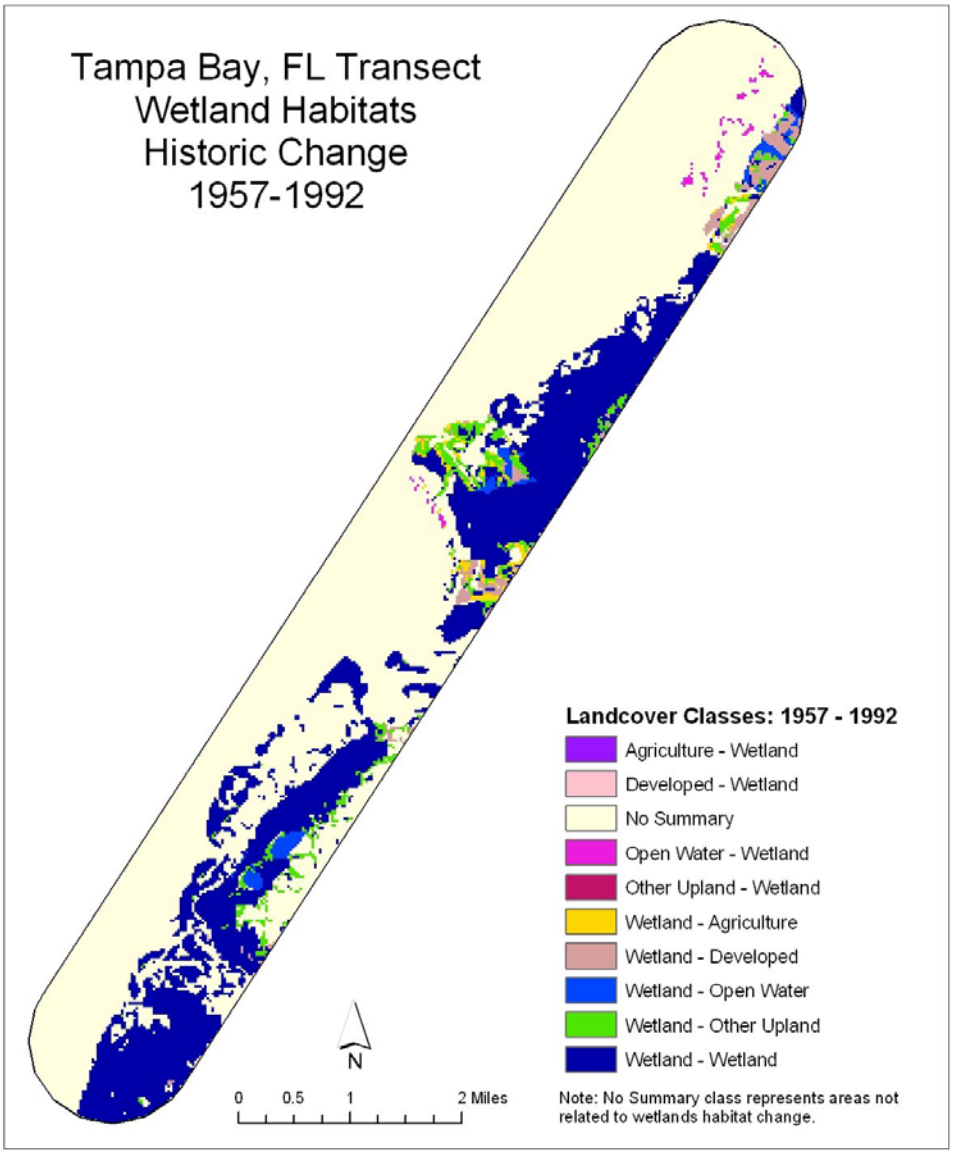


Figure 7-09. Wetland habitats change from 1957-1992, Tampa Bay, FL transect

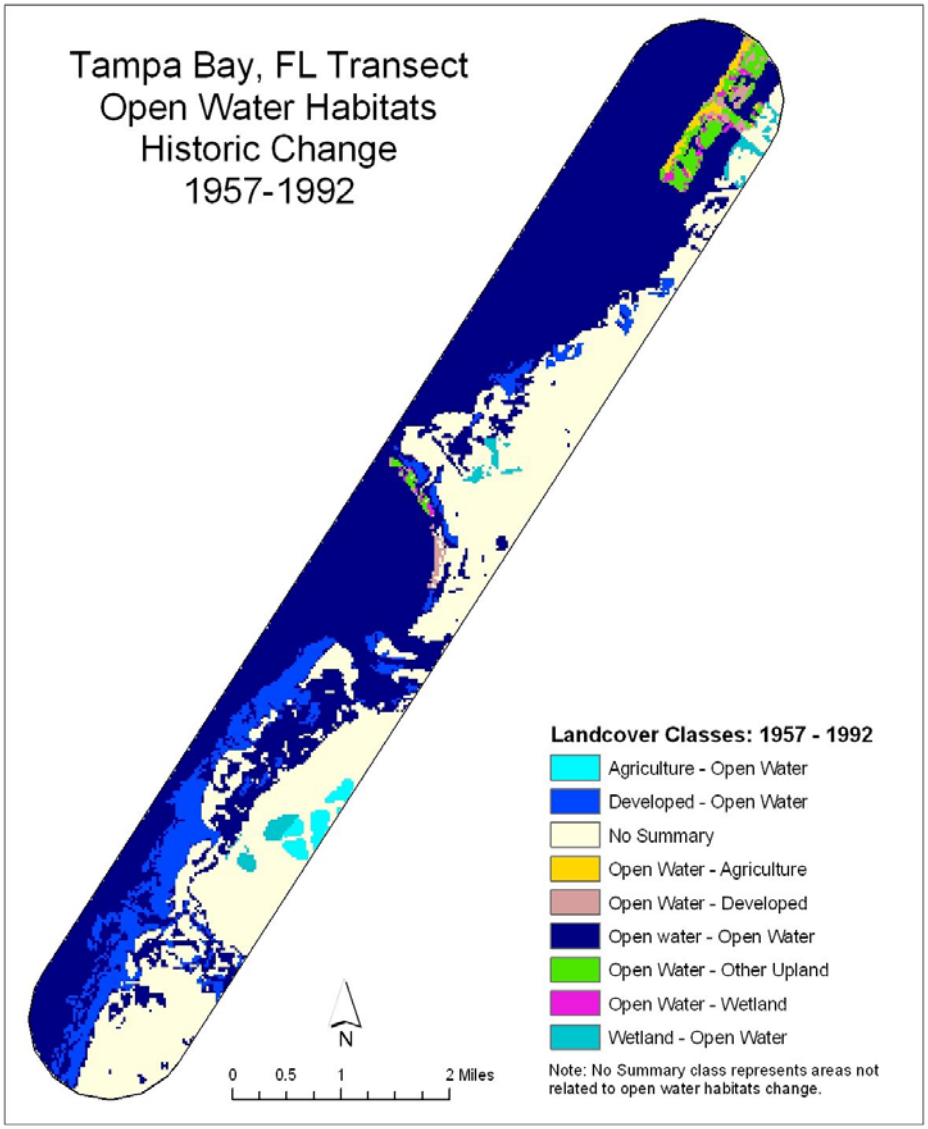


Figure 7-10. Open water habitats change from 1957-1992, Tampa Bay, FL transect.

Historical (1957 – 1992) Change Tables

Although the 1992 NLCD coverage did not map out mangrove classes specifically for comparison, aerial interpretation and knowledge from the NWI 1982 dataset of the location of mangroves helped delineation of the mangrove areas in the 1957 photos. Overall, wetlands classes, in particular woody wetlands (including mangroves), sustained a fairly substantial loss within this transect. The overall wetland loss, primarily from two large dredge and fill developed sites -- a community park and marina development centrally located in Figure 7-04 and the community of Apollo Beach at the north end of the transect. Apollo Beach is a classic Florida canal dredge and fill residential and commercial development located directly on the coast and created at the expense of open water habitats and coastal wetlands. Filling of wetlands created the residential development on the north side of the mouth of the Little Manatee River in the transect.

Table 7-05. Acreage and percent change of land cover classes from 1957-1992. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

Tampa Bay, FL Transect - Dataset Acreage and Change by Land Cover Classes					
	HIST57 Acres	NLCD92 Acres	Change 57-92 Acres	Change 57-92 Percent	57-92 Gain/Loss
Wetlands Total	***3,455.79***	***2,839.09***	***-616.70***	***-17.85%*** [a]	***loss***
Emergent Wetlands	191.70	175.47	-16.23	-8.47% [b]	loss
Woody Wetlands Total	3,241.18	2,628.26	-612.92	-18.91% [c]	loss
Woody Wetlands (undetermined)	722.56	2,628.26	1,905.70	263.74%	gain
Shrub-scrub Wetlands	61.38	0.00	NA	NA	
Mangroves	2,457.24	0.00	NA	NA	
Estuarine Forested Wetlands	0.00	0.00	0.00	0.00%	
Palustrine Forested Wetlands	0.00	0.00	0.00	0.00%	
Natural (non-armored) Shoreline	22.91	35.36	12.45	54.37% [d]	gain
Open Water Total	***6,957.18***	***6,826.86***	***-130.32***	***-1.87%*** [e]	***loss***
Open Water	6,079.39	5,949.06	-130.32	-2.14%	loss
Aquatic Bed Total	877.79	877.79	0.00	0.00% [f]	
Aquatic Bed (undetermined)	877.79	877.79	0.00	0.00%	
Palustrine Aquatic Beds	0.00	0.00	0.00	0.00%	
Estuarine Aquatic Beds	0.00	0.00	0.00	0.00%	
Coral Reefs	0.00	0.00	0.00	0.00%	
Oyster Reefs/Shell Bottom	0.00	0.00	0.00	0.00%	
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	0.00	0.00	0.00	0.00%	
Developed	***34.25***	***355.83***	***321.58***	***938.96%***	***gain***
Agriculture	***300.23***	***284.44***	***-15.79***	***-5.26%***	***gain***
Other Upland	***0.22***	***441.45***	***441.23***	***198400.00%***	***gain***
TOTAL	***10,747.68***	***10,747.68***			

Note: The following footnotes indicate an actual total gain/loss of wetlands or open water habitats of at least/most the indicated amount. These numbers look strictly at change to development which is less likely to be misclassified.

[a] Wetlands total loss of at least 5.47% (189.04 acres)

[b] Emergent wetlands loss/gain of 0% (0 acres)

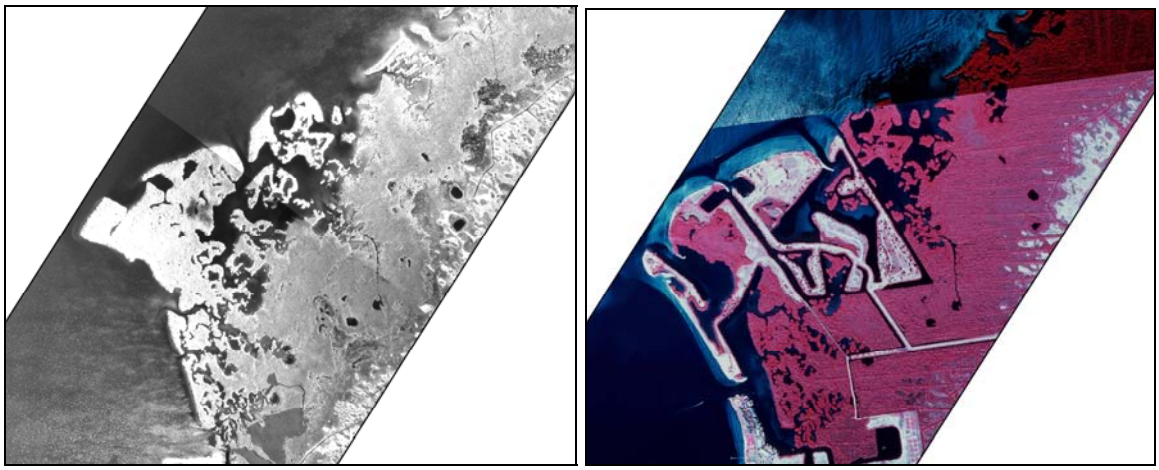
[c] Woody wetlands total loss of at least 5.371% (174 acres)

[d] Natural (non-armored) shoreline loss of at least 60.19% (13.79 acres)

[e] Open water total loss of at least 1.18% (82.06 acres)

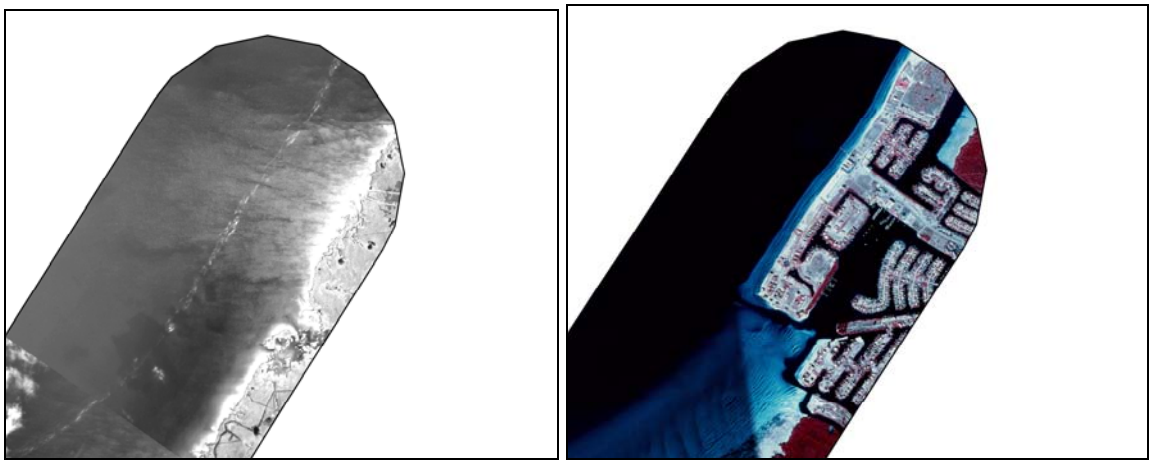
[f] Aquatic bed total loss/gain of 0% (0 acres)

Other upland, mostly associated with the two dredge and fill sites, gained 100% of its acreage from either wetland or open water habitats in this historical change analysis (Table 7-07). Figure 7-11 shows areas of wetlands loss to other upland and development at a community park (E.G. Simmons County Park) in the central shoreline of the transect. Some development at the site appears in the 1957 imagery. Open water classes showed a 1% loss, 82 acres to development, mainly in the northern portion of the transect where Apollo Beach was created through the conversion of wetlands and open waters (Tables 7-05 and 7-06). Figure 7-12a and 7-12b provide an aerial view of this section of the transect and Apollo Beach in 1957 and most recently in 2004.



(a) (b)

Figure 7-11. An area of wetlands loss to other upland classes and development. The wetlands shown in the 1957 aerial photography (a) are Other Upland and Developed in the 2004 DOQQs (b).



(a) (b)

Figure 7-12. An area of Open Water loss to Developed. The Open Water in the 1957 aerial photography (a) is a marina – Developed – in the 2004 DOQQs (b).

Table 7-06. Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes from 1957-1992.

Tampa Bay, FL Transect - Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 57-92 Acres**	**Change 57-92 Percent**	**57-92 Gain/Loss**
Wetland Habitats	Developed, Agriculture, Other Upland	545.31		
Developed, Agriculture, Other Upland	Wetland Habitats	0.00		

From	To	Change 57-92 Acres	Change 57-92 Percent	57-92 Gain/Loss
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		-545.31	-15.78%	loss
Open Water Habitats	Developed, Agriculture, Other Upland	287.33		
Developed, Agriculture, Other Upland	Open Water Habitats	85.62		
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		-201.71	-2.90%	loss
Wetland Habitats	Other Upland	281.33		
Other Upland	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Other Upland		-281.33	-8.14%	loss
Wetland Habitats	Agriculture	74.95		
Agriculture	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Agriculture		-74.95	-2.17%	loss
Wetland Habitats	Developed	189.04		
Developed	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Developed		-189.04	-5.47%	loss
Open Water Habitats	Other Upland	156.12		
Other Upland	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Other Upland		-156.12	-2.24%	loss
Open Water Habitats	Agriculture	49.15		
Agriculture	Open Water Habitats	85.62		
Open Water Habitats Gain/Loss to Agriculture		36.47	0.52%	gain
Open Water Habitats	Developed	82.06		
Developed	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Developed		-82.06	-1.18%	loss

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

A gain in acreage of natural shoreline is reported in Table 7-05 as opposed to a predicted loss resulting from historic dredge and fill at the two main areas of conversion noted above. Table 7-05 properly documents a loss of wetlands generally and emergent and woody wetlands specifically. The same aquatic beds class totals for the two dates appear to be an artifact of application of the class scheme as opposed to actual mapping details. The overall gain of upland classes presented in Table 7-05 appears reasonable and consistent with wetland and open water conversion acreage figures presented.

Historical (1957 – 1992) Change Summary

The overall loss of wetlands from 1957 to 1992 is reported as about 616 acres, or about 18% of the transect total. This is an annual rate of loss for the period of about 0.5% per year. The loss of wetlands to uplands was reported as 545 acres. The major part of wetland loss during the period occurred at two large areas of dredging and filling in wetland and open water habitats -- at one site to create a large community park. The other large development sites converted wetlands to commercial and residential development on filled land with water access and dredged canals and basins. Overall, the transect

suffered wetland conversion at a considerably lower rate than other Tampa Bay shoreline wetland areas, and considerably slower than those that occurred along the central west coast of Florida. Just over 200 acres of open water acreage was reported converted to non-wet classes, much of it undoubtedly at the large development sites in the transect.

Table 7-07. Change matrix representing change in acres between land cover classes from 1957 to 1992. Values in the gray shaded cells are acres of no change.

Tampa Bay, FL Land Cover Change Aerial Photos 1957 to NLCD 1992 (by acres)

			1957										
			Wetland Habitats					Open Water Habitats		Non-Wet Land Cover			
			Emergent Wetlands	Woody Wetlands	Shrub-scrub Wetlands	Mangroves	Natural (Non-armored) Shoreline	Open Water	Aquatic Bed	Developed	Agriculture	Other Upland	Acreage Totals for 1992 Classification
1992	Wetland Habitats	Emergent Wetlands	163.46	0.00	0.00	0.00	0.89	11.12	0.00	0.00	0.00	0.00	175.47
		Woody Wetlands	0.00	556.65	0.00	2,069.61	0.00	2.00	0.00	0.00	0.00	0.00	2,628.26
		Natural (Non-armored) Shoreline	0.00	0.00	0.00	5.78	5.56	24.02	0.00	0.00	0.00	0.00	35.36
	Open Water Habitats	Open Water	0.00	45.15	0.00	63.38	0.00	5,754.91	0.00	0.00	85.62	0.00	5,949.06
		Aquatic Bed	0.00	0.00	0.00	0.00	0.00	0.00	877.79	0.00	0.00	0.00	877.79
	Non-Wet Land Cover	Developed	0.00	19.57	33.14	122.54	13.79	82.06	0.00	30.47	54.26	0.00	355.83
		Agriculture	0.00	0.89	28.24	45.37	0.44	49.15	0.00	0.00	160.35	0.00	284.44
		Other Upland	28.24	100.30	0.00	150.56	2.22	156.12	0.00	3.78	0.00	0.22	441.45
		Acreage Totals for 1957 Classification	191.70	722.56	61.38	2,457.24	22.91	6,079.39	877.79	34.25	300.23	0.22	**10,747.68**

This table presents estimates of acreage by classification and the number of acres that changed classification between the two dates. The data shows the numbers of acres that have changed from the 1957 date to the 1992 date. The table reads down (1957/from) and to the left (1992/to).

Section 7.4 CAF Change Summary (1957 – 2004)

A summary of estimated habitat and other land cover change within the Gulf Coast CAF region for the period 1957 to 2004 is shown in Table 7-08. The table shows actual measured acres lost and gained for the transect at Tampa Bay for both the historical and recent time periods. In addition, the percent of acres lost and gained for the transect is shown. These specific transect data were used in conjunction with regional information regarding the CAF, to develop estimates for habitat change within the CAF as a whole.

In general, the change data from the Tampa transect does a reasonable job of predicting historical wetland changes within the CAF region; however, changes over the more recent time period from 1992 to 2004 are not represented well by the Tampa transect. This is primarily due to classification issues and errors within the different data sets for the Tampa region. Losses in emergent wetlands were estimated to be 17 to 40% for the historical time period, with roughly 7 to 15% of the loss occurring during the more recent time period. The reduction was based on stricter regulatory controls within the Gulf Coast states that have started to curb the destruction of emergent wetlands, as well as a number of wetland restoration programs that have been successful in increasing the areal extent of emergent wetlands. The losses estimated for the Gulf Coast CAF represent some of the highest losses for the country, primarily resulting from altered hydrodynamic flow caused by a navigation and flood control project; reduced sediment supply; subsidence due to oil, gas and fresh water extraction; dredge and fill operations; and development.

Woody wetland totals were also estimated to have declined significantly within the Gulf Coast CAF, losing 19 to 36% over the historical time period and 9 to 16% during the more recent time period. These losses have occurred primarily in the bottomland hardwood forests of the alluvial plains and swamp areas. Much of the loss in woody wetlands can be attributed to agricultural conversion, silviculture, and urbanization. Mangrove losses, primarily to the south of Tampa, were estimated to be on the order of 5 to 10% over the historic time period, and 4 to 8% over the 12-year period from 1992 to 2004. Losses in mangrove resources have been attributed mainly to commercial and residential development; however, some of these losses have also been offset by the creation of suitable mangrove habitat on tidal flats and around dredge spoil islands. Natural non-armored shoreline areas within the CAF were estimated to have been reduced by 14 to 32% over the historical time period, with 7 to 17% of the loss occurring more recently. These losses have been the highest along the barrier island and headland shorelines associated with the Mississippi delta, and along the barriers in Texas. Changes around the highly dynamic tidal inlets have also resulted in losses to natural (non-armored) shorelines.

Changes in open water habitats for the Gulf Coast CAF region were estimated to be significantly different than in the Tampa Bay transect for both the historical and recent time periods. The Tampa Bay transect shows a switch from losses in open water habitats during the historic time period to large gains in open water habitat over the recent time period. In contrast to this, open water habitat for the entire Gulf Coast CAF was actually estimated to have increased by approximately 8 to 16% over the historical time period,

with 5 to 11% of the gain occurring in the recent period. These gains are primarily the result of subsidence in the western portion of the CAF due to oil, gas and fresh water extraction, coupled with reduced sediment supply caused by damming and flood water diversion projects. The end result has been an increase in open water habitats, as the tidal flat and emergent wetland areas have been reduced in size and lowered in elevation. Aquatic bed habitats were estimated to have losses of 5 to 10% over the historical time period. These losses are primarily the result of reductions in inland palustrine aquatic beds caused by increased development pressures and agriculture.

Finally, for the non-wet land cover classes, changes in the Tampa Bay transect were most useful in determining changes for the CAF region during the recent (1992-2004) time period, and not for the historical (1957-2004) time period. Historical percentages of change computed from the Tampa Bay transect are skewed by the data resolution and classification differences, and could not be used as a guide for the Gulf Coast CAF during the period. As such, historic non-wet land cover values prepared for the Gulf Coast CAF were based primarily on relative comparisons with adjacent CAF regions and information presented in the CAF description. Developed lands were estimated to have increased by 56 to 81% over the historic time period, with 36 to 56% of the gain occurring over the recent time period. The surge in development within coastal Florida, New Orleans/Baton Rouge, and the Houston/Galveston area has driven the overall increase in development over the recent time period. Agricultural lands were also estimated to have increased, ranging from 8 to 23% over the historical time period and 5 to 16% over the more recent time period. An increase in agriculture within the Gulf Coast CAF has been one of the factors responsible for wetland loss.

Table 7-08. Estimated target habitat group and land cover change from 1957-2004 for the Gulf Coast CAF region based on local expert analysis of recent and historic habitat change of the Tampa Bay, FL transect. Estimated acreages were calculated using estimated percent change in conjunction with the NLCD 1992 acres for each target habitat group and land cover type (Table 7-01). Also see Appendix C, Tables 13-04i – 04j for further detailed acreage values.

		Tampa Bay, FL Transect				Gulf Coast CAF Region			
		1957-1992 Historic Acres Gain/Loss	1957-1992 Historic Percent Gain/Loss	1982-1992 Recent Acres Gain/Loss	1982-1992 Recent Percent Gain/Loss	Historic 1957 to 2004 Estimated Acres Gain/Loss	Historic 1957 to 2004 Estimated Percent Gain/Loss	Recent 1992 to 2004 Estimated Acres Gain/Loss	Recent 1992 to 2004 Estimated Percent Gain/Loss
Wetland Habitats	***Wetlands Total[1]***	***-616.70***	***-17.85%***	***-1,826.08***	***-38.98%***	***-2,797,161 to -6,865,489***	***-18% to -38%***	***-1,259,362 to -2,800,397***	***-8% to -16%***
Wetland Habitats	Emergent Wetlands	-16.23	-8.47%	161.24	278.85%	-1,291,423 to -3,655,179	-17% to -40%	-548,277 to -1,370,692	-7% to -15%
Wetland Habitats	Woody Wetlands Total[2]	-612.92	-18.91%	-96.52	-3.57%	-1,469,369 to -3,132,076	-19% to -36%	-696,017 to -1,392,034	-9% to -16%
Wetland Habitats	Woody Wetlands (undetermined)*	no data	no data	no data	no data	no data	no data	no data	no data
Wetland Habitats	Shrub-scrub Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
Wetland Habitats	Mangroves	no data	no data	no data	no data	no data	-5% to -10%	no data	no data
Wetland Habitats	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
Wetland Habitats	Palustrine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
Wetland Habitats	Natural (non-armored) Shoreline	12.45	54.37%	-1,890.80	-98.15%	-28,209 to -70,910	-14% to -32%	-15,068 to -37,671	-7% to -17%
Open Water Habitats	***Open Water Total[3]***	***-130.32***	***-1.87%***	***1,571.00***	***30.15%***	***170,565 to 332,728***	***8% to 16%***	***109,649 to 219,298***	***5% to 11%***
Open Water Habitats	Open Water	-130.32	-2.14%	no data	no data	no data	no data	no data	no data
Open Water Habitats	Aquatic Bed Total[4]	0.00	0.00%	-966.08	-52.65%	no data	-5% to -10%	no data	no data
Open Water Habitats	Aquatic Bed (undetermined)**	no data	no data	no data	no data	no data	no data	no data	no data
Open Water Habitats	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
Open Water Habitats	Estuarine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
Open Water Habitats	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
Open Water Habitats	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Open Water Habitats	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Open Water Habitats	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***321.58***	***938.96%***	***73.61***	***25.64%***	***1,310,344 to 1,822,020***	***56% to 81%***	***842,364 to 1,263,546***	***36% to 56%***
Non Wet	***Agriculture***	***-15.79***	***-5.26%***	***61.16***	***24.04%***	***1,116,583 to 3,087,138***	***8% to 23%***	***717,803 to 2,153,410***	***5% to 16%***
Non Wet	***Other Upland***	***441.23***	***198400.00%***	***120.32***	***38.70%***	***2,011,455 to -1,849,241***	***8% to -7%***	***1,293,078 to -1,293,078***	***5% to -5%***

1 "Emergent Wetlands", "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", "Palustrine Forested Wetlands", and "Natural (non-armored) Shoreline" have been summarized in "Wetlands Total".
2 "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", and Palustrine Forested Wetlands" have summarized in "Woody Wetlands Total".
3 "Aquatic Beds", Palustrine Aquatic Beds", Estuarine Aquatic Beds", "Coral Reefs", "Oyster Reefs/Shell Bottom", "Hard Bottom" and "Soft Bottom" have been summarized in "Open Water Total".
4 "Aquatic Beds", "Palustrine Aquatic Beds", and "Estuarine Aquatic Beds" have been summarized in "Aquatic Bed Total".
* "Woody Wetlands (undetermined)" includes wetlands not specifically identified by system (palustrine, estuarine, etc.) and/or type of woody vegetation (shrub-scrub, forested, etc.).
** "Aquatic Bed (undetermined)" includes aquatic beds not specifically identified by system (palustrine, estuarine, etc.).

Section 8.0 Pacific Coast CAF

Section 8.1 CAF Description

The Pacific Coast CAF Region is approximately 40,710,579 acres in size, and includes parts of three states: Washington, Oregon, and California. In some areas, most notably along the Columbia River and the western foothills of the Cascade Mountains, the CAF Region extends as far as 140 miles inland, and as such encompasses a broad range of wetland types. Elevation within the Pacific Coast CAF Region ranges from sea level to approximately 1000 feet above sea level. With its broad latitudinal range, the region supports a diverse assemblage of ecosystems, from the arid coastal chaparral of southern California to the cool, mesic conifer forests of Washington and Oregon. Approximately 14% of the region is composed of densely populated regions, and urban areas account for 2,014,770 acres, slightly less than 5% of total land area. Major urban areas include Seattle-Tacoma (Washington), Portland (Oregon), San Francisco-Oakland (California), Los Angeles (California), and San Diego (California). Federal land ownership, particularly through the U.S. Forest Service and the Bureau of Land Management, is extensive: the federal government owns 12,313,933 acres, or approximately 30.25% of land area in the Pacific Coast CAF Region. Human population growth from 1990 to 2000 was approximately 14%, increasing from 26,458,165 persons to 30,278,155 persons ((ESRI, 2000 and ESRI, 2002).

Assessment of West Coast wetlands condition has been done most recently as part of the National Coastal Condition Report II (EPA 2004) and the National Wetlands Inventory in 2002. The NWI reported a loss of 1,720 acres of estuarine wetlands, which translates to a rate of 0.54%. The long-term rate of loss is 3.4%. These wetland loss estimates do not include the amount of wetlands that have been lost due to shoreline alteration. A survey for the Puget Sound Nearshore Area completed in 2000 found that at that time 33% of saltwater shorelines in the state had been armored with bulkhead or riprap (Puget Sound Water Quality Action Team, 2002).

Section 8.2 Recent (1992) Land Cover Data Summary

Figure 8-01 shows the mapped land cover classes for the Pacific CAF region. The data was based on the 1992 USGS National Land Cover Dataset (NLCD).

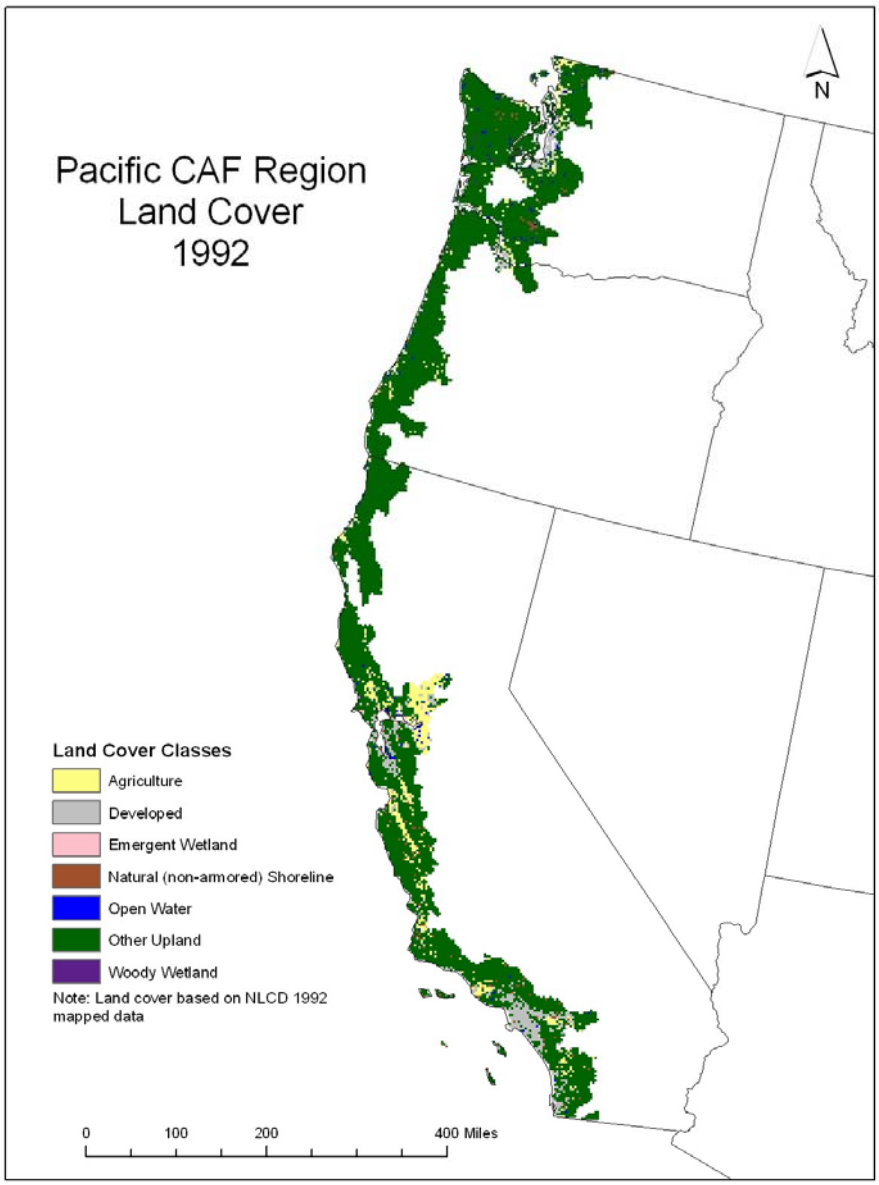


Figure 8-01. Pacific CAF Region land cover classes, 1992.

Rough estimates of total area of land cover, based on the 1992 NLCD classification and C-CAP 2000, are presented in Table 8-01. Table 8-01 also contains acreage and percent change for the target habitat types for the C-CAP data as well as percent change between 1992 and 2000.

The change in wetland habitats between 1992 and 2000 C-CAP datasets represents a 44% gain (319,198 acres). Roughly 165,000 came from other upland and an estimated 618,000 was classified from agriculture (Table 8-02). Given the extreme percentage of gain for wetlands, but an actual loss of wetlands to development (~15,000 acres), this tends to point to a variation in datasets classification techniques rather than an actual gain of wetlands. Based on change to development, wetlands overall lost 2% of it's acreage between 1992 and 2000.

Natural shoreline also experienced a high level of loss. This loss was largely to the other upland class. Loss of natural shoreline due to development was 45,870 acres (8.7%). This change from 1992 to 2000 likely presents a much more reasonable estimate of loss.

Open water habitats experienced a fair amount of loss to development, other upland, and agriculture classes, but another large percentage comes from change to emergent and natural shoreline which might be more representative of natural successional change and/or imagery dates of each classification.

Table 8-01. Acreage and percent change of land cover classes from 1992-2000. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

Pacific CAF Region - Dataset Acreage and Change by Land Cover Classes					
	NLCD92 Acres	C-CAP00 Acres	Change 92-00 Percent	Change 92-00 Percent	92-00 Gain/Loss
Wetlands Total	***713,027.02***	***1,030,253.70***	***317,226.68***	***44.49%*** [a]	***gain***
Emergent Wetlands	101,806.33	366,329.58	264,523.25	259.83% [b]	gain
Woody Wetlands Total	85,144.91	592,752.35	507,607.43	596.17% [c]	gain
Woody Wetlands (undetermined)	85,144.91	0.00	-85,144.91	-100.00%	
Shrub-scrub Wetlands	0.00	275,125.36	NA	NA	
Mangroves	0.00	0.00	0.00	0.00%	
Estuarine Forested Wetlands	0.00	400.31	NA	NA	
Palustrine Forested Wetlands	0.00	317,226.68	NA	NA	
Natural (non-armored) Shoreline	526,075.78	71,171.78	-454,904.00	-86.47% [d]	loss
Open Water Total	***397,510.10***	***350,921.79***	***-46,588.31***	***-11.72%*** [e]	***loss***
Open Water	397,510.10	348,989.42	-48,520.67	-12.21%	loss
Aquatic Bed Total	0.00	1,932.37	NA	NA	
Aquatic Bed (undetermined)	0.00	0.00	0.00	0.00%	
Palustrine Aquatic Beds	0.00	707.65	NA	NA	
Estuarine Aquatic Beds	0.00	1,224.71	NA	NA	
Coral Reefs	0.00	0.00	0.00	0.00%	
Oyster Reefs/Shell Bottom	0.00	0.00	0.00	0.00%	
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	0.00	0.00	0.00	0.00%	
Developed	***2,675,305.72***	***2,880,160.44***	***204,854.71***	***7.66%***	***gain***
Agriculture	***3,313,632.04***	***1,621,125.27***	***-1,692,506.77***	***-51.08%***	***loss***
Other Upland	***33,376,239.98***	***34,593,253.66***	***1,217,013.68***	***3.65%***	***gain***
TOTAL	***40,475,714.87***	***40,475,714.87***			

Note: The following footnotes indicate an actual total gain/loss of wetlands or open water habitats of at least/most the indicated amount. These numbers look strictly at change to development which is less likely to be misclassified.

[a] Wetlands total loss of at least 2.18% (15541.89 acres)

[b] Emergent wetlands loss of at least 13.03% (13267.48 acres)

[c] Woody wetlands total gain of at most 20.04% (17,060 acres)

[d] Natural (non-armored) shoreline loss of at least 8.72% (45,870 acres)

[e] Open water total loss of at least 0.35% (1,411 acres)

The potential causes for loss in habitat can be further examined by looking at Table 8-02, which includes percentages of change in wetland and open water habitats due to conversion to development, agriculture, and/or other upland.

Table 8-02. Percent of Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes from 1992-2000.

Pacific CAF Region - Percent of Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 92-00 Acres**	**Change 92-00 Percent**	**92-00 Gain/Loss**
Wetland Habitats	Developed, Agriculture, Other Upland	543,269.38		
Developed, Agriculture, Other Upland	Wetland Habitats	807,737.48		
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		264,468.10	37.06%	gain
Open Water Habitats	Developed, Agriculture, Other Upland	52,757.25		
Developed, Agriculture, Other Upland	Open Water Habitats	58,927.52		
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		6,170.28	1.55%	gain
Wetland Habitats	Other Upland	471,160.88		
Other Upland	Wetland Habitats	636,499.37		
Wetland Habitats Gain/Loss to Other Upland		165,338.48	23.17%	gain
Wetland Habitats	Agriculture	18,192.14		
Agriculture	Wetland Habitats	636,499.37		
Wetland Habitats Gain/Loss to Agriculture		618,307.23	86.64%	gain
Wetland Habitats	Developed	53,916.36		
Developed	Wetland Habitats	38,374.47		
Wetland Habitats Gain/Loss to Developed		-15,541.89	-2.18%	loss
Open Water Habitats	Other Upland	44,100.18		
Other Upland	Open Water Habitats	42,061.07		
Open Water Habitats Gain/Loss to Other Upland		-2,039.12	-0.51%	loss
Open Water Habitats	Agriculture	2,827.94		
Agriculture	Open Water Habitats	12,448.41		
Open Water Habitats Gain/Loss to Agriculture		9,620.47	2.41%	gain
Open Water Habitats	Developed	5,829.13		
Developed	Open Water Habitats	4,418.05		
Open Water Habitats Gain/Loss to Developed		-1,411.08	-0.35%	loss

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

A more detailed breakdown of changes in land cover classes between 1992 and 2000 for the Pacific CAF region can be seen in Table 8-03. This table shows the distribution and change in number of acres for each land cover class between 1992 and 2000. The table also shows the number of acres that remained unchanged for each land cover class over the recent eight-year period. These data support the findings from Table 8-02.

Table 8-03. Change matrix representing change in acres between land cover classes from 1992 to 2000. Values in the gray shaded cells are acres of no change.

Pacific CAF Region Land Cover Change NLCD 1992 to C-CAP 2000 (by acres)										
		1992								
			Wetland Habitats			Open Water Habitats	Non-Wet Land Cover			
			Emergent Wetlands	Woody Wetlands	Natural Non-armored) Shoreline	Open Water	Developed	Agriculture	Other Upland	Acreage Totals for 2000 Classification
2000	Wetland Habitats	Emergent Wetlands	51,710.00	11,845.73	18,368.72	34,335.16	15,925.29	72,196.12	161,948.56	366,329.58
		Shrub-scrub Wetlands	6,801.65	17,868.78	4,730.73	7,645.63	10,429.98	34,478.60	193,170.00	275,125.36
		Estuarine Forested Wetlands	30.25	3.11	15.12	59.82	41.59	39.14	211.27	400.31
		Palustrine Forested Wetlands	3,848.50	17,803.84	1,302.77	5,086.78	7,630.95	23,445.49	258,108.34	317,226.68
		Natural (Non-armored) Shoreline	474.59	688.53	18,097.18	21,799.34	4,346.66	2,704.29	23,061.20	71,171.78
	Open Water Habitats	Open Water	3,748.87	1,579.88	10,685.06	274,740.18	4,384.47	12,397.26	41,453.71	348,989.42
		Palustrine Aquatic Beds	2.89	19.35	6.23	382.74	24.24	17.57	254.64	707.65
		Estuarine Aquatic Beds	15.12	42.48	68.27	703.20	9.34	33.58	352.71	1,224.71
	Non-Wet Land Cover	Developed	2,657.81	1,041.69	50,216.86	5,829.13	1,962,458.39	176,375.59	681,580.97	2,880,160.44
		Agriculture	3,223.13	1,767.13	13,201.88	2,827.94	24,057.07	1,368,685.94	207,362.19	1,621,125.27
		Other Upland	29,293.52	32,484.41	409,382.96	44,100.18	645,997.74	1,623,258.46	31,808,736.39	34,593,253.66
		Acreage Totals for 1992 Classification	101,806.33	85,144.91	526,075.78	397,510.10	2,675,305.72	3,313,632.04	33,376,239.98	**40,475,714.87**

This table presents estimates of acreage by classification and the number of acres that changed classification between the two dates. The data shows the numbers of acres that have changed from the 1992 date to the 2000 date. The table reads down (1992/from) and to the left (2000/to).

Section 8.3 Transect Analysis Results

Section 8.3.1 Columbia River, OR Transect

Transect Location

The location of the Columbia River, OR-WA transect within the Pacific CAF region is illustrated in Figure 8-02. The placement of the transect can be seen in more detail in Figure 8-03. Overall, the Columbia River transect provides a reasonable estimate of wetland conditions in the large estuarine systems of the Pacific Northwest. But it may not perform as well in describing the status and trends of wetlands in the smaller estuaries and coastal systems in the region. For example, river-mouth estuaries closer to the ocean and further from large inland cities experience different ecological pressures (for example, salinity) and are likely subject to different development pressures and agricultural practices. Thus, although the transect probably provides a reasonable estimate of conditions for large estuaries such as the Tillamook and the Columbia, it may not adequately capture the situation in smaller estuaries such as the Siletz River of Oregon or the Stillaguamish River of Washington.

Because patterns of wetland change observed on each transect are the basis for making region-wide interpretations about the status of wetland habitats, it is critical to evaluate potential sources of discrepancy between the transect and the region. Most of the wetland habitats typical of the CAF region are represented within the Columbia River transect. Freshwater wetlands are probably overrepresented since the transect is well inland from the Oregon/Washington coastline. This transect may also underestimate the extent of wetland loss within the CAF region due to a number of features found in the transect that are not found in the region as a whole. First, some of the transect falls within the Columbian White-tailed Deer National Wildlife Refuge (CWTDNWR); wetlands within the refuge are largely protected from anthropogenic change. Second, population growth has been relatively stable in the area surrounding the Columbia River transect, due in part to urban growth boundaries mandated by the State of Oregon that have limited urban sprawl and development around Portland. Indeed, all of the small towns present in and around the transect have experienced only small increases in population relative to the rest of the region. For example, the number of housing units in Clatsop County, the Oregon county containing much of the transect, have increased by only 44% since 1950; in contrast, Clackamas County, another suburban county outside of Portland, has witnessed a nearly 600% increase in housing units over the same time period. Thus, the transect location is somewhat unusual for the region as a whole, which has witnessed very significant population growth and urban sprawl.

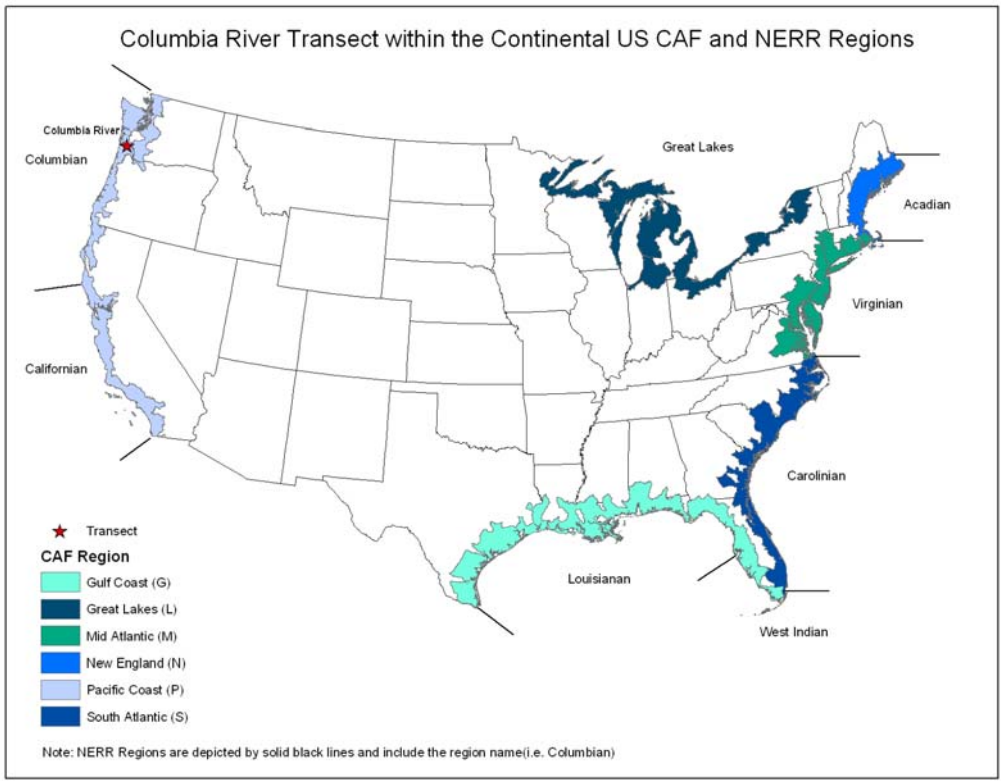


Figure 8-02. Location of the Columbia River, OR-WA transect within the Pacific CAF region.

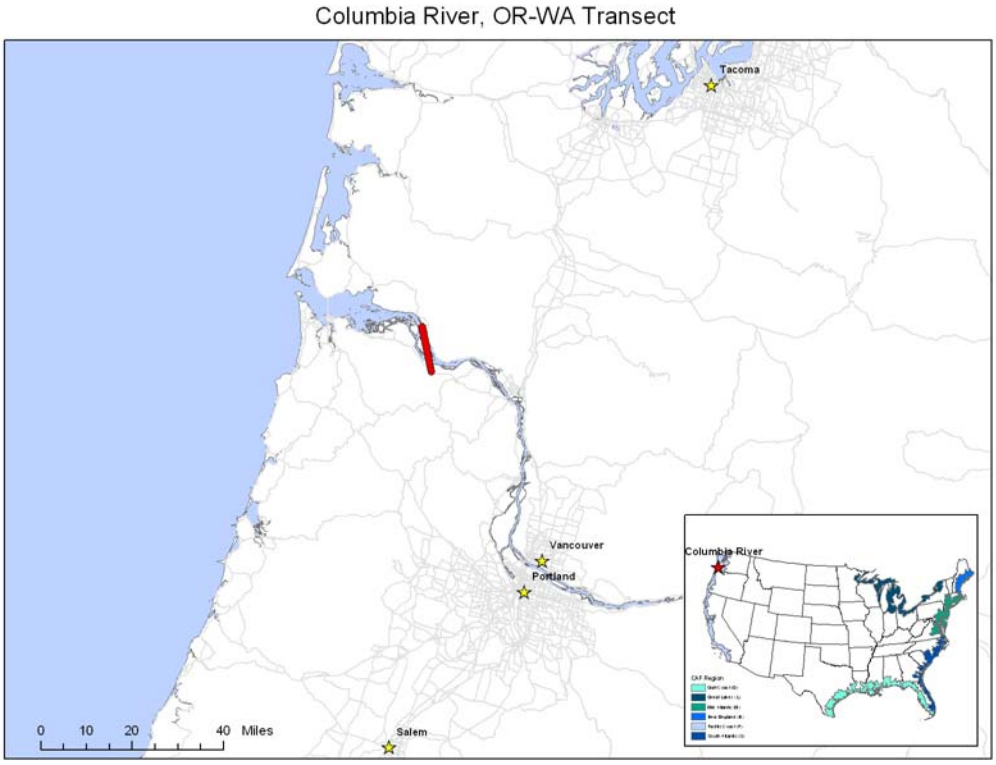


Figure 8-03. Columbia River, OR-WA transect placement. Transect is mapped in red.

Transect Description

I. Distance to Coast
   a. The Columbia River transect is roughly 30 miles inland, and thus wetland status and trends as observed within the transect may not be strongly correlated with status and trends of coastal wetlands. Coastal wetlands are structurally and compositionally different, and thus may vary in sensitivity to environmental stressors.
   b. In addition, anthropogenic pressures may vary between coastal and interior wetlands; for instance, over-water structures (docks, marinas, shipping facilities) may be an important source of wetland loss in coastal wetlands but less significant among inland wetlands except in and along developing and expanding cities.
   c. Given the wide boundaries of the CAF, with some areas as far as 140 miles inland, this transect is reasonably representative in terms of its distance to the coast.
   d. The wide boundaries of the CAF do suggest, however, that attempts to characterize the CAF with one or two transects are apt to be both imprecise and inaccurate.

II. Salinity
   a. Saltwater intrusion varies significantly, and is greatest when freshwater flows are lowest. However, detectable levels of saltwater only reach the transect area under extremely low flows; a recent study found the maximum extent of saltwater intrusion to be 49 km (30.5 mi) inland from the mouth of the Columbia River. More commonly, saltwater intrusion is limited to less than 37 km (23 mi) inland. Thus, the Columbia River transect is not likely to be representative of the brackish and saltwater conditions found closer to the coast and to Puget Sound.

III. Topography/Elevation Range
   a. Elevation along the transect ranges from sea level to 100 feet above sea level (asl). This range is relatively representative of conditions throughout the CAF, most of which is within 0-500 feet asl.
   b. Upland forests on both north and south margins of the Columbia Transect are likely representative of forested conditions as one proceeds inland from the coast throughout most portions of the CAF.
   c. Columbia transect reflects the anticipated elevation gradient from coast inland and the associated vegetative community changes.
   d. Because of its topography (and hydrology), the Columbia River transect has likely been a suitable location for agriculture and rural development. As a consequence, wetland loss within the transect may be greater than in more rugged, higher elevation regions of the CAF that do not support agriculture or rural development. However, the Columbia River transect, due to its amenable conditions, has likely been occupied and used by humans for a longer period of time than other regions within the CAF. As a consequence, significant wetland loss may have occurred within the transect prior to date at which historical wetland abundance was estimated.

By underestimating the historical extent of wetlands within the transect, this could lead to a concomitant underestimate in the extent of wetland loss.

IV. Proximity to City

a. The transect is approximately 70 miles from the nearest major urban area, which is likely representative of the CAF, which has only 2 major urban areas: Seattle-Tacoma and Portland.
b. The transect is also close to the rural hamlet of Cathlamet, WA, which, like many small rural communities in the CAF, likely contributes to wetland loss through fill and removal impacts associated with development. Other nearby infrastructure includes a public boat ramp at Westport, OR, a paper mill in Wauna, OR, and a car ferry between Puget Island and Westport, OR. Scattered, low density development within the transect is likely representative of much of the non-urban portions of the CAF.
c. Population density within the transect is estimated at approximately 5-30 people per square mile. This density is typical of the Coast Range of Oregon and much of the Oregon coast excluding high-density towns such as Seaside or Astoria, but is less dense than much of the Interstate 5 corridor of Washington and Oregon. Density in the Cascade Mountain foothills of Washington is also slightly higher. The transect is not likely to be representative of conditions within the more urbanized portions of the CAF, but likely does capture trends the rural areas of the CAF.
d. Population growth in the vicinity of the transect has been limited and has lagged behind nearby areas. For example, the 1950 U.S. Census reported 24,697 housing units in Clatsop County (the Oregon county containing the majority of the transect); in 2000, 35,630 housing units were present. Much of the growth in the region surrounding the transect has been within the coastal towns. In comparison, nearby Clackamas County, Oregon, grew from 57,130 housing units in 1950 to 338,391 housing units in 2000.

V. Land Ownership

a. Some portion of the transect is on the Columbian White-tailed Deer National Wildlife Refuge, and will thus likely underestimate wetland loss in the region as a whole.

VI. Dominant Land Uses

a. As noted above, some of the transect is within the CWTDNWR, which will tend to underestimate the amount of wetland loss. At the same time, much of the remaining portion of the transect is in agricultural, which should result in a greater degree of wetland loss. On the whole, this mix of land ownerships may be a fairly good sub sample of the CAF region.
b. In addition, the Columbia River transect appears to significantly overestimate the amount of agricultural land along the CAF's coastline. However, much of this agricultural development appears to have been present by the time of the earliest aerial photograph used to estimate historical wetland abundance.

c. The transect, which is lies diagonally across the Columbia River, almost certainly overestimates the ratio of open water to land within the CAF. This likely leads to an underestimate in the degree of change in wetland abundance, as the amount of open water is a fairly static quantity. Changes in land cover at other randomly placed transects within the CAF would likely be far more dynamic.
d. Discuss topographic differences along a hypothetical coast to inland transect – (west to east) versus the Columbia transect.
e. Discuss primary landforms and elevation gradients in OR, WA, and Nor-Cal.
f. I think the Columbia transect appears to overestimate the amount of wetland when compared to the CAF (e.g., the preserve, the amount of land below 30 ft. elevation). Discuss and resolve.

VII. Extent of Shoreline Armoring
a. Neither extensive riprap revetments nor dock and marina developments were evident within the Columbia River Transect. This is likely reflective of conditions throughout rural areas of the CAF. However, the amount of shoreline armoring in other parts of the CAF and NERR may be significantly different; for example in major ports such as Seattle, Portland, San Francisco, or San Diego and in surrounding areas where recreational boating is a common recreational activity.

VIII. Shipping
a. Columbia River is a heavily traveled shipping lane, and as such is dredged frequently. I would expect that any effects on wetland communities (for example, from dredging, competition with introduced plants, presence of over-water structures associated with shipping) would be somewhat more important on this transect than through the region as a whole.

IX. Dredging.
a. See above.

X. Major Natural Disasters
a. None on this transect. Major natural disasters that would affect rates of wetland loss/gain are not common in this region.
b. Major disasters unlikely in transect and CAF (earthquake).

Recent Transect Maps

Figures 8-04 shows the 1995 Digital Orthophoto Quarter Quadrangles (DOQQs) of the Columbia River, OR/WA transect. The DOQQs were used as a visual reference for interpreting recent land cover.

Figure 8-04. 1995 DOQQ of Columbia River OR-WA transect.

Figure 8-05 and 8-06 depict the changes in wetland habitats and open water habitats from 1992 to 2000 respectively. The wetlands change map shows areas that changed from wetland to non-wetland classes and non-wetland to wetland classes. Similarly, the open water change map displays open water to non-open water classes and non-open water to open water classes. These maps are helpful in determining where wetlands and open water habitat changes occurred and which classes they changed between.

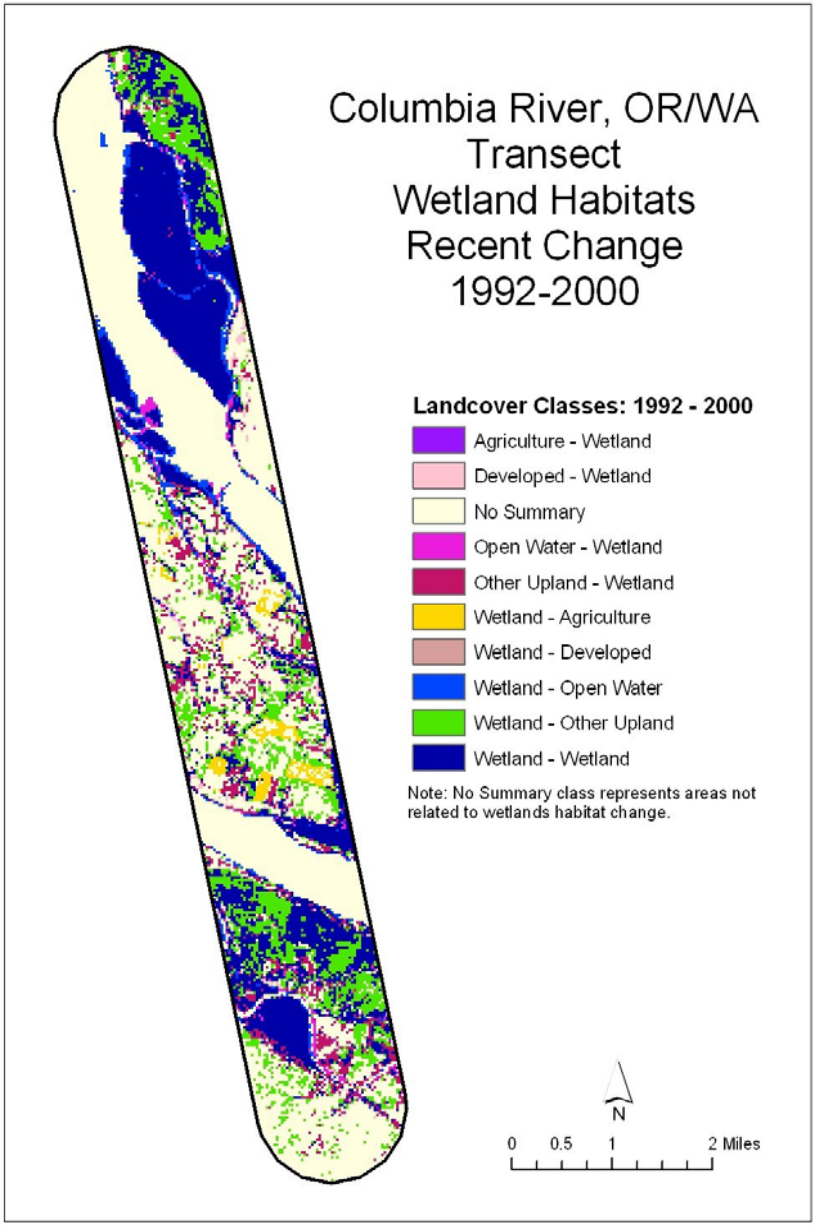


Figure 8-05. Wetland habitats change from 1992-2000, Columbia River. OR-WA transect.

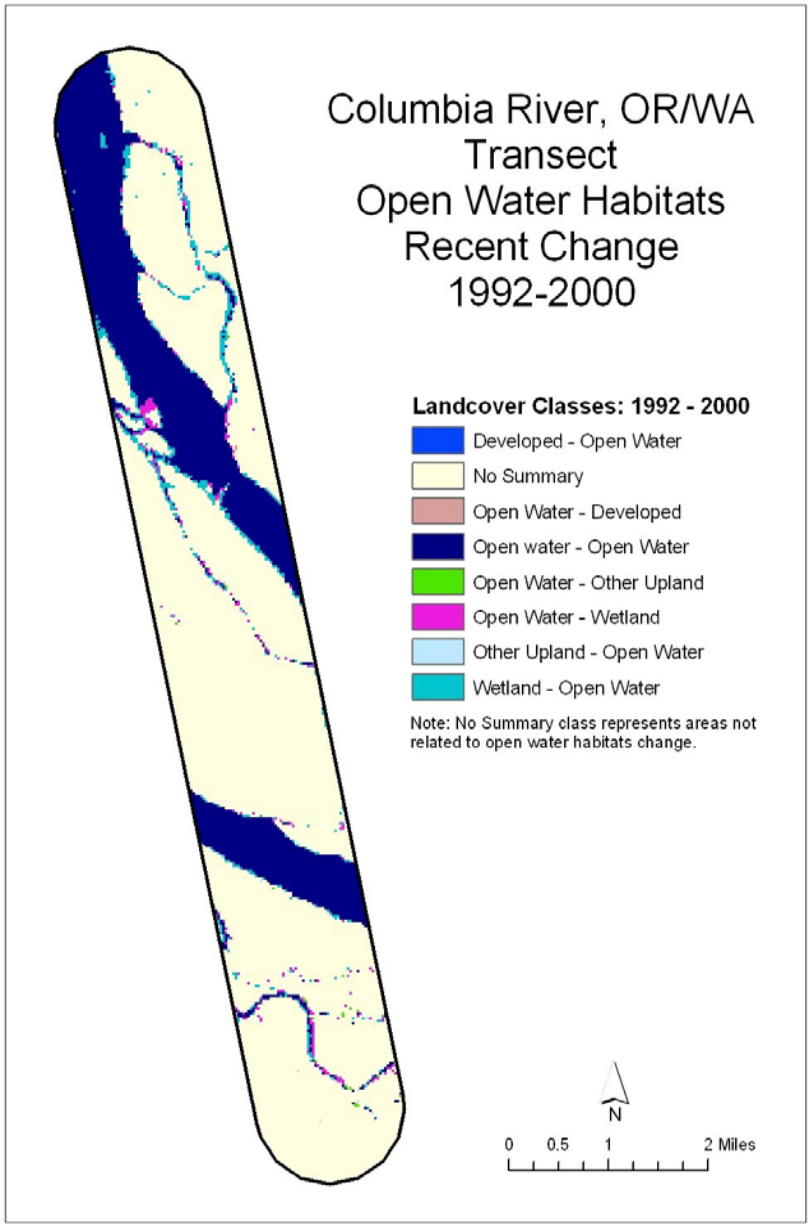


Figure 8-06. Open water habitats change from 1992-2000, Columbia River. OR-WA transect.

Recent (1992 – 2000) Change Tables

Overall, there were roughly 10,765 acres within the Columbia transect. Emergent and shrub-scrub wetland habitats experienced high amounts of loss, with approximate declines of roughly 24% and 21% respectively, while natural shoreline area lost half of its areal extent (Table 8-04). Yet when strictly comparing change between emergent, shrub-scrub, and natural shoreline with development, we find gains of 3.38, 2.51, and 1.56% respectively.

In contrast, the acreage of agriculture increased by more than 11,000%. This enormous increase is likely due to classification differences; for example, NLCD data in 1992 may have classified pasture or hayfields as other upland, whereas the 2000 C-CAP data would likely classify these areas as agriculture.

One change to note is the loss of developed land. A large acreage of what was classified as developed in 1992 changed to emergent and shrub-scrub wetlands as well as other upland. Again, while time does not usually see a loss of development, these changes might be representative of different mapping techniques and abilities to capture development within a 30-meter pixel range. In these terms, developed acreage in 1992 might have fallen into another classification within the 30-meter pixel and the error was not in favor of development.

Table 8-04. Acreage and change of land cover classes from 1992 to 2000. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

Columbia River, OR-WA Transect - Dataset Acreage and Change by Land Cover Classes					
	C-CAP92 Acres	C-CAP00 Acres	Change 92-00 Acres	Change 92-00 Percent	92-00 Gain/Loss
Wetlands Total	***4,460.80***	***3,546.09***	***-914.71***	***-20.51%*** [a]	***loss***
Emergent Wetlands	1,505.61	1,140.44	-365.17	-24.25% [b]	loss
Woody Wetlands Total	2,570.00	2,214.16	-355.83	-13.85% [c]	loss
Woody Wetlands (undetermined)	0.00	0.00	0.00	0.00%	
Shrub-scrub Wetlands	1,567.88	1,238.29	-329.59	-21.02% [d]	loss
Mangroves	0.00	0.00	0.00	0.00%	
Estuarine Forested Wetlands	0.00	0.00	0.00	0.00%	
Palustrine Forested Wetlands	1,002.11	975.87	-26.24	-2.62% [e]	loss
Natural (non-armored) Shoreline	385.19	191.48	-193.71	-50.29% [f]	loss
Open Water Total	***2,647.17***	***2,834.20***	***187.03***	***7.07%*** [g]	***gain***
Open Water	2,647.17	2,834.20	187.03	7.07%	gain
Aquatic Bed Total	0.00	0.00	0.00	0.00%	
Aquatic Bed (undetermined)**	0.00	0.00	0.00	0.00%	
Palustrine Aquatic Beds	0.00	0.00	0.00	0.00%	
Estuarine Aquatic Beds	0.00	0.00	0.00	0.00%	
Coral Reefs	0.00	0.00	0.00	0.00%	
Oyster Reefs/Shell Bottom	0.00	0.00	0.00	0.00%	

	C-CAP92 Acres	C-CAP00 Acres	Change 92-00 Acres	Change 92-00 Percent	92-00 Gain/Loss
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	0.00	0.00	0.00	0.00%	
Developed	***384.30***	***198.60***	***-185.70***	***-48.32%***	***loss***
Agriculture	***3.34***	***377.40***	***374.07***	***11213.33%***	***gain***
Other Upland	***3,269.65***	***3,808.96***	***539.31***	***16.49%***	***gain***
TOTAL	***10,765.25***	***10,765.25***			

Note: The following footnotes indicate an actual total gain/loss of wetlands or open water habitats of at least/most the indicated amount. These numbers look strictly at change to development which is less likely to be misclassified.

[a] Wetlands total gain of at most 2.36% (105 acres)

[b] Emergent wetlands gain of at most 3.38% (50 acres)

[c] Woody wetlands total gain of at most 1.88% (48 acres)

[d] Shrub-scrub wetlands gain of at most 2.51% (39 acres)

[e] Palustrine forested wetlands gain of at most 0.89% (8 acres)

[f] Natural (non-armored) shoreline gain of at most 1.56% (6 acres)

[g] Open water total gain of at most 0.11% (2..89 acres)

The potential causes for loss in habitat can be further examined by looking at Table 8-05, which includes percentages of change in wetland and open water habitats due to conversion to development, agriculture, and/or other upland.

Table 8-05. Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes from 1992-2000.

Columbia River Transect - Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 92-00 Acres**	**Change 92-00 Percent**	**92-00 Gain/Loss**
Wetland Habitats	Developed, Agriculture, Other Upland	1,527.41		
Developed, Agriculture, Other Upland	Wetland Habitats	783.94		
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		-743.47	-16.67%	loss
Open Water Habitats	Developed, Agriculture, Other Upland	8.23		
Developed, Agriculture, Other Upland	Open Water Habitats	24.02		
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		15.79	0.60%	gain
Wetland Habitats	Other Upland	1,369.95		
Other Upland	Wetland Habitats	659.40		
Wetland Habitats Gain/Loss to Other Upland		-710.55	-15.93%	loss
Wetland Habitats	Agriculture	140.78		
Agriculture	Wetland Habitats	659.40		
Wetland Habitats Gain/Loss to Agriculture		518.62	11.63%	gain
Wetland Habitats	Developed	16.68		
Developed	Wetland Habitats	121.87		
Wetland Habitats Gain/Loss to Developed		105.19	2.36%	gain
Open Water Habitats	Other Upland	7.12		
Other Upland	Open Water Habitats	20.02		
Open Water Habitats Gain/Loss to Other Upland		12.90	0.49%	gain
Open Water Habitats	Agriculture	0.00		

From	To	Change 92-00 Acres	Change 92-00 Percent	92-00 Gain/Loss
Agriculture	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Agriculture		0.00	0.00%	
Open Water Habitats	Developed	1.11		
Developed	Open Water Habitats	4.00		
Open Water Habitats Gain/Loss to Developed		2.89	0.11%	gain

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

A more detailed breakdown of changes in land cover classes between 1992 and 2000 for the Columbia River transect can be seen in Table 8-06. This table shows the distribution and change in number of acres between 1992 and 2000. The table also shows the number of acres that remained unchanged over the recent eight-year period. These data support the findings from Table 8-05.

Recent (1992 – 2000) Change Summary

Wetlands as a group declined over the recent period. Within the wetland group, all habitats under consideration declined: emergent wetlands, woody wetlands, and natural shoreline. Although some of the apparent loss of wetland habitats reflects natural shifts among wetland types, wetland habitats as a group declined as a consequence of conversion to development, agriculture, or other upland. Indeed, the only habitats that increased in areal extent during the period were non-wetland (developed, agriculture, or other upland and open water habitats).

Table 8-06. Change matrix representing change in acres between land cover classes from 1992 to 2000. Values in the gray shaded cells are acres of no change.

Columbia River Transect Land Cover Change C-CAP 1992 to C-CAP 2000 (by acres)											
			1992								
			Wetland Habitats				Open Water Habitats	Non-Wet Land Cover			
			Emergent Wetlands	Shrub-scrub Wetlands	Palustrine Forested Wetlands	Natural Non-armored) Shoreline	Open Water	Developed	Agriculture	Other Upland	Acreage Totals for 2000 Classification
2000	Wetland Habitats	Emergent Wetlands	354.05	131.88	48.70	57.16	37.58	62.05	1.33	447.68	1,140.44
		Shrub-scrub Wetlands	155.68	665.18	222.62	15.12	12.23	42.03	0.89	124.54	1,238.29
		Palustrine Forested Wetlands	52.71	342.93	476.81	22.24	10.23	10.01	0.44	60.49	975.87
		Natural (Non-armored) Shoreline	17.35	4.00	4.45	82.95	48.26	7.78	0.00	26.69	191.48
	Open Water Habitats	Open Water	33.14	16.01	29.36	201.04	2,530.63	4.00	0.00	20.02	2,834.20
	Non-Wet Land Cover	Developed	11.12	2.67	1.11	1.78	1.11	130.77	0.00	50.04	198.60
		Agriculture	118.76	16.68	5.34	0.00	0.00	0.67	0.00	235.96	377.40
		Other Upland	762.81	388.52	213.72	4.89	7.12	126.99	0.67	2,304.23	3,808.96
		Acreage Totals for 1992 Classification	1,505.61	1,567.88	1,002.11	385.19	2,647.17	384.30	3.34	3,269.65	**10,765.25**

This table presents estimates of acreage by classification and the number of acres that changed classification between the two dates. The data shows the numbers of acres that have changed from the 1992 to 2000. The table reads down (1992/from) and to the left (2000/to).

Historical Transect Maps

Figure 8-07 shows the 1948 aerial photos of the Columbia River, OR/WA transect. The 1948 aerial photography was used to classify land cover for the historic time period. Figures 8-08 and 8-09 depict the changes in wetland habitats and open water habitats from 1948 to 2000 respectively. The wetlands change map shows areas that changed from wetland to non-wetland classes and non-wetland to wetland classes. Similarly, the open water change map displays open water to non-open water classes and non-open water to open water classes. These maps are helpful in determining where wetlands and open water habitat changes occurred and which classes they changed between.

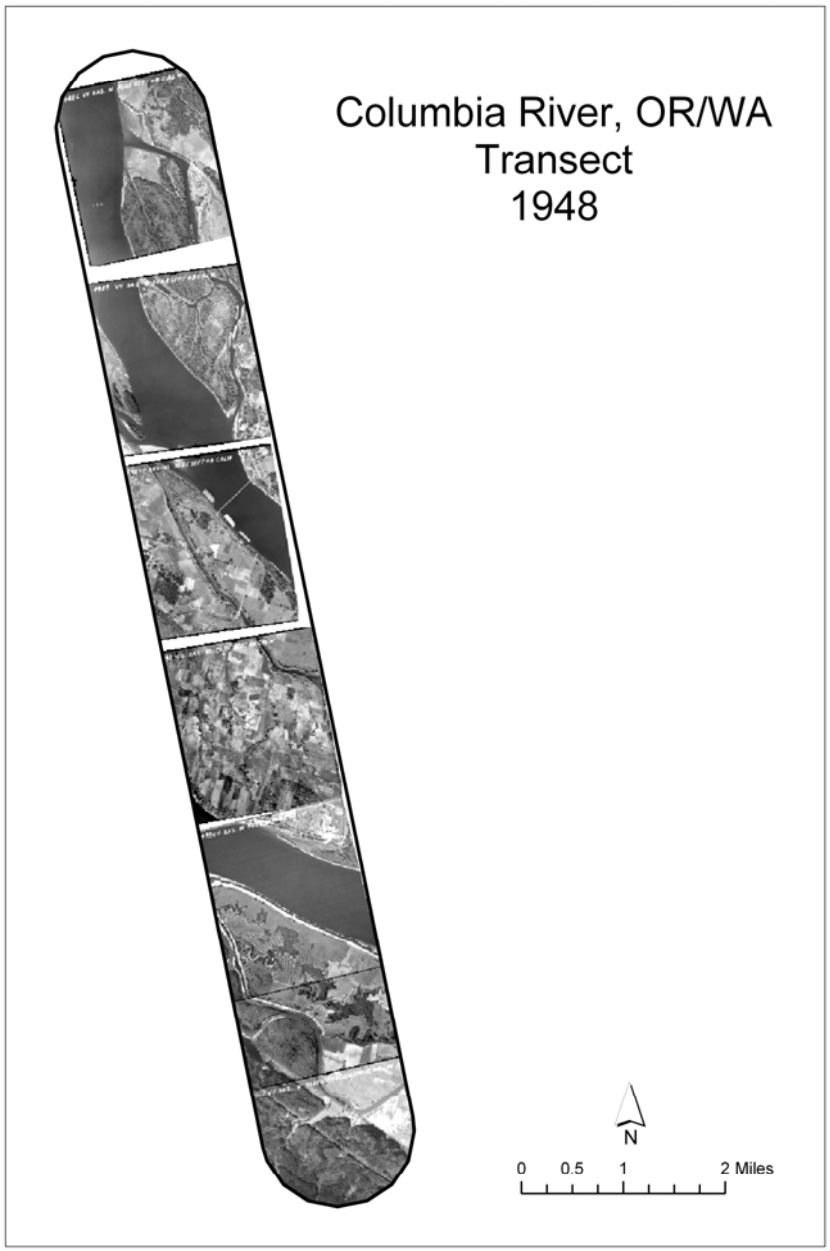


Figure 8-07. 1948 aerial photos of Columbia River transect

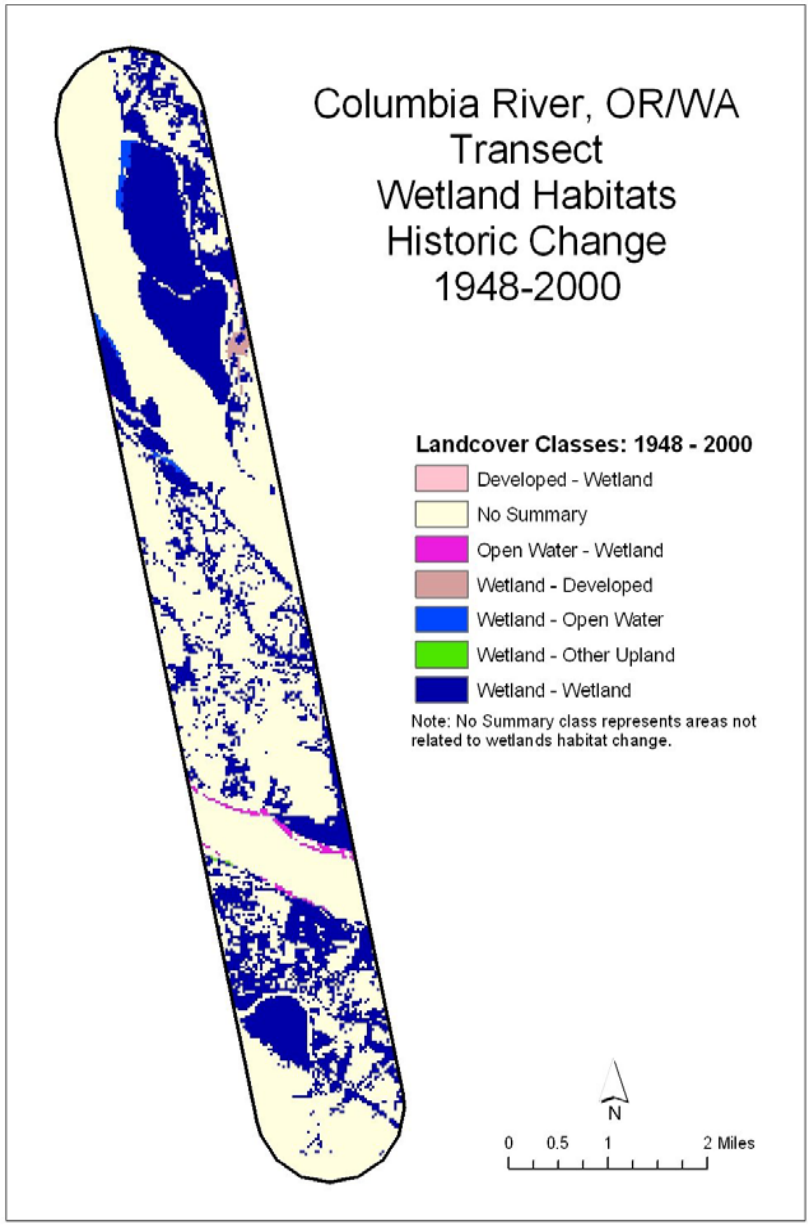


Figure 8-08. Wetland habitats change from 1948-2000, Columbia River transect.

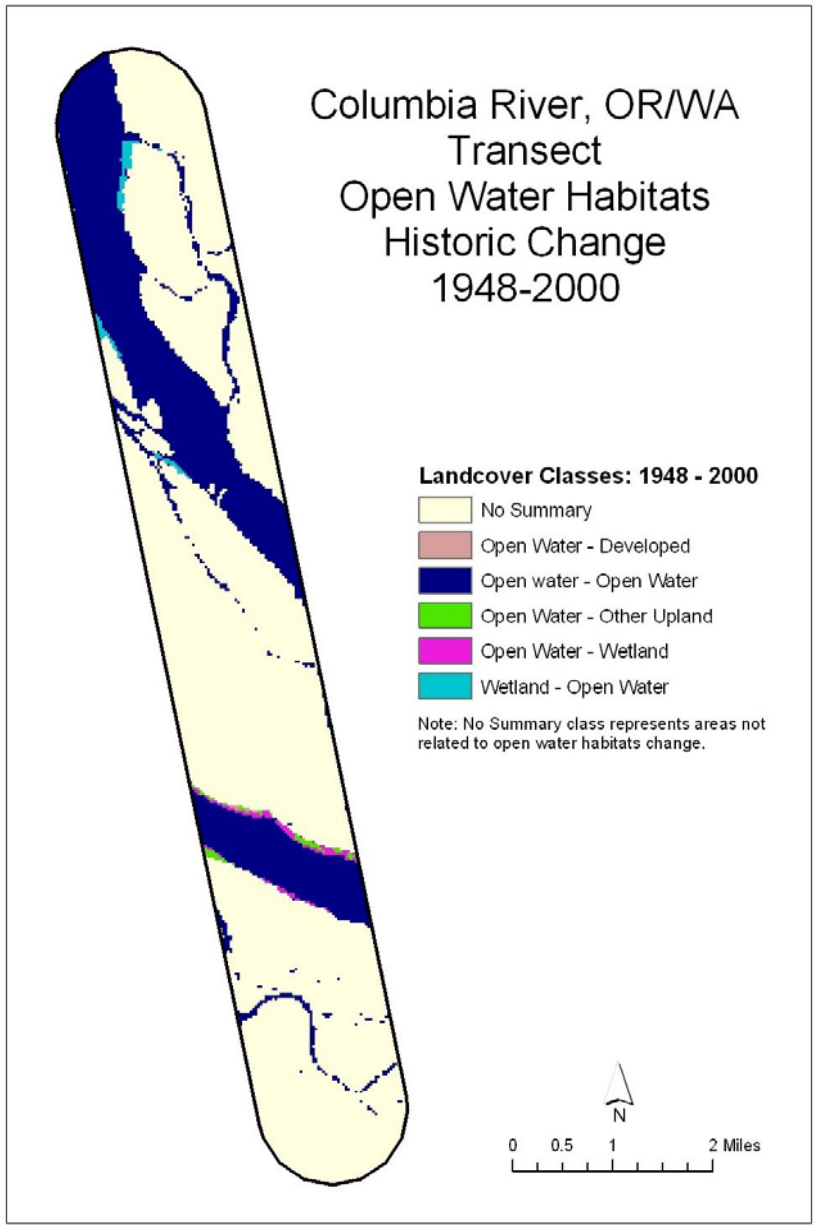


Figure 8-09. Open water habitats change from 1948-2000, Columbia River transect.

Historical (1948 – 2000) Change Tables

The areal extent of land cover classes was relatively stable between 1948 and 2000, even more so than between 1992 and 2000 (Table 8-07). Emergent wetlands experienced the greatest reduction in area at a loss of 21 percent (316 acres), although the actual loss of emergent wetlands to development was less than half a percent (6 acres).

Shrub-scrub and forested wetlands increased in extent, much of which appears to have been a result of natural succession within emergent wetlands. When comparing these wetland changes to development, shrub-scrub actually loses 26 acres (-2.43%) while palustrine forested wetlands are left with a minimal change of .67 acres (.08%).

The amount of open water, which increased between 1992 and 2000, declined slightly when compared between 1948 and 2000. Some of the decline in open water is attributable to development (.13%), but most is due to the conversion of open water to wetland habitats and other upland (Table 8-08). In some cases, the loss of open water habitats may be due to either gross differences in river levels between sampling periods, natural channel movements, or variation in the resolution of the different sampling methods.

Table 8-07. Acreage and change of land cover classes from 1948 to 2000. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

Columbia River, OR-WA Transect - Dataset Acreage and Change by Land Cover Classes					
	HIST48 Acres	C-CAP00 Acres	Change 48-00 Acres	Change 48-00 Percent	48-00 Gain/Loss
Wetlands Total	***3,523.40***	***3,485.82***	***-37.58***	***-1.07%*** [a]	***loss***
Emergent Wetlands	1,433.78	1,117.76	-316.02	-22.04% [b]	loss
Woody Wetlands Total	1,905.92	2,172.80	266.87	14.00% [c]	gain
Woody Wetlands (undetermined)	0.00	0.00	0.00	0.00%	
Shrub-scrub Wetlands	1,069.50	1,199.60	130.10	12.16% [d]	gain
Mangroves	0.00	0.00	0.00	0.00%	
Estuarine Forested Wetlands	0.00	0.00	0.00	0.00%	
Palustrine Forested Wetlands	836.43	973.20	136.77	16.35% [e]	gain
Natural (non-armored) Shoreline	183.70	195.26	11.56	6.30% [f]	gain
Open Water Total	***2,868.00***	***2,836.42***	***-31.58***	***-1.10%*** [g]	***loss***
Open Water	2,868.00	2,836.42	-31.58	-1.10%	loss
Aquatic Bed Total	0.00	0.00	0.00	0.00%	
Aquatic Bed (undetermined)	0.00	0.00	0.00	0.00%	
Palustrine Aquatic Beds	0.00	0.00	0.00	0.00%	
Estuarine Aquatic Beds	0.00	0.00	0.00	0.00%	
Coral Reefs	0.00	0.00	0.00	0.00%	
Oyster Reefs/Shell Bottom	0.00	0.00	0.00	0.00%	
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	0.00	0.00	0.00	0.00%	

	HIST48 Acres	C-CAP00 Acres	Change 48-00 Acres	Change 48-00 Percent	48-00 Gain/Loss
Developed	***126.10***	***191.48***	***65.38***	***51.85%***	***gain***
Agriculture	***382.07***	***382.07***	***0.00***	***0.00%***	
Other Upland	***3,865.67***	***3,869.45***	***3.78***	***0.10%***	***gain***
TOTAL	***10,765.25***	***10,765.25***			

Note: The following footnotes indicate an actual total gain/loss of wetlands or open water habitats of at least/most the indicated amount. These numbers look strictly at change to development which is less likely to be misclassified.

[a] Wetlands total loss of at least 0.91% (32.02 acres)

[b] Emergent wetlands loss of at least 0.47% (6.67 acres)

[c] Woody wetlands total loss of at least 1.33% (25.35 acres)

[d] Shrub-scrub wetlands loss of at least 2.43% (26.02 acres)

[e] Palustrine forested wetlands gain of at most .08% (0.67 acres)

[f] Natural (non-armored) shoreline loss/gain of 0% (0 acres)

[g] Open water total loss of at least 0.13% (3.78 acres)

The potential causes for loss in habitat can be further examined by looking at Table 8-08, which includes percentages of change in wetland and open water habitats due to conversion to development, agriculture, and/or other upland.

Table 8-08. Percent of Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes from 1948-2000.

Columbia River Transect - Percent of Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 48-00 Acres**	**Change 48-00 Percent**	**48-00 Gain/Loss**
Wetland Habitats	Developed, Agriculture, Other Upland	38.47		
Developed, Agriculture, Other Upland	Wetland Habitats	4.45		
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		-34.03	-0.97%	loss
Open Water Habitats	Developed, Agriculture, Other Upland	35.14		
Developed, Agriculture, Other Upland	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		-35.14	-1.23%	loss
Wetland Habitats	Other Upland	2.00		
Other Upland	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Other Upland		-2.00	-0.06%	loss
Wetland Habitats	Agriculture	0.00		
Agriculture	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Agriculture		0.00	0.00%	
Wetland Habitats	Developed	36.47		
Developed	Wetland Habitats	4.45		
Wetland Habitats Gain/Loss to Developed		-32.02	-0.91%	loss
Open Water Habitats	Other Upland	31.36		
Other Upland	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Other Upland		-31.36	-1.09%	loss
Open Water Habitats	Agriculture	0.00		
Agriculture	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Agriculture		0.00	0.00%	

From	To	Change 48-00 Acres	Change 48-00 Percent	48-00 Gain/Loss
Open Water Habitats	Developed	3.78		
Developed	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Developed		-3.78	-0.13%	loss

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

A more detailed breakdown of changes in land cover classes between 1948 and 2000 for the Columbia River transect can be seen in Table 8-09. This table shows the distribution and change in number of acres between 1948 and 2000. The table also shows the number of acres that remained unchanged over the 52-year period. These data support the findings from Table 8-08.

Historical (1948 – 2000) Change Summary

As analyzed here, there was little net change in the amount of wetlands within the transect between 1948 and 2000. Most of the change appeared to reflect natural successional patterns, for example shifts from emergent wetlands to scrub-shrub and forested wetlands. Depositional changes in the Columbia River resulted in changes from open water to wetlands. Only a very small percentage of wetland change can be attributed directly to development or other upland. Although the apparent stasis may reflect reality, for example because most development in the region occurred prior to 1948, the lack of significant change may also be due to differences in how data were collected in 1948 (aerial photo interpretation) and 2000 (digital C-CAP). However, even if the results accurately reflect trends in land cover classes within the Columbia River transect, it is questionable whether similar trends are likely at the regional level.

Table 8-09. Change matrix representing change in acres between land cover classes from 1948 to 2000. Values in the gray shaded cells are acres of no change.

Columbia River Transect Land Cover Change Aerial Photos 1948 to C-CAP 2000 (by acres)											
		1948									
			Wetland Habitats				Open Water Habitats	Non-Wet Land Cover			
			Emergent Wetlands	Shrub-scrub Wetlands	Palustrine Forested Wetlands	Natural Non-armored) Shoreline	Open Water	Developed	Agriculture	Other Upland	Acreage Totals for 2000 Classification
2000	Wetland Habitats	Emergent Wetlands	980.54	46.04	71.61	8.90	10.67	0.00	0.00	0.00	1,117.76
		Shrub-scrub Wetlands	198.82	930.50	61.38	6.23	2.67	0.00	0.00	0.00	1,199.60
		Palustrine Forested Wetlands	219.28	53.82	689.20	3.11	3.34	4.45	0.00	0.00	973.20
		Natural (Non-armored) Shoreline	0.00	6.23	10.45	140.55	38.03	0.00	0.00	0.00	195.26
	Open Water Habitats	Open Water	28.47	6.89	0.00	22.91	2,778.16	0.00	0.00	0.00	2,836.42
	Non-Wet Land Cover	Developed	6.67	26.02	3.78	0.00	3.78	121.65	0.00	29.58	191.48
		Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	382.07	0.00	382.07
		Other Upland	0.00	0.00	0.00	2.00	31.36	0.00	0.00	3,836.09	3,869.45
		Acreage Totals for 1948 Classification	1,433.78	1,069.50	836.43	183.70	2,868.00	126.10	382.07	3,865.67	**10,765.25**

This table presents estimates of acreage by classification and the number of acres that changed classification between the two dates. The data shows the numbers of acres that have changed from 1948 to 2000. The table reads down (1948/from) and to the left (2000/to).

Section 8.3.2 San Pablo Bay, CA Transect

Transect Location

The location of the San Pablo Bay, CA transect within the Pacific CAF region is illustrated in Figure 8-10. A more detailed placement map of the transect is presented in Figure 8-11. Historically, much of the area crossed by the San Pablo Bay transect was part of a large wetland complex. Seasonal emergent wetlands, including vernal pool complexes in areas with impervious soils, graded into brackish marshes that fringed the major creeks entering the Bay. Numerous tidal pans were scattered between the channels of tidal creeks. However, beginning in the 1880's, most of the tidal creeks had been channelized and wetland areas diked to facilitate agricultural production, especially of hayfields and pasture. The vast majority of wetlands had been converted to agriculture by the 1930's. In addition to direct conversion to other uses, some wetland loss is attributable to changes in salinity (mostly due to changes in flow regime and channel geomorphology) and the spread of invasive plants. The area around the transect is part of the San Francisco Bay Area megalopolis, and has been heavily developed. Thus, wetland conditions within the San Pablo Bay transect are characteristic of large estuarine systems in highly urbanized areas of the region, but may not accurately portray wetland status and trends in wetlands further inland or in less developed areas.

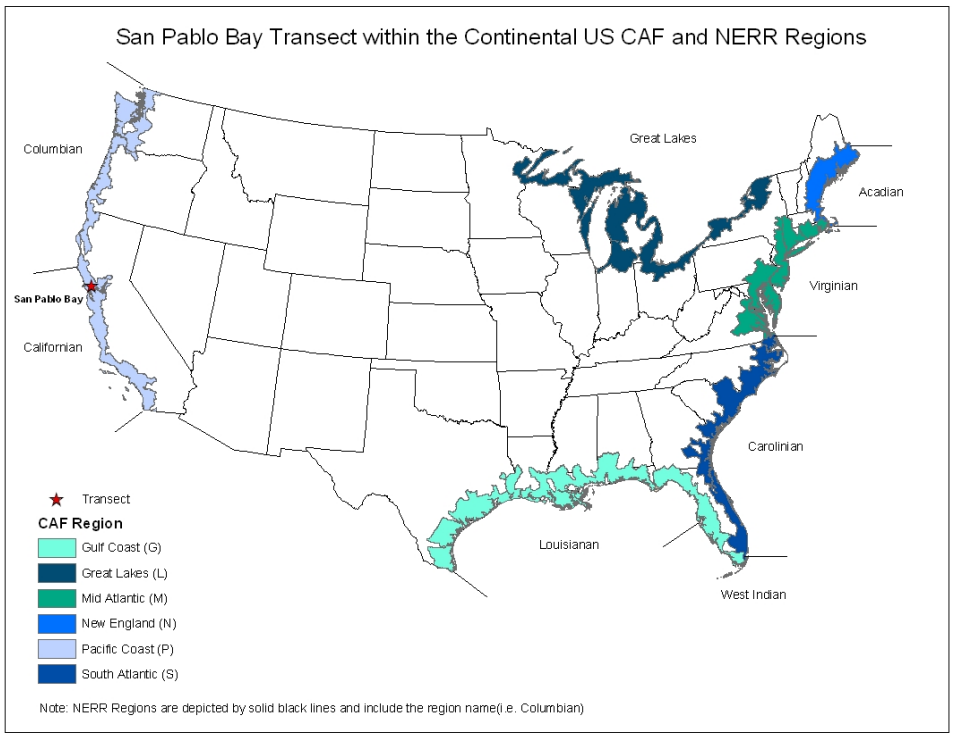


Figure 8-10. Location of San Pablo Bay, CA transect within the Pacific CAF region.

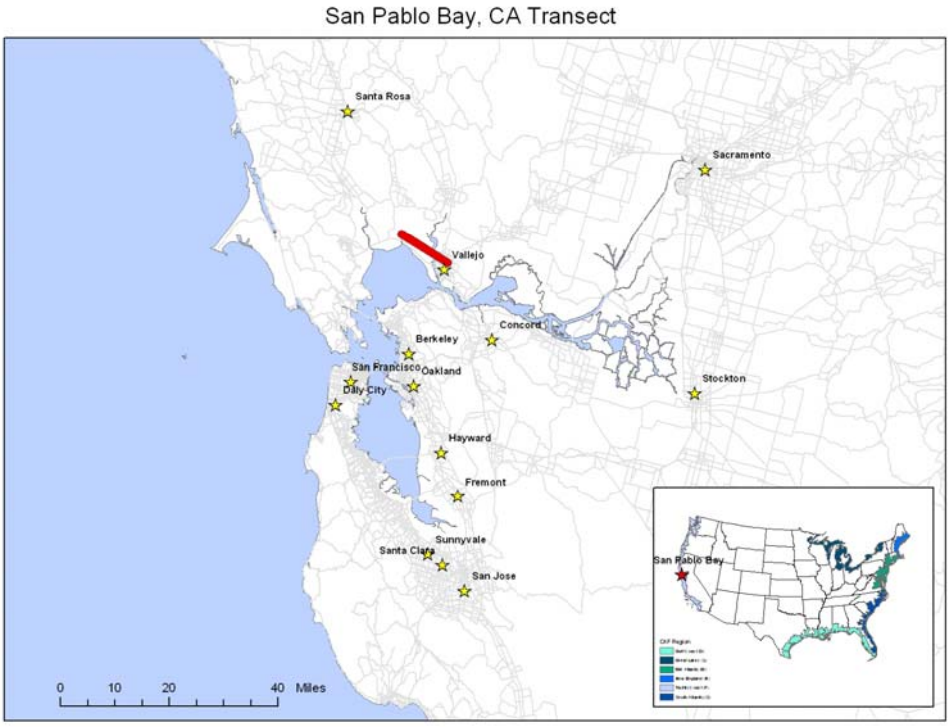


Figure 8-11. San Pablo Bay, CA transect placement. Transect is mapped in red.

Transect Description

I. Distance to Coast
   a. The San Pablo Bay transect is within 5-10 miles of San Pablo Bay, and thus wetland status and trends as observed within the transect should correlate well with status and trends of coastal wetlands in the region.
   b. Trends in land cover classes within this transect may not accurately reflect trends in wetlands further inland; as with the Upper Pacific CAF region, the Lower Pacific CAF contains areas as far as 70 miles inland.
   c. Attempts to characterize the CAF with one or two transects are apt to be both imprecise and inaccurate.

II. Salinity
   a. The San Pablo Bay transect, which crosses the once-extensive tidal marshes along Sonoma Creek, contains a variety of salinity conditions. Water varies from saline at the edge of San Pablo Bay to brackish within and along tidal creeks to fresh in the seasonal wetlands and moist grasslands that fringe the tidal marshes. Thus, this transect contains the full range of salinity conditions expected to occur in the region.

III. Topography/Elevation Range
   a. Elevation along the transect ranges from sea level to 200 feet above sea level (asl). This range is relatively representative of conditions throughout the CAF, most of which is within 0-500 feet asl.
   b. Because of its topography (and hydrology), the San Pablo Bay transect has been a suitable location for agriculture and rural development since the late 1800's. Development associated with agriculture, including several

major rail lines in the vicinity of the transect, has also left a significant imprint on the local environment. In addition, this transect is within one of the largest, and most developed, metropolitan areas of the United States and as a consequence, wetland loss may be greater than in more rural areas of the CAF. However, records indicate that most of the wetlands in the vicinity of the San Pablo Bay transect were destroyed prior to 1930; thus, much of this historical change may not be captured in this analysis.

IV. Proximity to City

a. The transect is within 30 miles of both San Francisco and Oakland.
b. The transect is also close to a number of smaller urban areas, most notably Vallejo, CA. The San Pablo Bay transect is within a highly developed metropolitan area. In addition to urban development, numerous roads and rail lines cross the transect. Relative to the CAF region as a whole, the transect likely overrepresents metropolitan and highly urbanized areas.
c. Population density within the transect is highly variable. Vallejo, CA has a population density of approximately 4,000 persons per mi^2, whereas the agricultural lands along Sonoma Creek west of Vallejo have less than 1 person per mi^2. Sonoma County has an average population density of 291 persons per mi^2. The average population density across all California counties is 627 persons per mi^2, which would indicate that the area surrounding the transect is apt to be less developed than expected. However, mean population density is biased upwards by outliers such as San Francisco County (population density > 17,000 persons per mi^2), and when the median population density (92 persons per mi^2) of California is considered, the transect appears to be a reasonable representation of population densities found throughout the CAF region.
d. Population growth in the vicinity of the transect has been greater than the average for California counties as a whole. The mean percent increase in population density for all California counties between 1990 and 2000 was approximately 13.4%; over this same period, Sonoma County grew by 14.8% and nearby Contra Costa County grew by 17.6%.

V. Land Ownership

a. The majority of the land within the transect is privately owned. No large tracts of protected land are evident within the transect. The western edge of the transect falls within the U.S. Naval Reservation.

VI. Dominant Land Uses

a. Most of the land in the vicinity of the transect is under agricultural production. Urban and residential areas are widespread. Transportation infrastructure, including highways and several rail lines, is prevalent within the vicinity of the transect. On the whole, this mix of land ownerships may be a fairly good subsample of the NERR region.
b. Much of the agricultural development and tidal channel modification was in place by the 1930's, prior to when the aerial photograph used to estimate historical wetland abundance was taken.

VII. Extent of Shoreline Armoring

a. Extensive diking has occurred throughout the area of the transect, and shoreline armoring is apparent along many of the larger channels of Sonoma Creek and Napa River. Extensive shoreline development has occurred along many of the tidal creeks, and aerial photos indicate

extensive bankside development in some areas. This is likely reflective of conditions throughout developed areas of the NERR, but, given the value of real estate around the Bay, may exaggerate the extent of shoreline armoring and development in other areas of the NERR.

VIII. Shipping

a. Mare Island near Vallejo once supported an active shipyard, and a boatyard upstream along the Napa River built boats for the US Navy during WWII. Larger and more important deepwater ports are found in the South Bay at Redwood City and the Port of San Francisco. Shipping will thus have a relatively small effect on the area surrounding the transect.

IX. Dredging.

a. Dredging was fairly common in most of the tidal creeks and rivers within the vicinity of the transect, mainly for flood control but also to facilitate navigation of the Napa River around Vallejo. More recently, dredging has been replaced by holistic flood prevention strategies, including wetland restoration, floodplain restoration, and bioengineering of banks. However, the historical legacy of the dredging that accompanied channelization and diking of the areas wetlands and tidal creeks will likely still be evident.

X. Major Natural Disasters

a. Flooding is fairly common on many of the tidal creeks and rivers. The most notable flood was along the Napa River in 1986, when 250 homes were destroyed following an extreme rain event (20 inches in 24 hours). The most recent large flood was in 1997, when a 10-year flood caused widespread damage.

b. Large earthquakes are common in the region.

Recent Transect Maps

Figure 8-12 shows the 1993 Digital Orthophoto Quarter Quadrangles (DOQQs) of the San Pablo Bay, CA transect. The DOQQs were used as a visual reference for interpreting recent land cover. Figures 8-13 and 8-14 depict the changes in wetland habitats and open water habitats from 1993 to 2000 respectively. The wetlands change map shows areas that changed from wetland to non-wetland classes and non-wetland to wetland classes. Similarly, the open water change map displays open water to non-open water classes and non-open water to open water classes. These maps are helpful in determining where wetlands and open water habitat changes occurred and which classes they changed between.

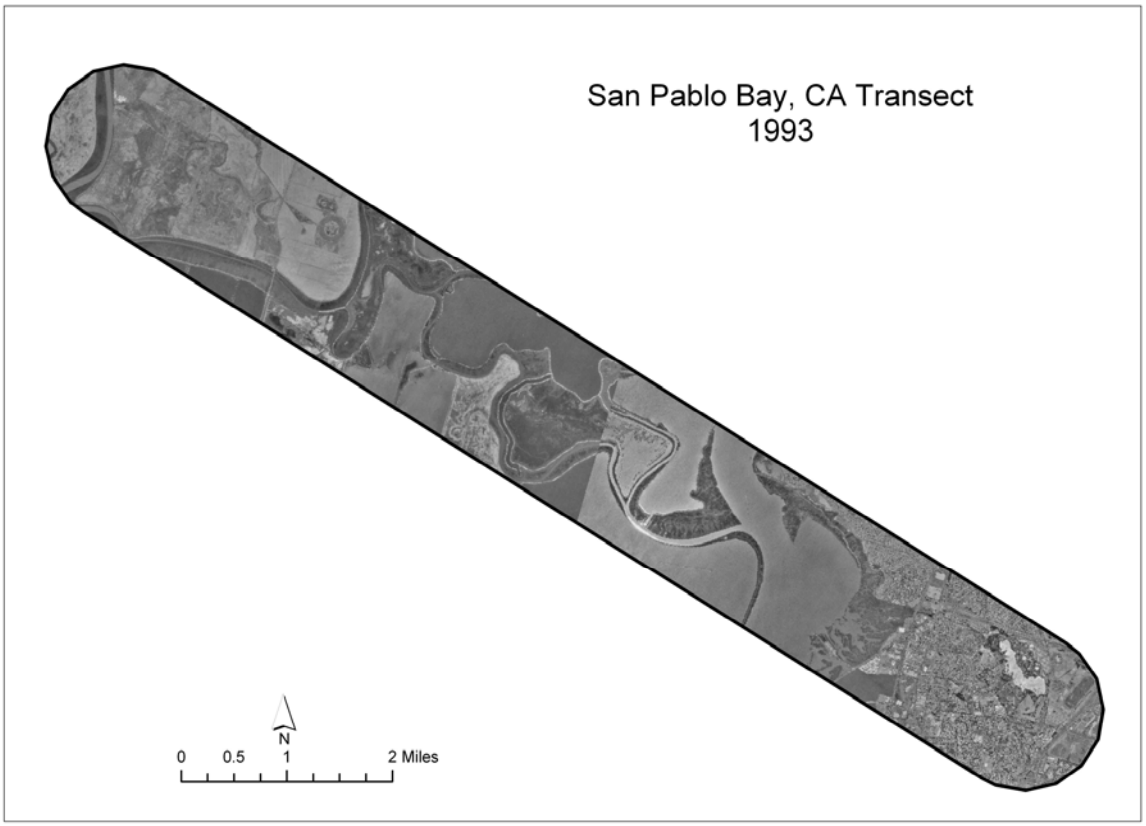


Figure 8-12. DOQQ 1993 of San Pablo Bay, CA transect

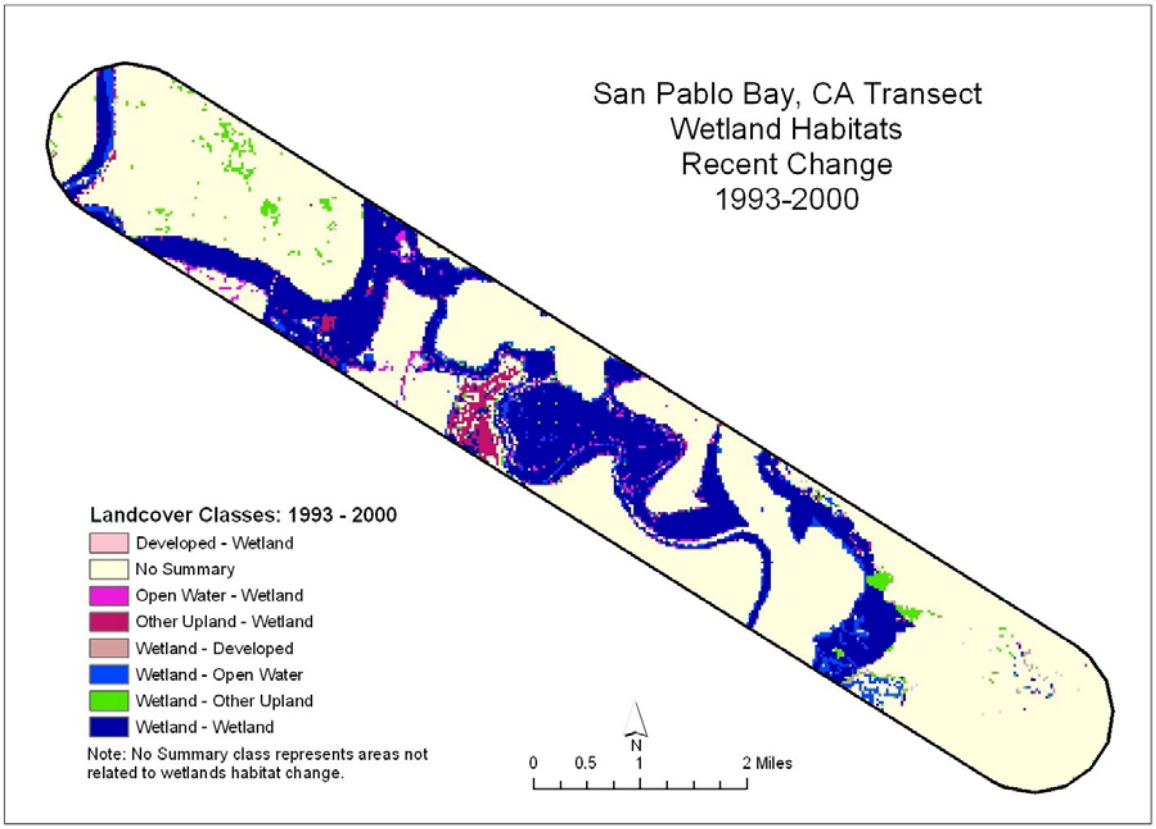


Figure 8-13. Wetland habitats change from 1993 to 2000, San Pablo Bay, CA transect.

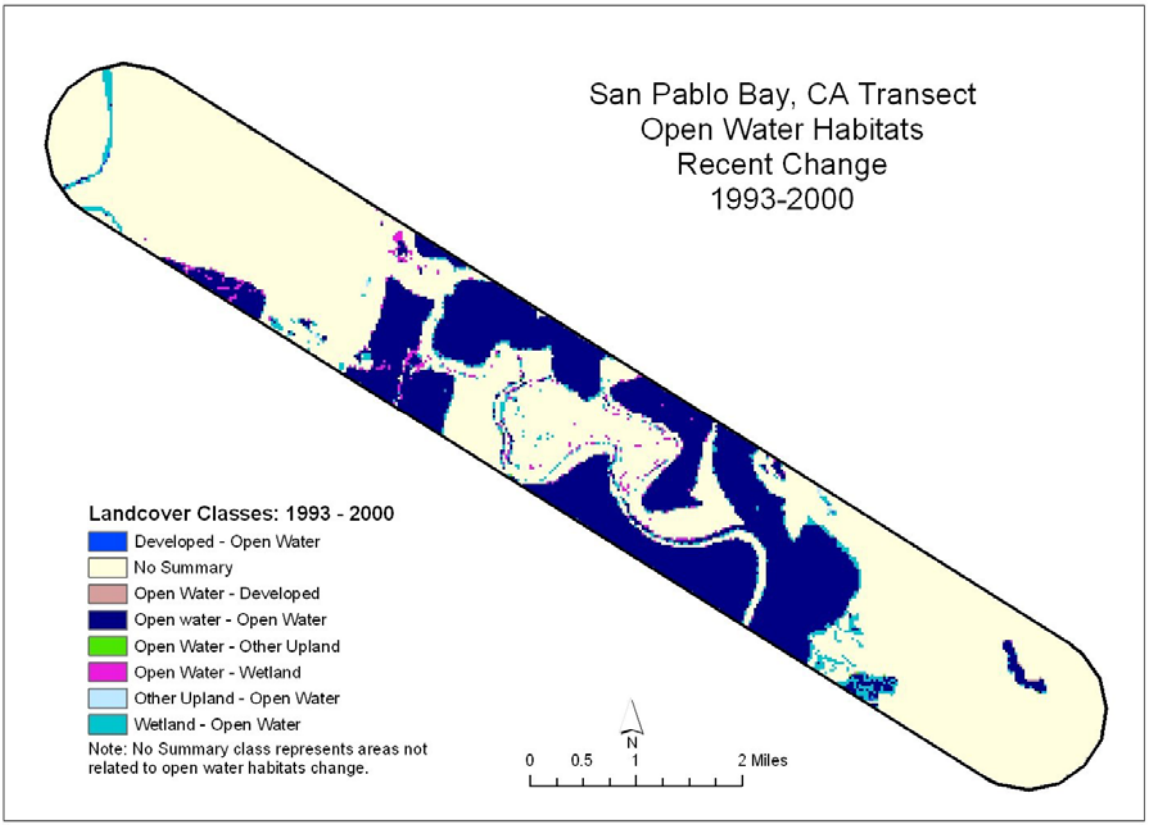


Figure 8-14. Open water habitats change from 1993 to 2000, San Pablo Bay, CA transect.

Recent (1993 – 2000) Change Tables

The most significant change noted during this recent period was a nearly 94% decline in the acreage of natural (non-armored) shoreline (Table 8-10). However, this loss is mainly attributable to change to emergent wetlands (161 acres at 48.26% loss from 1993 shoreline) and open water (133 acres at 39.87% loss of 1993 shoreline); both classes are susceptible to difference in classification of the datasets (Table 8-12).

Table 8-10. Acreage and change of land cover classes from 1993 to 2000. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

San Pablo Bay, CA Transect - Dataset Acreage and Change by Land Cover Classes					
	C-CAP93 Acres	**C-CAP00 Acres**	**Change 93-00 Acres**	**Change 93-00 Percent**	**93-00 Gain/Loss**
Wetlands Total	***3,040.58***	***2,932.94***	***-107.64***	***-3.54%*** [a]	***loss***
Emergent Wetlands	2,706.99	2,868.00	161.01	5.95% [b]	gain
Woody Wetlands Total	0.00	44.03	44.03	100.00%	
Woody Wetlands (undetermined)	0.00	0.00	0.00	0.00%	
Shrub-scrub Wetlands	0.00	40.70	40.70	100.00%	
Mangroves	0.00	0.00	0.00	0.00%	
Estuarine Forested Wetlands	0.00	0.00	0.00	0.00%	
Palustrine Forested Wetlands	0.00	3.34	3.34	100.00%	
Natural (non-armored) Shoreline	333.59	20.91	-312.69	-93.73% [c]	loss
Open Water Total	***3,114.64***	***3,310.13***	***195.49***	***6.28%*** [d]	***gain***

	C-CAP93 Acres	C-CAP00 Acres	Change 93-00 Acres	Change 93-00 Percent	93-00 Gain/Loss
Open Water	3,111.53	3,310.13	198.60	6.38%	gain
Aquatic Bed Total	3.11	0.00	-3.11	-100.00%	
Aquatic Bed (undetermined)	0.00	0.00	0.00	0.00%	
Palustrine Aquatic Beds	0.00	0.00	0.00	0.00%	
Estuarine Aquatic Beds	3.11	0.00	-3.11	-100.00%	
Coral Reefs	0.00	0.00	0.00	0.00%	
Oyster Reefs/Shell Bottom	0.00	0.00	0.00	0.00%	
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	0.00	0.00	0.00	0.00%	
Developed	***1,973.75***	***1,631.04***	***-342.71***	***-17.36%***	***loss***
Agriculture	***0.00***	***0.00***	***0.00***	***0.00%***	
Other Upland	***2,588.90***	***2,843.76***	***254.86***	***9.84%***	***gain***
TOTAL	***10,717.88***	***10,717.88***			

Note: It is important to note possible false errors due to classification differences and limitations of the datasets. The following footnotes provide another possible gain/loss number based solely on change between a land cover class and the developed class which is less prone to differences in classification from one dataset to another.

[a] Wetlands total loss of at least 0.50% (15.35 acres)

[b] Emergent wetlands gain of at most 0.57% (15.35 acres)

[c] Natural (non-armored) shoreline loss of at least 1.13% (3.78 acres)

[d] Open water total gain of at most 0.05% (1.56 acres)

Figure 8-15 shows areas of change from natural shoreline to emergent wetlands (in pink) and open water (in blue). Loss of natural shoreline to development was only 3.78 acres (1.13%).

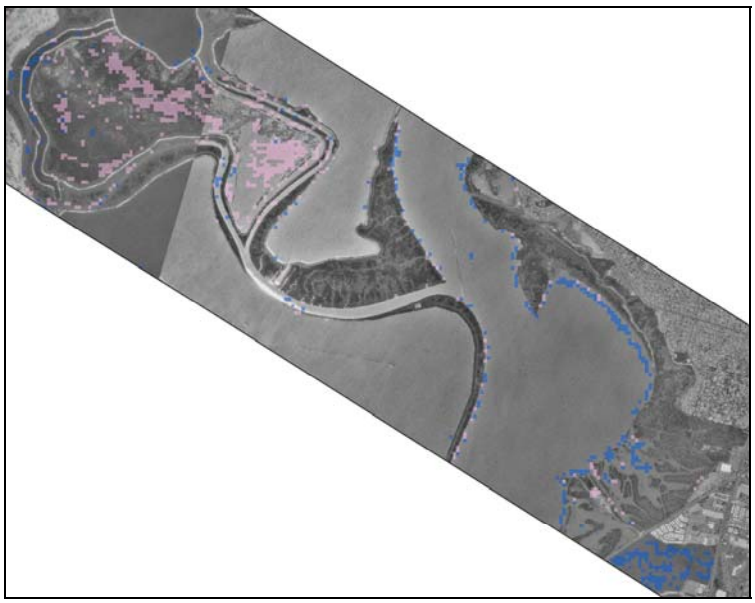


Figure 8-15. 1993 DOQQ showing change from natural shoreline to emergent wetlands (pink) and open water (blue) in C-CAP 1993 to C-CAP 2000.

The most surprising change within the recent change analysis of the San Pablo Bay transect is seen in the loss of acreage for development. This change might again be due to differences in scale and techniques in classifications between the two datasets. Most of the developed acreage changed to other upland habitats. Figure 8-16 shows an area of the transect which changed from development to other upland (green). As seen in the Figure,

there has been classification of houses in neighborhoods as other upland due to the intermittent trees. These 30-meter other upland classifications have overlapped into what should be classified as development but due to the scale of the data are misclassified as other upland.

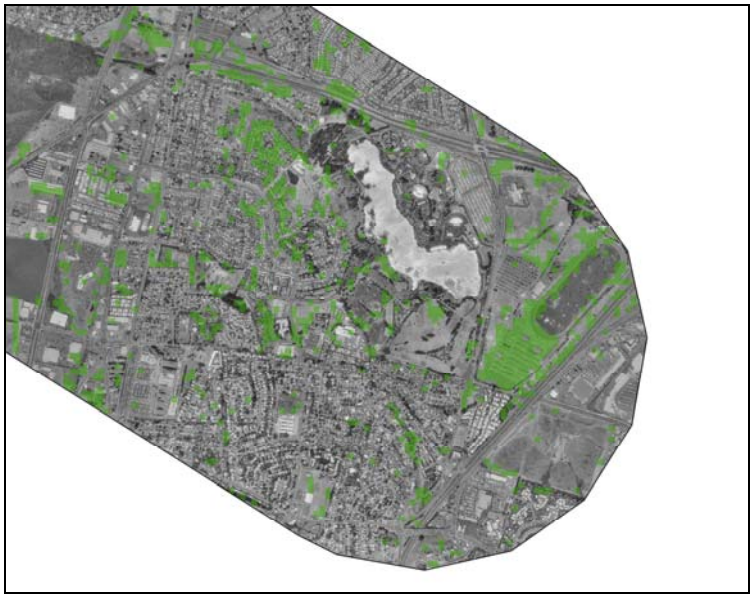


Figure 8-16. 1993 DOQQ showing change from development to other upland (green) in C-CAP 1993 to C-CAP 2000.

The potential causes for loss in habitats can be further examined by looking at Table 8-11, which includes percentages of change in wetland and open water habitats due to conversion to development, agriculture, and/or other upland.

Table 8-11. Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes from 1993-2000.

San Pablo Bay, CA Transect - Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 93-00 Acres**	**Change 93-00 Percent**	**93-00 Gain/Loss**
Wetland Habitats	Developed, Agriculture, Other Upland	191.26		
Developed, Agriculture, Other Upland	Wetland Habitats	267.10		
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		75.84	2.49%	gain
Open Water Habitats	Developed, Agriculture, Other Upland	7.12		
Developed, Agriculture, Other Upland	Open Water Habitats	19.13		
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		12.01	0.38%	gain
Wetland Habitats	Other Upland	164.57		
Other Upland	Wetland Habitats	225.06		
Wetland Habitats Gain/Loss to Other Upland		60.49	1.98%	gain
Wetland Habitats	Agriculture	0.00		
Agriculture	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Agriculture		0.00	0.00%	
Wetland Habitats	Developed	26.69		

From	To	Change 93-00 Acres	Change 93-00 Percent	93-00 Gain/Loss
Developed	Wetland Habitats	42.03		
Wetland Habitats Gain/Loss to Developed		15.35	0.50%	gain
Open Water Habitats	Other Upland	3.56		
Other Upland	Open Water Habitats	14.01		
Open Water Habitats Gain/Loss to Other Upland		10.45	0.33%	gain
Open Water Habitats	Agriculture	0.00		
Agriculture	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Agriculture		0.00	0.00%	
Open Water Habitats	Developed	3.56		
Developed	Open Water Habitats	5.12		
Open Water Habitats Gain/Loss to Developed		1.56	0.05%	gain

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

A more detailed breakdown of changes in land cover classes between 1993 and 2000 for the San Pablo Bay transect can be seen in Table 8-12. This table shows the distribution and change in number of acres between 1993 and 2000. The table also shows the number of acres that remained unchanged over the recent seven-year period. These data support the findings from Table 8-11. The bulk of the increase in emergent wetlands was due to the conversion of other upland and open water, with shifts from scrub-shrub wetlands and developed lands contributing lesser amounts. The conversion of developed land to emergent wetland should be viewed with some skepticism; none of the area shown as changing from developed to wetland in Figure 8-12 shows evidence of development in the 1993 photograph. The other significant change, the loss of natural shoreline, is due largely to an apparent increase in open water. The overall pattern during the recent time period is one of relative stasis, with little loss of wetlands to development or agriculture. Indeed, the most significant change, the loss of natural shoreline, was due to an increase in the amount of open water rather than direct human intervention.

Recent (1993 – 2000) Change Summary

Wetland habitats remained relatively stable during the recent time period. A small gain in the amount of emergent wetland was witnessed, as was a large decline in the amount of natural shoreline. The change in the amount of shoreline did not appear to result directly from human activity, as the bulk of the loss was due to conversion of natural shoreline to open water. Historical records indicate extensive human modification of the area within the transect during the late 1800's and early 1900's, thus it is not surprising that comparisons of recent conditions fail to reveal substantial change.

Table 8-12. Change matrix representing change in acres between land cover classes from 1993 to 2000. Values in the gray shaded cells are acres of no change.

San Pablo Bay, CA Land Cover Change Aerial Photos 1993 to C-CAP 2000 (by acres)									
		1993							
			Wetland Habitats		Open Water Habitats		Non-Wet Land Cover		
			Emergent Wetlands	Natural Non-armored) Shoreline	Open Water	Estuarine Aquatic Beds	Developed	Other Upland	Acreage Totals for 2000 Classification
2000	Wetland Habitats	Emergent Wetlands	2,329.14	173.91	114.53	0.44	34.92	215.06	2,868.00
		Shrub-scrub Wetlands	23.57	2.00	3.34	0.00	3.78	8.01	40.70
		Palustrine Forested Wetlands	1.33	0.00	0.89	0.00	0.00	1.11	3.34
		Natural (Non-armored) Shoreline	12.45	2.45	1.78	0.00	3.34	0.89	20.91
	Open Water Habitats	Open Water	169.02	135.44	2,983.87	2.67	5.12	14.01	3,310.13
	Non-Wet Land Cover	Developed	19.57	7.12	3.56	0.00	1,522.52	78.28	1,631.04
		Other Upland	151.90	12.68	3.56	0.00	404.09	2,271.54	2,843.76
		Acreage Totals for 1993 Classification	2,706.99	333.59	3,111.53	3.11	1,973.75	2,588.90	**10,717.88**

This table presents estimates of acreage by classification and the number of acres that changed classification between the two dates. The data shows the numbers of acres that have changed from 1993 to 2000. The table reads down (1993/from) and to the left (2000/to).

Historical Transect Maps

Figure 8-17 shows the 1958 aerial photos of the San Pablo Bay, CA transect. The 1958 aerial photography was used to classify land cover for the historic time period. Figures 8-18 and 8-19 depict the changes in wetland habitats and open water habitats from 1958 to 2000 respectively. The wetlands change map shows areas that changed from wetland to non-wetland classes and non-wetland to wetland classes. Similarly, the open water change map displays open water to non-open water classes and non-open water to open water classes. These maps are helpful in determining where wetlands and open water habitat changes occurred and which classes they changed between.

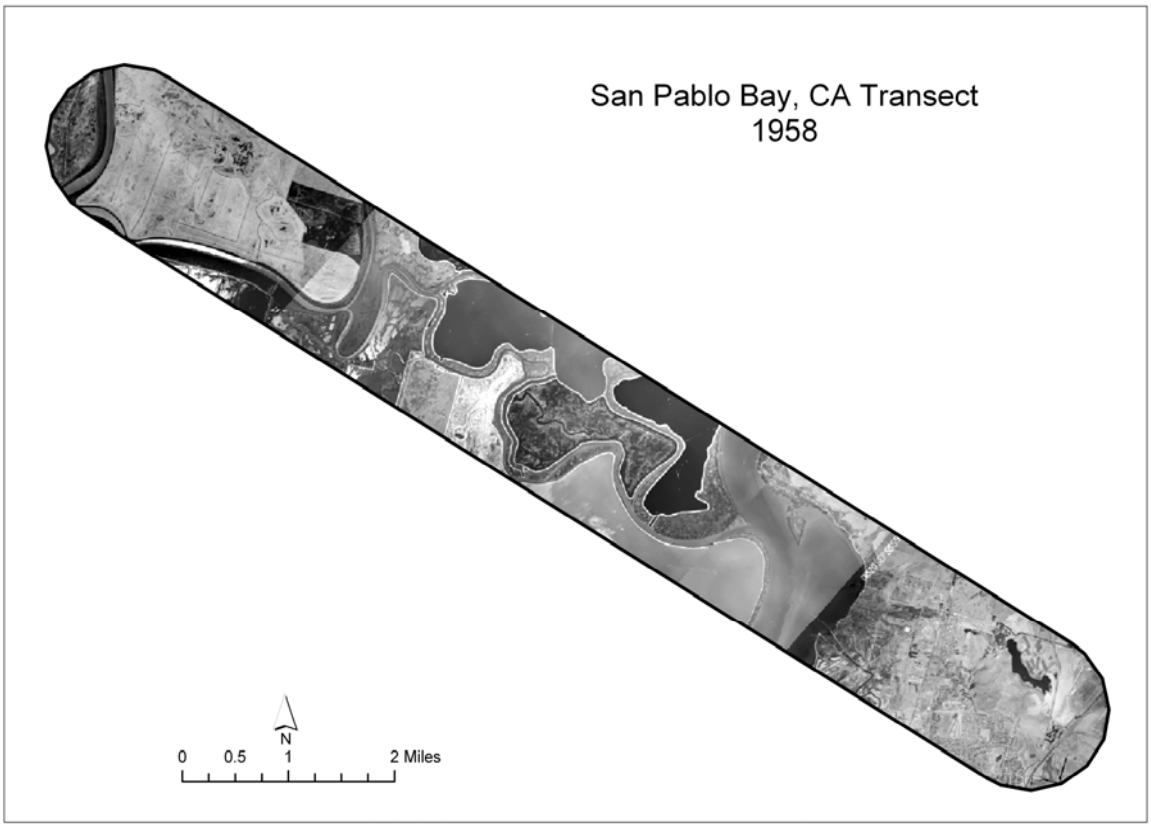


Figure 8-17. 1958 aerial photos of San Pablo Bay, CA transect.

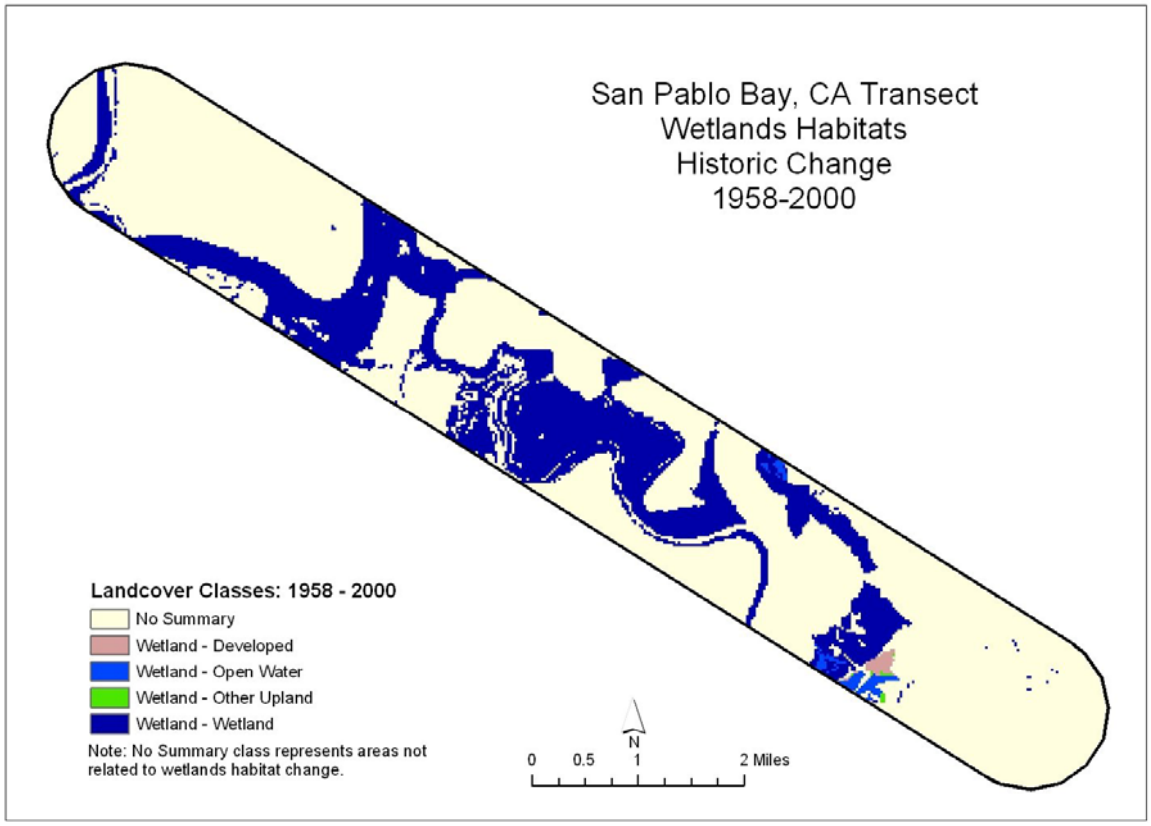


Figure 8-18. Wetland habitats change from 1958-2000, San Pablo Bay, CA transect.

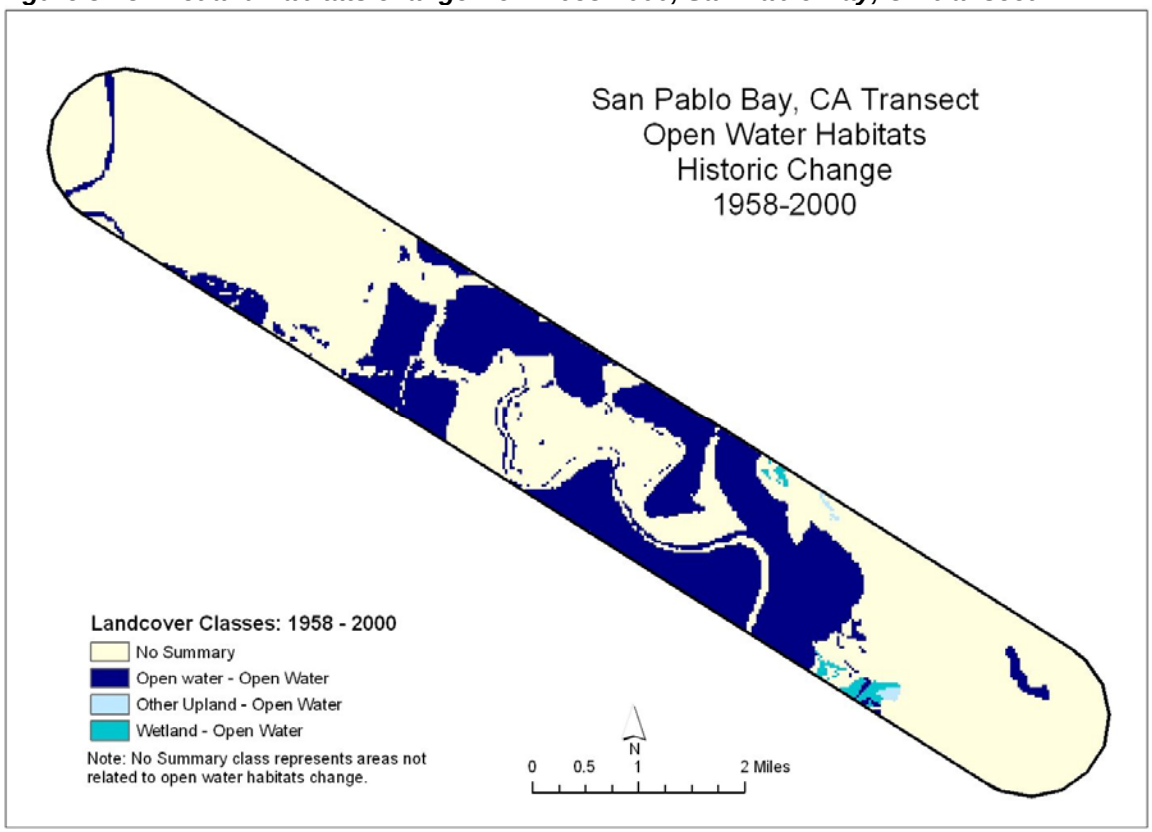


Figure 8-19. Open water habitats change from 1958-2000, San Pablo Bay, CA transect.

Historical (1958 – 2000) Change Tables

Examining conditions in 1958 and 2000 reveals little change in wetland habitats. The major cause of change for emergent wetlands was a shift towards open water, a trend also reflected in the recent change analysis. A small portion of emergent wetlands were lost to development at a loss of 30 acres (1%) (Table 8-13).

The 92.07 gain in open water habitats was strictly due to conversion from emergent wetlands (71.39 acres) and other upland (20.68 acres). As seen in Figure 8-20, most of this change occurred on the edge of the bay and streams.

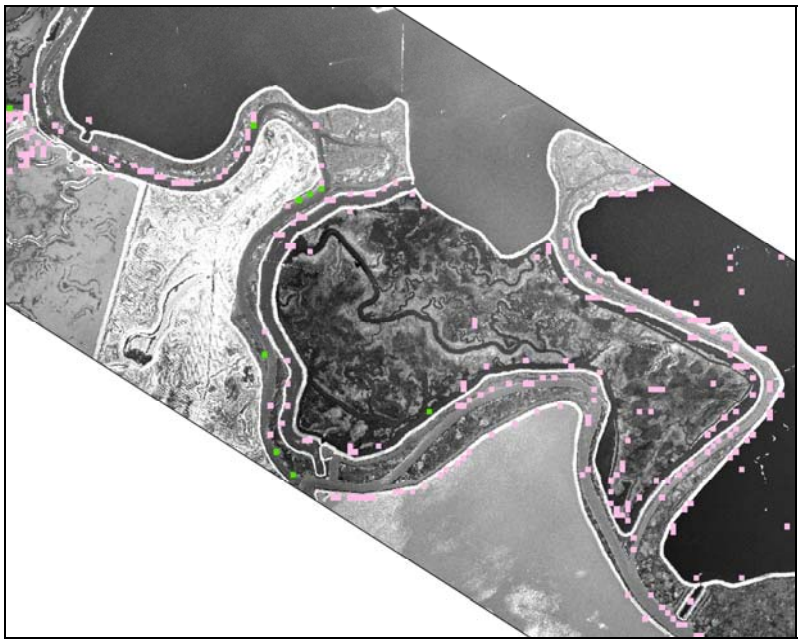


Figure 8-20. 1958 Aerial photo depicting areas that changed from emergent wetlands (pink) and other upland (green) to open water from 1958 to 2000.

Agriculture apparently disappeared from the transect. However, less than nine acres of agriculture were recognized in 1958. In addition, some lands that are used for agricultural purposes, such as hayfields or vineyards, may not be classified as agriculture but rather as other upland.

The extent of other upland decreased by approximately 25% between 1958 and 2000, almost all of which was converted to developed. In fact, the gain in acreage of developed land was due primarily to shifts from other upland (958 acres of the 994 acres gained), with smaller gains coming from conversion of emergent wetland and agriculture (Table 8-15).

Table 8-13. Acreage and change of land cover classes from 1958 to 2000. Please note that gains and losses in the table may reflect discrepancies in the types of data collected in the two different years. See footnotes below the table for alternative estimates that may better reflect actual habitat change.

San Pablo Bay, CA Transect - Dataset Acreage and Change by Land Cover Classes

	HIST58 Acres	C-CAP00 Acres	Change 58-00 Acres	Change 58-00 Percent	58-00 Gain/Loss
Wetlands Total	***3,050.59***	***2,943.84***	***-106.75***	***-3.50%*** [a]	***loss***
Emergent Wetlands	3,021.01	2,914.26	-106.75	-3.53% [b]	loss
Woody Wetlands Total	18.68	18.68	0.00	0.00%	
Woody Wetlands (undetermined)	0.00	0.00	0.00	0.00%	
Shrub-scrub Wetlands	15.79	15.79	0.00	0.00%	
Mangroves	0.00	0.00	0.00	0.00%	
Estuarine Forested Wetlands	0.00	0.00	0.00	0.00%	
Palustrine Forested Wetlands	2.89	2.89	0.00	0.00%	
Natural (non-armored) Shoreline	10.90	10.90	0.00	0.00%	
Open Water Total	***3,243.63***	***3,335.70***	***92.07***	***2.84%*** [c]	***gain***
Open Water	3,243.63	3,335.70	92.07	2.84%	gain
Aquatic Bed Total	0.00	0.00	0.00	0.00%	
Aquatic Bed (undetermined)	0.00	0.00	0.00	0.00%	
Palustrine Aquatic Beds	0.00	0.00	0.00	0.00%	
Estuarine Aquatic Beds	0.00	0.00	0.00	0.00%	
Coral Reefs	0.00	0.00	0.00	0.00%	
Oyster Reefs/Shell Bottom	0.00	0.00	0.00	0.00%	
Hard Bottom	0.00	0.00	0.00	0.00%	
Soft Bottom	0.00	0.00	0.00	0.00%	
Developed	***661.40***	***1,656.17***	***994.77***	***150.40%***	***gain***
Agriculture	***8.90***	***0.00***	***-8.90***	***-100.00%***	***loss***
Other Upland	***3,798.50***	***2,827.31***	***-971.20***	***-25.57%***	***loss***
TOTAL	***10,763.02***	***10,763.02***			

Note: It is important to note possible false errors due to classification differences and limitations of the datasets. The following footnotes provide another possible gain/loss number based solely on change between a land cover class and the developed class which is less prone to differences in classification from one dataset to another.

[a] Wetlands total loss of at least 0.99% (30.25 acres)

[b] Emergent wetlands loss of at least 1% (30.25 acres)

[c] Open water total loss/gain of 0% (0 acres)

The potential causes for loss in habitats can be further examined by looking at Table 8-14, which includes percentages of change in wetland and open water habitats due to conversion to development, agriculture, and/or other upland. The major cause of change for emergent wetlands was a shift towards open water, a trend also reflected in the recent change analysis. Some emergent wetlands were lost to development. The gain in acreage of developed land was due primarily to shifts from other upland, with smaller gains coming from conversion of emergent wetland and agriculture. Given the extent of urbanization around the transect, an increase in developed land at the expense of other classes, including agriculture and other upland, is not surprising.

Table 8-14. Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes from 1958-2000.

San Pablo Bay, CA Transect - Change in Wetlands and Open Water Habitats due to Development, Agriculture, or Other Upland Classes				
From	**To**	**Change 58-00 Acres**	**Change 58-00 Percent**	**58-00 Gain/Loss**
Wetland Habitats	Developed, Agriculture, Other Upland	35.36		
Developed, Agriculture, Other Upland	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Developed, Agriculture, Other Upland		-35.36	-1.16%	loss
Open Water Habitats	Developed, Agriculture, Other Upland	0.00		
Developed, Agriculture, Other Upland	Open Water Habitats	20.68		
Open Water Habitats Gain/Loss to Developed, Agriculture, Other Upland		20.68	0.64%	gain
Wetland Habitats	Other Upland	5.12		
Other Upland	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Other Upland		-5.12	-0.17%	loss
Wetland Habitats	Agriculture	0.00		
Agriculture	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Agriculture		0.00	0.00%	
Wetland Habitats	Developed	30.25		
Developed	Wetland Habitats	0.00		
Wetland Habitats Gain/Loss to Developed		-30.25	-0.99%	loss
Open Water Habitats	Other Upland	0.00		
Other Upland	Open Water Habitats	20.68		
Open Water Habitats Gain/Loss to Other Upland		20.68	0.64%	gain
Open Water Habitats	Agriculture	0.00		
Agriculture	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Agriculture		0.00	0.00%	
Open Water Habitats	Developed	0.00		
Developed	Open Water Habitats	0.00		
Open Water Habitats Gain/Loss to Developed		0.00	0.00%	

Note: This table compares wetland and open water habitats as a whole to non-wet land cover classes as a whole. The overall wetland and open water habitats are also compared to non-wet land cover classes individually in this table. Change to development indicates an actual change since developed land cover is highly unlikely to be misclassified. Agriculture and other upland classes are more susceptible to misclassification as wetlands and vice versa. These changes to agriculture and other upland might indicate a less certain actual change.

A more detailed breakdown of changes in land cover classes between 1958 and 2000 for the San Pablo Bay transect can be seen in Table 8-15. This table shows the distribution and change in number of acres between 1958 and 2000. The table also shows the number of acres that remained unchanged over the 42-year period. These data support the findings from Table 8-14.

Table 8-15. Change matrix representing change in acres between land cover classes from 1958 to 2000. Values in the gray shaded cells are acres of no change.

San Pablo Bay, CA Land Cover Change Aerial Photos 1958 to C-CAP 2000 (by acres)											
		1958									
			Wetland Habitats				Open Water Habitats	Non-Wet Land Cover			
			Emergent Wetlands	Shrub-scrub Wetlands	Palustrine Forested Wetlands	Natural Non-armored) Shoreline	Open Water	Developed	Agriculture	Other Upland	Acreage Totals for 2000 Classification
2000	Wetland Habitats	Emergent Wetlands	2,914.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,914.26
		Shrub-scrub Wetlands	0.00	15.79	0.00	0.00	0.00	0.00	0.00	0.00	15.79
		Palustrine Forested Wetlands	0.00	0.00	2.89	0.00	0.00	0.00	0.00	0.00	2.89
		Natural (Non-armored) Shoreline	0.00	0.00	0.00	10.90	0.00	0.00	0.00	0.00	10.90
	Open Water Habitats	Open Water	71.39	0.00	0.00	0.00	3,243.63	0.00	0.00	20.68	3,335.70
	Non-Wet	Developed	30.25	0.00	0.00	0.00	0.00	661.40	5.78	958.74	1,656.17
		Other Upland	5.12	0.00	0.00	0.00	0.00	0.00	3.11	2,819.08	2,827.31
		Acreage Totals for 1958 Classification	3,021.01	15.79	2.89	10.90	3,243.63	661.40	8.90	3,798.50	**10,763.02**

This table presents estimates of acreage by classification and the number of acres that changed classification between the two dates. The data shows the numbers of acres that have changed from 1958 to 2000.The table reads down (1958/from) and to the left (2000/to).

Historical (1958 – 2000) Change Summary

The transect showed a pattern of change expected given its proximity to the expansive metropolitan area surrounding the San Francisco Bay: declines in wetland habitats at the expense of development. However, wetland losses were relatively small, and most of the gain in developed land appeared to result from the conversion of other upland. Because other upland is a catch-all category, the exact nature of this change is unknown but may reflect the conversion of land used for agricultural production, most notably hayfields, to residential and commercial dwellings. That large wetland losses were not apparent is encouraging from a conservation standpoint, but optimism should be tempered as historical records indicate that extensive habitat modification occurred during the late 1800's and early 1900's. Thus, as has been noted on other transects, the historical photos from 1958 may not accurately capture the extent of change in wetland extent.

Section 8.4 CAF Change Summary (1948 – 2004)

As in the Great Lakes CAF region, the Pacific CAF region had complete land cover datasets available for two separate dates, which allowed for compilation of a change matrix from 1992 to 2000 (Table 8-03).Unlike any of the other CAF regions though, an analysis of two transects, in the Columbia River and San Pablo Bay, was used to interpret and determine overall change for the historic time period starting in 1948 to 2004 as well as for recent changes from 1992 to 2004.

The following analysis looks at trends presented in these two transects as well as the change presented in the Pacific CAF change matrix from 1992-2000. These trends have been summarized within the Pacific CAF region from 1948 to 2004 and 1992 to 2004 in Table 8-16. The table shows actual measured acres lost and gained for the transects at San Pablo Bay and the Columbia River for both the historical and recent periods. In addition, the percent of acres lost and gained for these transects are shown. These specific transect data and CAF matrix were used in conjunction with regional information regarding the CAF to develop estimates for change within the CAF as a whole.

At the CAF level, emergent wetlands showed a significant increase between 1992 and 2000. Overall, the area of emergent wetlands increased by 260%; of this increase, approximately 51% was due to land classified as other upland in 1992 apparently shifting to emergent wetland in 2000. Although some of this gain may be real, the large apparent shift from other upland to emergent wetland is more likely due to differences in how data were acquired. Data from 1992 are based on NLCD estimates, which are gathered at a single point in time. In contrast, the C-CAP data used to estimate wetland extent in 2000 are based on multiple sampling periods. Thus, grasslands that were dry during the 1992 sampling period, perhaps because sampling took place during summer or an otherwise dry period, may have appeared wet during one of the three sampling periods used in 2000, which would result in these areas being categorized as other upland in 1992 but as emergent wetland in 2000. In other words, seasonally wet areas have a greater chance of being detected during the multiple sampling periods of 2000 than during the single period in 1992. If this is the case, then some of the apparent gain in emergent wetlands may be due to an increased probability of detection in 2000, rather than reflecting actual change

in wetland extent. Estimating the extent to which this occurs would require detailed analyses of small areas using supplemental data sources (for example, aerial photos).

Although the apparent 260% increase in emergent wetland area is likely an overestimate, perhaps a significant overestimate, other lines of evidence support at least some increase in the area of emergent wetlands. For example, approximately 26% of the apparent increase in emergent wetland area was the result of a shift from agriculture land into emergent wetland. Some of the transition from agriculture to emergent wetland may result from differences in data acquisition between 1992 and 2000 (for example, wet hayfields or grass plantations), but the degree to which the transition is overestimated should be substantially smaller than for the transition from other upland to emergent wetland (50%). Other land cover classes contributed less significantly to the increase in emergent wetlands: approximately 11% of the gain was due to a shift from open water habitats, 6% from natural shoreline, and 4% from woody wetlands. The gain in emergent wetland at the expense of open water and natural shoreline may reflect colonization of newly available land, perhaps due to differences in water levels between 1992 and 2000, although it may also reflect the more extensive sampling period in 2000. For the same reason that seasonally wet areas may appear as other upland when sampling is limited to a single point in time, open water and natural shore may also exhibit intra-annual variation due to seasonally fluctuating water levels that confound comparisons of data acquired across multiple seasons with data acquired at only time in a year.

Because of the challenges in evaluating change based on data collected in different fashions, accurately quantifying the degree of change for emergent wetlands is difficult. Emergent wetlands may be especially problematic in this regard because they are grossly similar in physiognomy to certain categories of agriculture (for example, hayfields) or other upland (for example, grazed pasture) In the Columbia River transect, emergent wetlands declined by 22-25% in both the historic and recent time periods. The San Pablo transect recorded a slight increase in emergent wetlands during the seven-year recent time period, but historic losses were in the 3% range. The recent increase is not representative of conditions for these transects in other periods, and is not consistent with other reports of wetland extent for the region as a whole. For the CAF as a whole, a 7 to 40% decline was estimated for the historic period. Variability in the transect results widens the range estimated for the shorter recent period, with declines listed as ranging from 8 to 20%. These results appear to vary by location quite a bit, as the situations in the Columbia River and the San Pablo Bay appear to have diverged somewhat during recent years.

Woody wetlands also appeared to increase dramatically within the Pacific CAF from 1992 to 2000. However, nearly all of this change can be attributed to the procedure with which habitat groups were classified; in 1992, woody wetlands did not include shrub-scrub wetlands, palustrine forested wetlands, or estuarine forested wetlands. The addition of these subgroups to the woody wetland category accounts for all of the change, and it is impossible to determine how much land would have been assigned to these subgroups in 1992. However, some patterns emerge after excluding the area accounted for by new subgroups added to this category in 2000. Approximately 20% of the land classified as woody wetland in 1992 was classified as shrub-scrub wetland in 2000; another 20% was classified as estuarine forested wetland. Transition to other upland accounted for 38% of

the change in woody wetland, but much of this increase may reflect the enhanced ability of C-CAP data to discern wet areas from dry areas. Relatively little woody wetland was converted to agriculture (2%) or developed land (1.2%), which, after accounting for differences in habitat categories in 1992 and 2000, suggests that woody wetlands were relatively stable to slightly declining over the period. As with emergent wetlands, conclusions about the status of woody wetlands in the Pacific CAF must remain tentative due to procedural issues that confound comparisons among the NLCD and C-CAP data.

The extent of natural shoreline declined sharply between 1992 and 2000. Nearly all of this change was due to a difference in classification in 2000 of natural shoreline into other upland (81%) and developed (10%). As with emergent wetlands and woody wetlands, the extent of the shift of natural shoreline into other upland is questionable. Seasonal changes in water level, which will result in intra-annual variation in the extent of natural shoreline, are not captured in the 1992 data, which rely on a single sample. However, the 2000 data, captured over several sampling occasions, are more likely to detect these changes and thus generate an estimate of shoreline that takes into account high and low water flows. In contrast, the estimate of area of natural shoreline converted to development is more plausible and unlikely to be strongly biased by variation in data collection methodologies. Thus, the data suggest a decline in the amount of natural shoreline between 1992 and 2000, albeit a smaller decline than the estimated 89% when shifts to other upland are included. Most of the decline appears to be driven by increased waterfront development, as shifts from natural shoreline to other wetland categories were minor in amount.

Among the non-wet classes, the most significant change is the apparent decline in the amount of agriculture. However, most of this change (83%) is due to a shift into other upland. Some of this change may be real, reflecting the abandonment of agricultural fields, or it may instead reflect changing agricultural practices (for example, a shift from row crops to grass production) or, again, simply differences in the resolution and precision of the C-CAP data relative to the NLCD data. Total farmland in Oregon, Washington, and California decreased by 3.8% between 1992 and 2002, but the total acreage of cropland increased 4.0%. Thus, the 51% decline reported here is likely due to differences in methodology in how the NLCD and C-CAP data were collected. Other upland and developed land both experienced net increases in area, although each category had substantial losses to wetland and non-wetland habitats that were offset by the overall gain in acreage.

Overall, wetland habitat groups appeared to make net gains in acreage between 1992 and 2000. However, all of this gain was due to apparent increases in the amount of emergent wetland and woody wetland, which, as discussed above, should be viewed with some skepticism. Likewise, the apparent decline in non-wetland types was driven by the large change in acreage from agriculture to other upland, a shift which likely reflects differences in data collection methods. In general, because of inherent differences between the C-CAP and NLCD data, the results presented here almost certainly overestimate the degree of change among all habitat groups. Land use in the Pacific CAF has likely been far more stable than indicated by these data.

Conditions in the Pacific CAF changed considerably between 1948 and 2004. Following the end of the Second World War, logging operations in the west expanded. Urban development also accelerated due to the post-war housing boom. Many agricultural areas also expanded the amount of acreage under production. The combined effect of these changes reduced many of the natural aspects of estuaries in the region, while increasing the amount of the land cover that was dominated by human uses.

Examining the results from the Columbia River transect, we see that overall wetland losses from 1948 to 2000 for the area were approximately 1%, while the last 8 years of this period experienced high losses of around 20%. Examination of the subcategories shows that for the historic period, the shrub-scrub type wetlands increased by 12%, while in the last 8 years of this period they lost 21%. Although there are photo interpretation issues that may have contributed to overestimation of scrub-shrub wetlands in the historic air photos as compared with more recent satellite data, it is clear that there was some change in the Columbia River transect that led to an increase in shrub-scrub wetlands during the historic time period, largely from emergent wetlands. We suggest that river channel dredging and shoreline consolidation within the transect area created slightly more land area that was now high enough above the water to support shrub-scrub wetlands, perhaps at the expense of former mudflats with emergent wetland vegetation. The shift from more delicate wetland types like emergent to slightly more robust types such as scrub-shrub would be consistent with observed changes in wetlands that favor species less dependent upon specific hydrology for survival. In short, the shrubs could survive periodic flooding, as could emergents, but only the shrubs could survive the localized dry soils created by diking and land consolidation. However, over the entire time period, the forces causing overall wetland loss are much larger than these small-scale mechanisms. Thus, whatever the internal changes within wetland types, the overall trend for wetlands as a whole, along with sub-types, is toward decline.

The San Pablo Bay transect experienced extremely high losses of wetlands during the same historical period. Unlike the more isolated geographical location of the Columbia transect, agriculture in the San Pablo transect expanded dramatically during the historic period. This lead to an overall loss of wetlands of 3.54% Because of the difference in data sets, there is no detail at this site for types of wetlands. However, visual interpretation of the cover types in the transect show that a large amount of the previous wetlands were probably in the emergent wetlands class. This would be typical of the Bay Area as a whole and of the San Pablo Bay location specifically.

These two locations reflect many of the changes that have been affecting estuarine wetlands throughout the CAF. Channelization, conversion of wetlands to agriculture, and general development of wetland areas as part of the expansion of urban centers have all been major causes of wetland losses throughout this area from1948 to 2004. Although the rate of loss is slightly different in the two transects, the overall trend is clear: wetland area is declining and the area of emergent wetlands appears to account for much of the decline.

Table 8-16. Estimated target habitat group change from 1948-2004 for the Pacific Coast CAF region based on local expert analysis of recent and historic habitat change of the Columbia River and San Pablo Bay transects. Estimated acreages were calculated using estimated percent change in conjunction with the NLCD 1992 acres for each target habitat group and land cover type (Table 8-01). Also see Appendix C, Tables 13-04k – 04l for further detailed acreage values.

		Columbia River, OR-WA Transect				San Pablo Bay, CA Transect				Pacific CAF Region			
		1948-2000 Historic Acres Gain/Loss	1948-2000 Historic Percent Gain/Loss	1992-2000 Recent Acres Gain/Loss	1992-2000 Recent Percent Gain/Loss	1958-2000 Historic Acres Gain/Loss	1958-2000 Historic Percent Gain/Loss	1993-2000 Recent Acres Gain/Loss	1993-2000 Recent Percent Gain/Loss	Historic 1948 to 2004 Estimated Acres Gain/Loss	Historic 1948 to 2004 Estimated Percent Gain/Loss	Recent 1992 to 2004 Estimated Acres Gain/Loss	Recent 1992 to 2004 Estimated Percent Gain/Loss
Wetlands Habitat	***Wetlands Total[1]***	***-37.58***	***-1.07%***	***-914.71***	***-20.51%***	***-106.75***	***-3.50%***	***-107.64***	***-3.54%***	***-66,080 to -82,321***	***-10% to -15%***	***-118,915 to -247,153***	***-18% to -45%***
	Emergent Wetlands	-316.02	-22.04%	-365.17	-24.25%	-106.75	-3.53%	161.01	5.95%	-7,288 to -50,962	-7% to -40%	-5,096 to -25,481	-5% to -20%
	Woody Wetlands Total[2]	266.87	14.00%	-355.83	-13.85%	0.00	0.00%	44.03	100.00%	2,950 to -749	4% to -1%	-8,523 to -11,080	-12% to -15%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	no data	no data	no data	no data	no data	5% to 10%	no data	no data
	Shrub-scrub Wetlands	130.10	12.16%	-329.59	-21.02%	0.00	0.00%	40.70	100.00%	no data	no data	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	136.77	16.35%	-26.24	-2.62%	0.00	0.00%	3.34	100.00%	no data	10% to 15%	no data	no data
	Natural (non-armored) Shoreline	11.56	6.30%	-193.71	-50.29%	0.00	0.00%	-312.69	-93.73%	-57,434 to -35,099	-12% to -10%	-105,296 to -210,592	-22% to -60%
Open Water Habitats	***Open Water Total[3]***	***-31.58***	***-1.10%***	***187.03***	***7.07%***	***92.07***	***2.84%***	***195.49***	***6.28%***	***4,151 to -13,336***	***1% to -3%***	***19,963 to 31,941***	***5% to 7%***
	Open Water	-31.58	-1.10%	187.03	7.07%	92.07	2.84%	198.60	6.38%	no data	no data	no data	no data
	Aquatic Bed Total[4]	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed (undetermined)**	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data

		no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
NonWet	***Developed***	***65.38***	***51.85%***	***-185.70***	***-48.32%***	***994.77***	***150.40%***	***-342.71***	***-17.36%***	***1,114,932 to 2,586,643***	***50% to 200%***	***668,959 to 1,204,127***	***30% to 93%***
	Agriculture	***0.00***	***0.00%***	***374.07***	***11213.33%***	***-8.90***	***-100.00%***	***0.00***	***0.00%***	***-165,710 to -406,743***	***-5% to -12%***	***-165,710 to -331,421***	***-5% to -10%***
	Other Upland	***3.78***	***0.10%***	***539.31***	***16.49%***	***-971.20***	***-25.57%***	***254.86***	***9.84%***	***1,748,642 to 5,856,200***	***5% to 18%***	***3,338,317 to 5,007,475***	***10% to 15%***

1 "Emergent Wetlands", "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", "Palustrine Forested Wetlands", and "Natural (non-armored) Shoreline" have been summarized in "Wetlands Total".
2 "Woody Wetlands", "Shrub-scrub Wetlands", "Mangroves", "Estuarine Forested Wetlands", and Palustrine Forested Wetlands" have summarized in "Woody Wetlands Total".
3 "Aquatic Beds", Palustrine Aquatic Beds", Estuarine Aquatic Beds", "Coral Reefs", "Oyster Reefs/Shell Bottom", "Hard Bottom" and "Soft Bottom" have been summarized in "Open Water Total".
4 "Aquatic Beds", "Palustrine Aquatic Beds", and "Estuarine Aquatic Beds" have been summarized in "Aquatic Bed Total".
* "Woody Wetlands (undetermined)" includes wetlands not specifically identified by system (palustrine, estuarine, etc.) and/or type of woody vegetation (shrub-scrub, forested, etc.).
** "Aquatic Bed (undetermined)" includes aquatic beds not specifically identified by system (palustrine, estuarine, etc.).

Section 9.0 Coastal Continental US

Section 9.1 Overview

The central questions that this document seeks to address are: What is the extent and condition of estuarine and Great Lakes wetlands in the continental United States?, and: How have the extent and type of wetland and open water habitats changed during the historical period (1938 to 2004), and more recently (1992 to 2004)?. Also important to determine are the reasons for these changes, derived mostly from analyzing what appears in locations where wetlands are no longer present.

Findings from previous studies on this topic have primarily addressed overall wetland loss starting from the baseline of completely natural conditions prior to the establishment of the US in North America. During the 200-year period from 1780 to 1980, estimates are that 50% of the existing wetlands in the conterminous US were lost (Dahl 1990). Estimates are not available for strictly coastal wetlands from this study.

Section 9.2 Recent and Historical (1938-2004) Change Summary

Results

The total area for all six CAF regions is roughly 230,000,000 acres. Figure 9-01 shows percentage of land cover for these regions based on 1992 National Land Cover Dataset mapping.

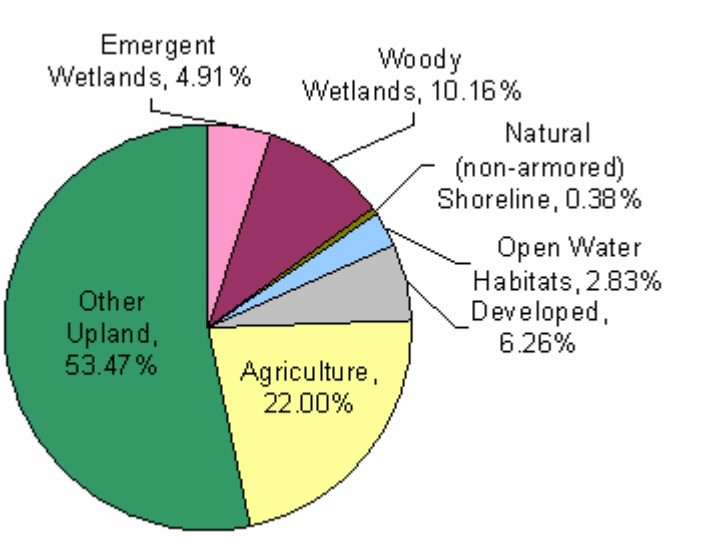


Figure 9-01. Percentage of Emergent Wetlands, Woody Wetlands, Natural (non-armored) Shoreline, Open Water Habitats, Agriculture, Development and Other Upland classes within the lower 48 continental CAF regions, 1992.

For the coastal Continental US, both the recent and historical periods have seen losses in wetlands in all areas examined. Table 9-01 summarizes overall continental change based on CAF regions.

There appears to be an acceleration of the rates of loss in the recent period as compared with the historic period as a whole. There are a number of factors that could explain these results. Population has continued to increase. In the most recent time period, expansion has been associated with a housing boom that began during the 1990's and accelerated with the decline in interest rates from 2001. Most new construction has been concentrated in suburban areas, spreading further from urban cores. Combined with the continuing movement of the United States population to cities near the coastlines, these socioeconomic factors have contributed to the observed increase in rates of decline.

There are also geospatial aspects of coastal wetland conditions that are a strong factor in the observed data. Studies done in detail on the Columbia River estuary (Garono et al. 2003) observe that the structure of wetlands along estuaries and rivers has changed from the beginning of the historic period to the recent period. Previously, wetlands tended to be strung out along lines of water flow, either tidal or riverine, and were connected. Agricultural, commercial, and residential development has fragmented the wetland landscape. Most coastal wetlands now exist as patches in a more developed matrix. The process of fragmentation tends to lead to a point where losses become much faster as patches become too small to survive disturbances or maintain their previous hydrological and vegetative character.

Fragmentation also has implications on the regulatory side for wetlands. Changes in the U.S. Army Corps of Engineers rules on development of wetlands relaxed restrictions on development of small, isolated wetlands. This has led to an increase in the rate of conversion that is observed in the data from this study.

Although there are regional variations, one theme is quite clear: losses have tended to be due to increased development around cities and along transportation corridors. The rate of wetland loss to developed area roughly tracks the rate of population increase in each region. This trend is strongest in the CAFs and transects that are closest to urban centers. Only in the Gulf Coast CAF are there substantial wetland losses due to agricultural expansion, especially in the recent period. These resulted in losses to the woody wetlands category of 19-36% from 1957 to 2004 (Table 9-02).

Emergent wetlands are among the most sensitive to change. These wetlands are based in shallow, typically muddy substrates that are maintained within a range of inundation and support wetland plant species with tolerances to the inundation and salinity ranges. Changes in sediment supply, channel configuration, and in the amount of natural shoreline are all reflected in the emergent wetland category. In all regions, emergent wetlands declined anywhere from 7 to 40%, with most regions reporting declines averaging 10 to 20% during the historic period. In the recent time period, estimated losses continued at relatively the same rates as for the overall historical period. (Table 9-03).

Woody wetlands were distinctly identified in the regions which had data from the C-CAP mapping effort or regional data. In most of these regions except for the Pacific CAF, woody wetlands declined at an estimated 7-52% in the historic time period, with an

overall average loss of 21%. Recently, the regions averaged a loss of approximately 15%, with the New England CAF leading the high end of the range with a 38% loss. Results based on the transects yielded small increases in the amount of woody wetlands in the Pacific CAF at the Columbia River Transect and in the Great Lakes CAF at the Chicago transect. In both cases there appear to be some classification errors between other upland and woody wetlands which contribute to the estimated increase in the category. A transition from the emergent wetland class to the woody wetland class due to shoreline consolidation seems to be the other major factor in the increases at these sites.

The amount of natural shoreline declined in all of the regions. The typical decline was estimated in the 4-23% range, with slightly higher rates in the historic period than in the recent. The range of loss was estimated as up to 32% on the Gulf Coast and 28% on the South Atlantic coast. Slight increases in natural shoreline were recorded from the San Pablo Bay transect, reflecting protection of wetlands in that location. Overall losses in natural shoreline of 10 to 12% from 1948 to 2004 were estimated for the Pacific CAF region, yet large decreases in the past 12 years (22 to 60% of original 1948 acreage) have created an anomaly in the overall continental calculations for this class (Table 9-01).

The amount of open water for each region varies widely, and the estimates for this category contain very wide ranges. Open water, to some extent, should be the inverse of the amount of shoreline. Since only the non-armored/natural shoreline is identified, it is hard to give any firm interpretation to the estimates of the open water category. Further, the amount of open water in each CAF is strongly influenced by geographic and topographic factors. These factors strongly bias the numbers towards areas with large coastal waterways. Indeed, the Gulf Coast region shows a large increase of over 300,000 acres in the amount of open water during the historic period, primarily the result of subsidence in the western portion of the CAF due to oil, gas and fresh water extraction, coupled with reduced sediment supply caused by damming and flood water diversion projects. This is in contrast to the loss of open water in the other regions during this period. Since reliable numbers for both the category as a whole, and for the sub-categories of aquatic bed types, are not available, analysis of this category does not shed much light on the overall situation of coastal wetlands.

Development is identified as one of the primary factors in wetland losses throughout the coastal United States. Developed lands increased by 20-50% in the historic time period in all regions but the Gulf Coast where the rate is 56-81% and the Pacific Coast which has increases of 50 to 200%. During the more recent time period, the rate of development from historic dates is estimated in the 11-30% range for all but the Gulf Coast and Pacific Coast, where it was estimated at 36-56% and 30 to 93% of the historic baseline acreage. This reflects the trend in population growth, with the southern tier states having seen large migrations from northern states.

Agriculture has declined over the historic period at rates ranging from 5 to 35% in all regions except the Gulf Coast and Great Lakes, where agriculture expanded between 7 and 23%. The rate of decline slowed during the recent time period to the 3-16% range in

most of the regions, while the rate of growth for the Gulf Coast and Great Lakes slowed to 5 to 16% and 2 to 10% respectively.

The other upland category is less reliable as an indicator because it summarizes all not otherwise categorized land. It also reflects more strongly the overall size and shape of the CAF as it is projected inland, rather than focusing strictly on the coast. For these reasons we have reported the results as part of the overall tables, but not analyzed them further.

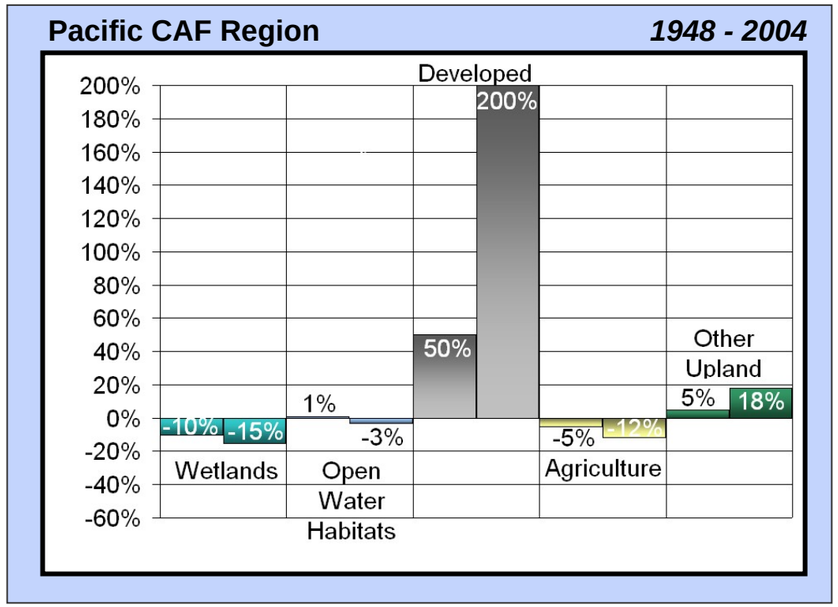
Table 9-01. Overall calculated acreage and percentage of change for CAF regions. These calculations are based on the estimates for each individual CAF region from 1938-57to 2004 (historic) and 1992-2004(recent).

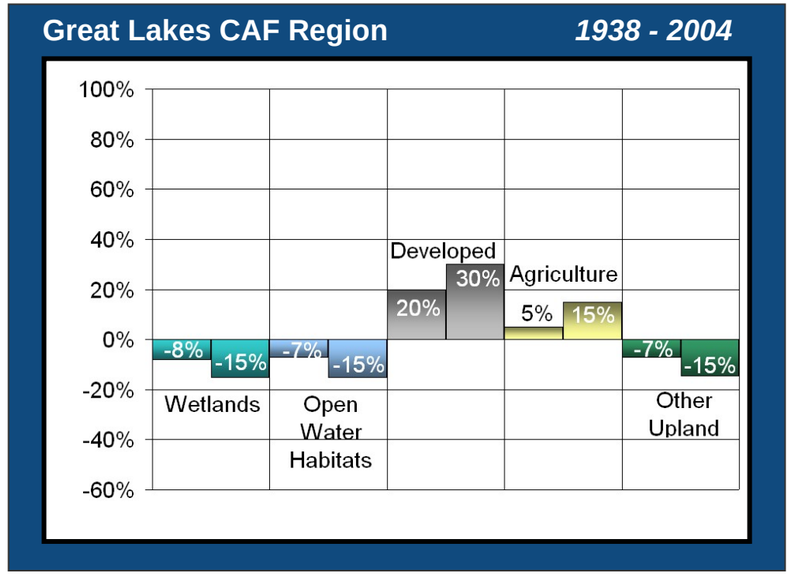
		Continental US CAF Regions (Acres)	Continental US CAF Regions (Percentages)	Continental US CAF Regions (Acres)	Continental US CAF Regions (Percentages)
		1938-57 to 2004	**1938-57 to 2004**	**1992 to 2004**	**1992 to 2004**
Wetland Habitats	***Wetlands Total***	***-4,888,837 to -11,713,875***	***-13% to -28%***	***-2,701,946 to -6,269,256***	***-7% to -15%***
	Emergent Wetlands	-1,776,708 to -4,433,446	-14% to -32%	-840,230 to -1,955,865	-7% to -14%
	Woody Wetlands Total	-2,852,470 to -7,136,229	-12% to -27%	-1,730,271 to -4,038,809	-7% to -15%
	Woody Wetlands (undetermined)	no data	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data
	Mangroves	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data
	Natural (non-armored) Shoreline	-104,330 to -146,736	-12% to -20%	-131,445 to -274,581	-15% to -37%
Open Water Habitats	***Open Water Total***	***-89,265 to -331,414***	***-1% to -4%***	***-70,988 to -146,334***	***-1% to -2%***
	Open Water	no data	no data	no data	no data
	Aquatic Bed Total	no data	no data	no data	no data
	Aquatic Bed (undetermined)	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data
Non Wet	***Developed***	***4,738,113 to 7,718,689***	***38% to 69%***	***2,542,118 to 4,368,761***	***21% to 39%***
	Agriculture	***-1,302,692 to -2,299,073***	***-2% to -4%***	***688,477 to -138,390***	***1% to -.3%***
	Other Upland	***-446,459 to -6,180,179***	***-.4% to -5%***	***2,115,437 to 2,952,419***	***1% to 2%***

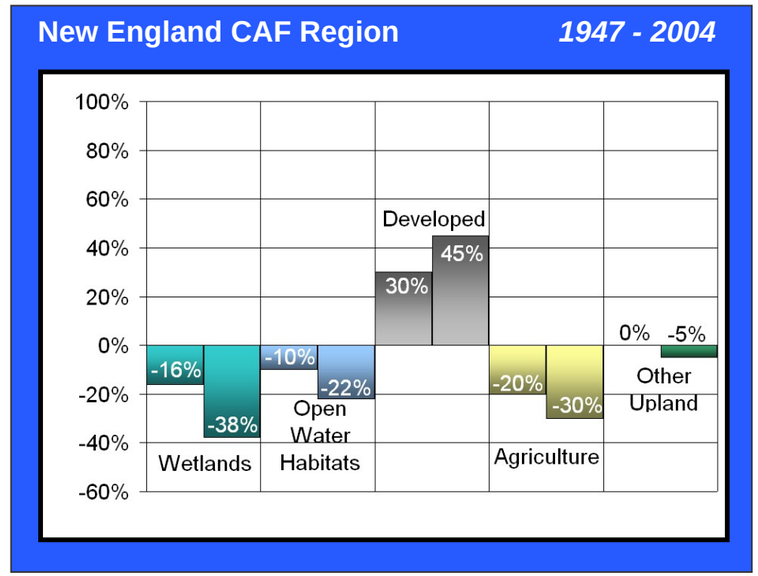
Table 9-02. Estimated percentages of gain or loss by CAF region during respective historical time period.

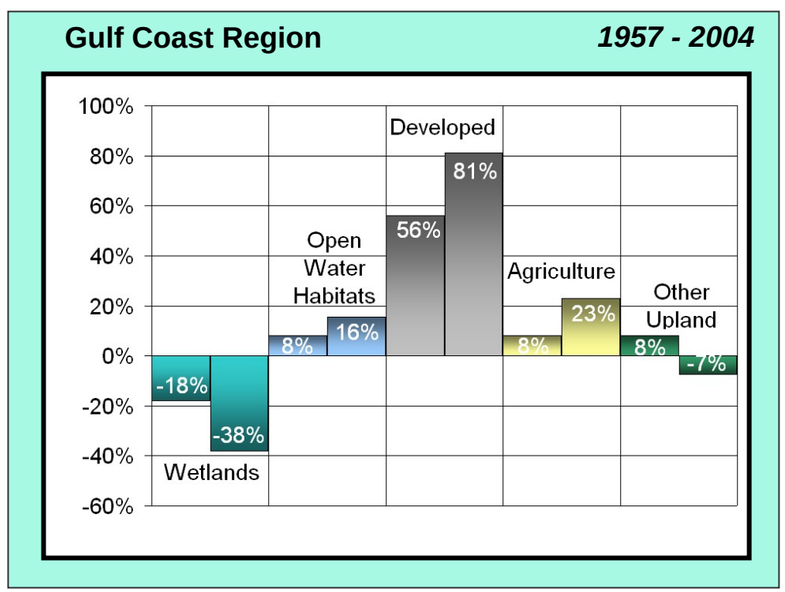
		Gulf Coast CAF Region	Mid Atlantic CAF Region	South Atlantic CAF Region	Great Lakes CAF Region	New England CAF Region	Pacific CAF Region
		1957-2004	1939-2004	1953-2004	1938-2004	1947-2004	1948-2004
Wetland Habitats	***Wetlands Total***	***-18% to -38%***	***-17% to -42%***	***-8% to -19%***	***-8% to -15%***	***-16% to -38%***	***-10% to -15%***
	Emergent Wetlands	-17% to -40%	-17% to -21%	-8% to -11%	-10% to -20%	-13% to -28%	-7% to -40%
	Woody Wetlands Total	-19% to -36%	-17% to -52%	-7% to -21%	-7% to -15%	-17% to -43%	4% to -1%
	Woody Wetlands (undetermined)	no data	no data	no data	no data	no data	5% to 10%
	Shrub-scrub Wetlands	no data	5% to -5%	-5% to -15%	5% to -5%	-10% to -15%	no data
	Mangroves	-5% to -10%	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	-10% to -20%	5% to -5%	-5% to -10%	-2% to -5%	10% to 15%
	Natural (non-armored) Shoreline	-14% to -32%	-17% to -24%	-10% to -28%	-7% to -15%	-10% to -17%	-12% to -10%
Open Water Habitats	***Open Water Total***	***8% to 16%***	***-12% to -22%***	***0% to -7%***	***-7% to -15%***	***-10% to -22%***	***1% to -3%***
	Open Water	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total	-5% to -10%	no data	0% to -3%	no data	-5% to -10%	no data
	Aquatic Bed (undetermined)	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	0% to -10%	no data	no data	-3% to -10%	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	0% to -5%	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data
NonWet	***Developed***	***56% to 81%***	***35% to 50%***	***30% to 45%***	***20% to 30%***	***30% to 45%***	***50% to 200%***
	Agriculture	***8% to 23%***	***-25% to -35%***	***-20% to -35%***	***5% to 15%***	***-20% to -30%***	***-5% to -12%***
	Other Upland	***8% to -7%***	***-10% to -20%***	***-5% to -10%***	***-7% to -15%***	***0% to -5%***	***5% to 18%***

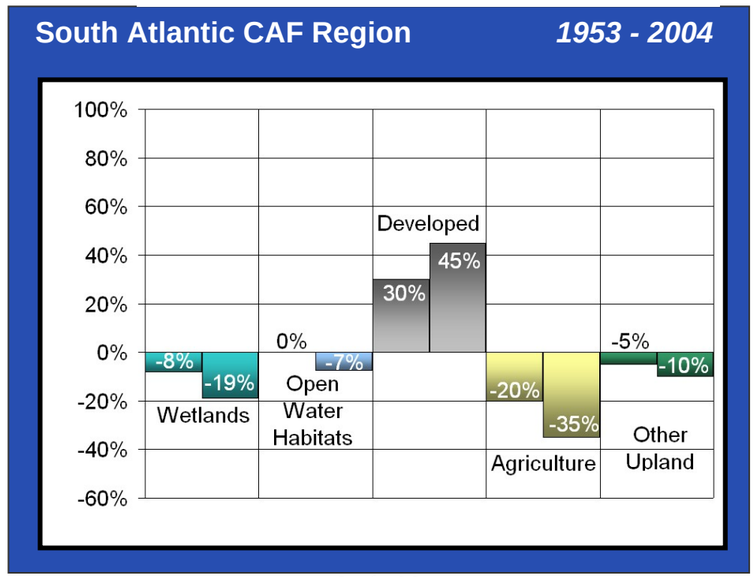
Figure 9-02. Percentage of Change in Extent of Wetlands, Open Water Habitats, Development, Agriculture, and Other Upland Since Historic Baseline Year











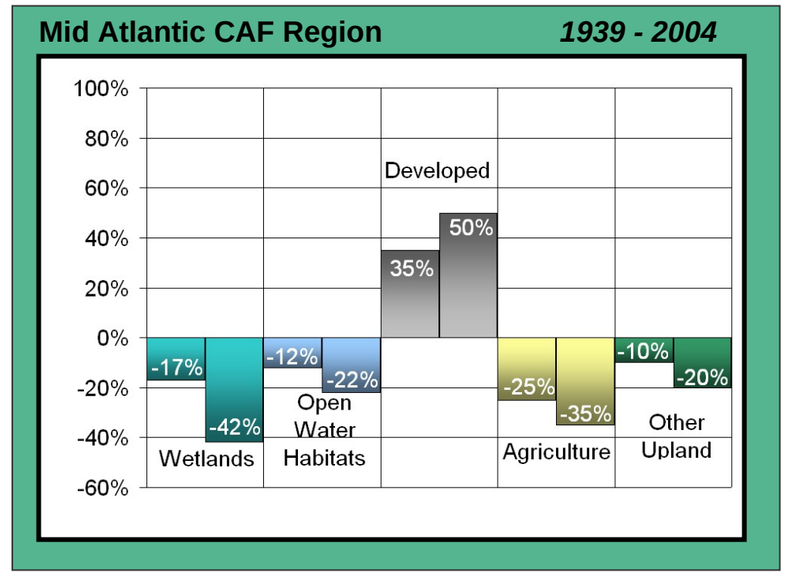
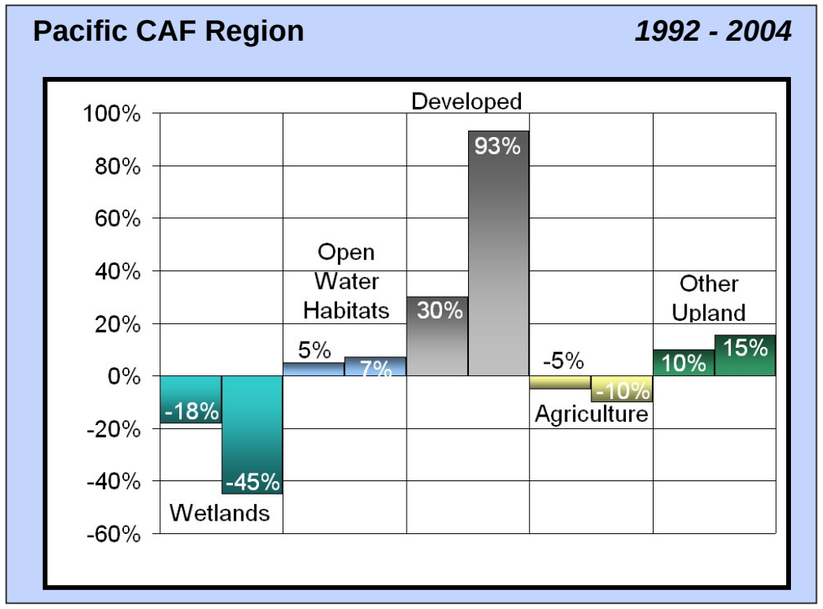
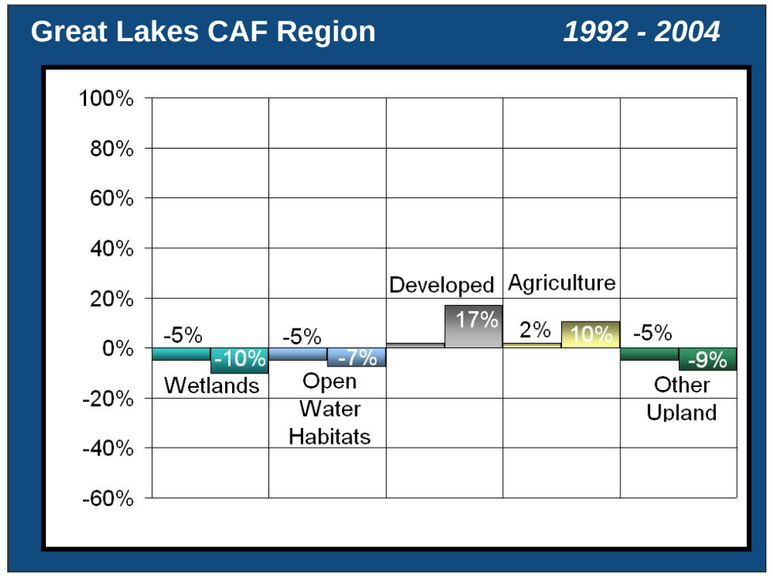


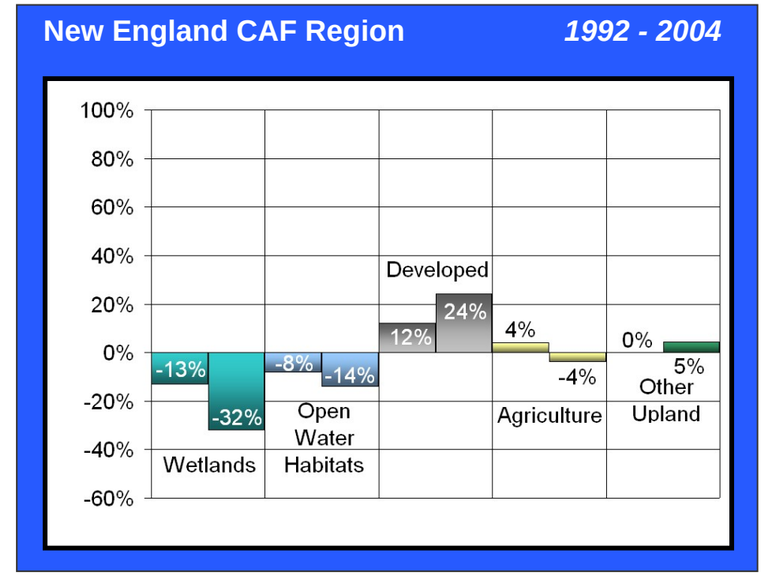
Table 9-03. Estimated percentages of gain or loss by CAF region during the recent (1992-2004) time period.

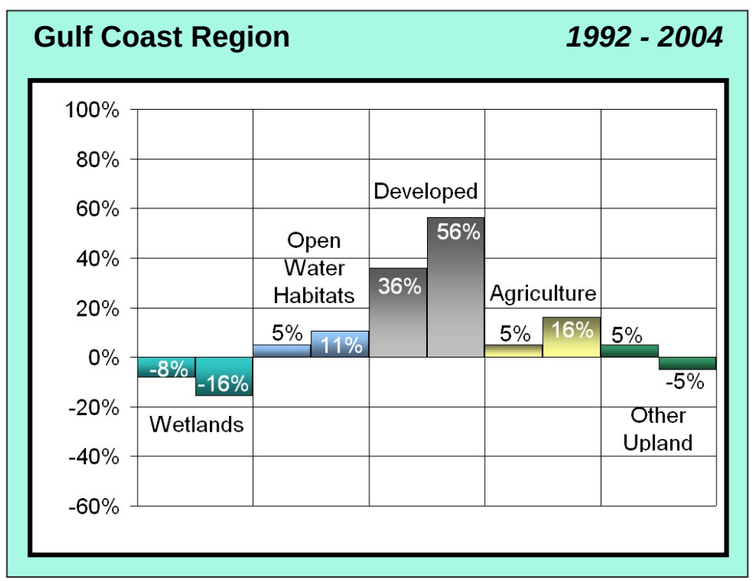
		Gulf Coast CAF Region	Mid Atlantic CAF Region	South Atlantic CAF Region	New England CAF Region	Great Lakes CAF Region	Pacific CAF Region
		1992-2004	1992-2004	1992-2004	1992-2004	1992-2004	1992-2004
Wetland Habitats	***Wetlands Total***	***-8% to -16%***	***-13% to -26%***	***-5% to -13%***	***-13% to -32%***	***-5% to -10%***	***-18% to -45%***
	Emergent Wetlands	-7% to -15%	-11% to -14%	-5% to -10%	-9% to -20%	-5% to -14%	-5% to -20%
	Woody Wetlands Total	-9% to -16%	-15% to -32%	-5% to -14%	-15% to -38%	-5% to -9%	-12% to -15%
	Woody Wetlands (undetermined)	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data	no data	no data
	Natural (non-armored) Shoreline	-7% to -17%	-11% to -16%	-5% to -18%	-7% to -11%	-5% to -9%	-22% to -60%
Open Water Habitats	***Open Water Total***	***5% to 11%***	***-10% to -16%***	***0% to -5%***	***-8% to -14%***	***-5% to -7%***	***5% to 7%***
	Open Water	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total	no data	no data	no data	no data	no data	no data
	Aquatic Bed (undetermined)	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data
NonWet	***Developed***	***36% to 56%***	***18% to 30%***	***17% to 24%***	***12% to 24%***	***2% to 17%***	***30% to 93%***
	Agriculture	***5% to 16%***	***-4% to -16%***	***-9% to -16%***	***4% to -4%***	***2% to 10%***	***-5% to -10%***
	Other Upland	***5% to -5%***	***0% to 7%***	***-3% to -8%***	***0% to 5%***	***-5% to -9%***	***10% to 15%***

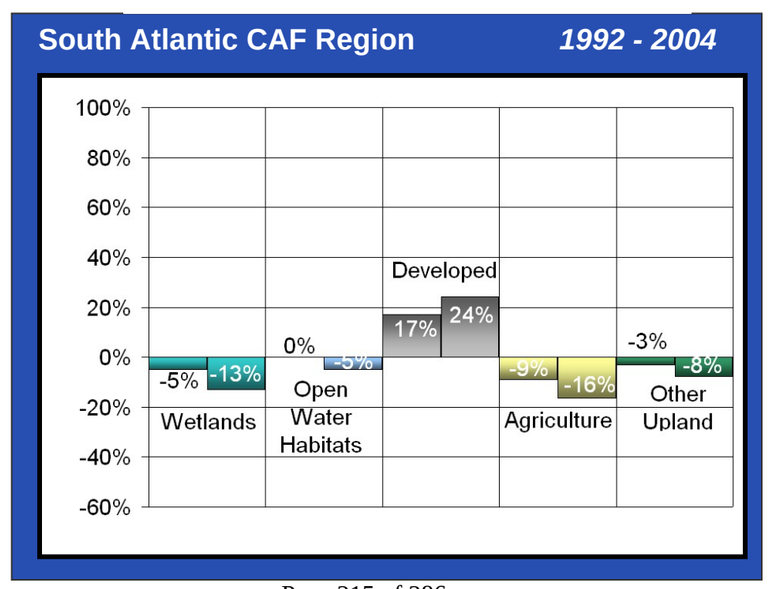
Figure 9-03. Percentage of Recent Change in Extent of Wetlands, Open Water Habitats, Development, Agriculture, and Other Upland (1992 to 2004)

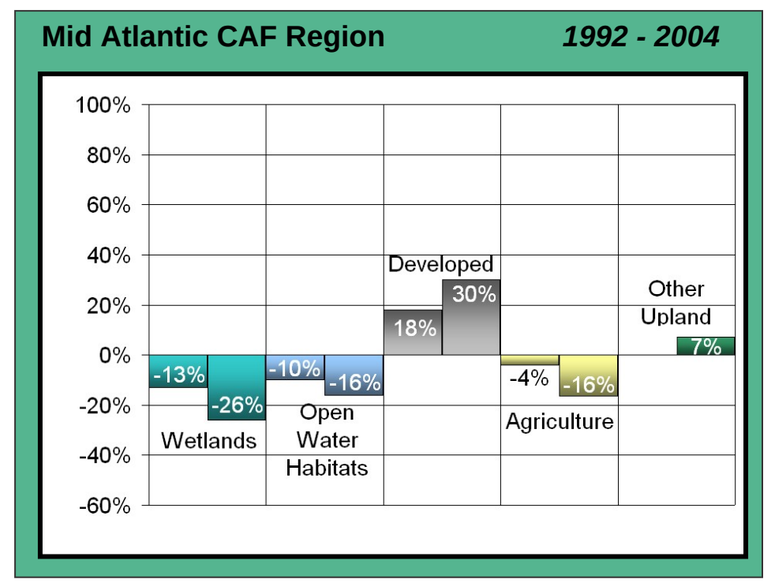












Regional Comparisons and Priorities

The data from the different regions of the continental United States are remarkably consistent for the broad picture of wetland extent and loss. In the broad categories that are comparable from region to region, the overall picture is of coastal wetland extent continuing to shrink in the face of development pressure. In most areas of the country this pressure has come from urban population pressures. The growth of agriculture in the Gulf Coast CAF, particularly in forested bottomlands along the Mississippi River, has also resulted in large losses of wetlands.

The absolute area of loss varies regionally much more than the rate of loss. Some of this is due to differences in the overall size of the varying CAFs. The Gulf Coast is lumped together, as is the West Coast, whereas the Atlantic Coast is divided into three CAFs. However, the regional differences also reflect the distribution of coastal wetlands due to the geography of the continent. Although there are some differences among the time spans of the historic periods for the different regions, they are still roughly comparable, especially given the magnitude of the different estimates.

The Gulf Coast has experienced by far the largest absolute losses of any region in the country. In addition, as noted, it is the only region that appears to be losing wetlands to both development and agriculture. In other areas of the country, the decline in agriculture over the historic period appears to have served as something of a buffer against overall loss of wetland area. The re-naturalization of agricultural lands and shorelines appears to be correlated meaningfully with slowed rates of wetland loss in the recent time period.

Although the more detailed data from the C-CAP studies are only available for some regions, these data also point to other regional differences. Woody wetlands are a category that has a number of interpretation problems, but the overall estimates indicate that in some locations this habitat may benefit from changes that eliminate emergent wetlands.

There are also special categories of open water habitat that are present only in one or two CAFs. These include the coral reef s, oyster reefs, and some of the aquatic bed types. The presence of these types in only some locations around the U.S. is a good example of the need for a regional focus on certain habitat types.

At the national level, priorities for restoration can be viewed in several ways: (1) areas of rapid loss, as examined above, (2) areas of widespread loss, and (3) locations with the highest return on restoration investments. Among the regions, as the data show, there is some broad comparability in overall rates of loss.

An examination of the estimated actual acreage of wetlands by CAF shows that the Gulf Coast CAF has by far the most widespread losses (Table 9-04 and 9-05). The estimates for the Gulf Coast range between estimates of 2.7 million acres to over 6.8 million acres of wetlands lost in the historic period. These numbers are much higher than in any other region. The dubious distinction of second place in the losses category goes to the South Atlantic CAF, where between 841,000 and 2 million acres of wetlands have been lost in

the historic period. The Great Lakes Region is ranked third, with losses between 643,000 and over 1.2 million acres. The Mid Atlantic CAF is fourth, with losses possibly as high as 1 million acres. The New England region has losses in the 146,000 to 359,000 acre range. The Pacific CAF had a loss of wetlands overall (66,000 – 82,000 acres), mostly attributable to recent losses in emergent wetlands (7,000 to 50,000 acres) and natural (non-armored) shorelines (105,000 to 210,000), although woody wetlands had an overall possible gain of up to 2,800 acres over the entire historic period. During the recent time period, however, woody wetlands declined by 8,500 to 11,000 acres in the region.

The ranking changes slightly when the total amount of natural shoreline is examined. The Pacific Coast takes the lead with losses of 35,000 to 57,000 acres. The creation of tidal mudflats and small islands through dredge spoil deposition added considerable shoreline and wetland area in large river mouths such as the Columbia River. However, high losses from other locations in these estuaries during the recent time period have offset these gains. The Gulf Coast has lost between 28,000 and 70,000 acres of shoreline in the historic period. The South Atlantic has lost between 7,000 and 22,000 acres. New England and the Mid-Atlantic have experienced similar amounts of loss: as low as 3,300 and as high as 8,800.

Consequently, it is clear that in absolute terms, the Gulf Coast CAF has lost the most acres of wetlands, as well as the most natural shoreline. The loss of woody wetlands in this CAF exceeds the losses elsewhere by 2 to 10 times. The loss of forested wetlands to agriculture has been identified as one of the leading causes of this loss in the Gulf Coast region. Thus these areas may be a good choice for targeting of restoration or preservation efforts.

Agriculture declined in three of the regions during both the historic and the recent periods. The Mid- and South Atlantic regions as well as the Pacific region all saw declines in the total acres classified as agriculture. The largest increase in agriculture, of 1,116,000 to 3,087,000 acres, was in the Gulf Coast region, although the estimated range overlaps somewhat with the 876,000- to 2,588,000-acre estimate for the Great Lakes region. Small increases in agriculture during the recent period were also estimated for the New England region.

Table 9-04. Estimated acreages of gain or loss by CAF region during respective historical time periods.

		Gulf Coast CAF Region	Mid Atlantic CAF Region	South Atlantic CAF Region	New England CAF Region	Great Lakes CAF Region	Pacific CAF Region
		1957-2004	1939-2004	1953-2004	1947-2004	1938-2004	1948-2004
Wetland Habitats	***Wetlands Total***	***-2,797,161 to -6,865,489***	***-393,264 to -1,117,792***	***-841,879 to -2,059,666***	***-146,657 to -359,145***	***-643,796 to -1,229,463***	***-66,080 to -82,321***
	Emergent Wetlands	-1,291,423 to -3,655,179	-142,748 to -178,949	-201,192 to -270,913	-34,772 to -77,567	-99,284 to -199,875	-7,288 to -50,962
	Woody Wetlands Total	-1,469,369 to -3,132,076	-244,422 to -912,566	-549,443 to -1,736,181	-103,833 to -269,956	-488,353 to -1,084,701	2,950 to -749
	Woody Wetlands (undetermined)	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data	no data	no data
	Natural (non-armored) Shoreline	-28,209 to -70,910	-6,093 to -8,861	-7,573 to -22,321	-3,366 to -5,871	-1,654 to -3,674	-57,434 to -35,099
Open Water Habitats	***Open Water Total[3]***	***170,565 to 332,728***	***-85,452 to -163,000***	***0 to -76,949***	***-73,616 to -172,652***	***-104,913 to -238,204***	***4,151 to -13,336***
	Open Water	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total	no data	no data	no data	no data	no data	no data
	Aquatic Bed (undetermined)	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data
Non-Wet	***Developed***	***1,310,344 to 1,822,020***	***1,219,527 to 1,704,307***	***514,497 to 721,993***	***211,173 to 309,808***	***367,640 to 573,918***	***1,114,932 to 2,586,643***
	Agriculture	***1,116,583 to 3,087,138***	***-2,256,112 to -3,069,043***	***-1,655,721 to -3,169,927***	***-214,331 to -332,432***	***876,218 to 2,588,316***	***-165,710 to -406,743***
	Other Upland	***2,011,455 to -1,849,241***	***-1,691,510 to -4,186,487***	***-713,723 to -1,429,081***	***0 to -570,577***	***-1,801,323 to -4,000,993***	***1,748,642 to 5,856,200***

Table 9-05. Estimated acreages of gain or loss by CAF region during recent (1992-2004) time period.

		Gulf Coast CAF Region	Mid Atlantic CAF Region	South Atlantic CAF Region	New England CAF Region	Great Lakes CAF Region	Pacific CAF Region
		1992-2004	1992-2004	1992-2004	1992-2004	1992-2004	1992-2004
Wetland Habitats	***Wetlands Total***	***-1,259,362 to -2,800,397***	***-309,688 to -686,125***	***-509,558 to -1,410,488***	***-114,757 to -298,732***	***-389,666 to -826,361***	***-118,915 to -247,153***
	Emergent Wetlands	-548,277 to -1,370,692	-95,038 to -118,798	-121,774 to -243,548	-23,015 to -56,258	-47,029 to -141,088	-5,096 to -25,481
	Woody Wetlands Total	-696,017 to -1,392,034	-210,592 to -561,579	-384,197 to -1,152,591	-89,462 to -238,565	-341,480 to -682,960	-8,523 to -11,080
	Woody Wetlands (undetermined)	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data	no data	no data
	Natural (non-armored) Shoreline	-15,068 to -37,671	-4,057 to -5,747	-3,587 to -14,349	-2,280 to -3,909	-1,157 to -2,313	-105,296 to -210,592
Open Water Habitats	***Open Water Total***	***109,649 to 219,298***	***-69,628 to -118,367***	***0 to -53,807***	***-57,612 to -108,023***	***-73,360 to -117,376***	***19,963 to 31,941***
	Open Water	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total	no data	no data	no data	no data	no data	no data
	Aquatic Bed (undetermined)	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data
Non-Wet	***Developed***	***842,364 to 1,263,546***	***613,551 to 1,022,584***	***290,803 to 387,737***	***83,189 to 166,378***	***43,252 to 324,388***	***668,959 to 1,204,127***
	Agriculture	***717,803 to 2,153,410***	***-356,228 to -1,424,913***	***-735,876 to -1,471,752***	***40,825 to -40,825***	***360,796 to 1,803,978***	***-165,710 to -331,421***
	Other Upland	***1,293,078 to -1,293,078***	***0 to 1,522,359***	***-419,404 to -1,118,411***	***0 to 516,236***	***-1,259,572 to -2,519,144***	***3,338,317 to 5,007,475***

Section 9.3 Suggestions for Future Study

The primary impediment during this study has been the lack of comparable data sets. The lack of comparability was a major source of possible error in the current study, and has been identified in other studies of wetland extent as a challenge to interpretation The lack of comparability was an issue both in terms of the wetland categories, and in terms of the imaging techniques used by the different studies. A second dataset comparable to the C-CAP data is needed in future studies to provide a good look at the extent and changes underway in coastal wetlands. This dataset should, at a minimum, repeat as much of the observation as possible from the pilot C-CAP study, including imaging at the same resolution.

Of course, as technology improves, new studies will also have the opportunity to improve on past research. Imaging the coastal wetlands at a resolution much higher than the 30 meters per pixel standard of the C-CAP study is now quite technically feasible. By using current data at a high resolution, it may be easier to interpret historical trends more accurately. Higher resolutions are important in classifying and measuring wetland extent because of the convoluted shorelines and habitat patch configurations found in these habitats. Scattered pixels at a low resolution may show themselves to be connected and classifiable into wetland categories at a higher resolution. Also, having all the frames interpreted from similar data sources (aerial photos), by the same “person”, and for the same goal (as opposed to comparing C-CAP’s wetland-emphasized data with the NLCD general land cover-oriented data) might provide a better analysis. Even the comparison between the historic and recent time periods in this study demonstrates the importance of being able to classify all wet habitats.

The addition of other parts of the spectrum to the imaging techniques is also recommended for future studies. It is vital to be able to determine the water content of the soil for identification of wetlands. The analysis of woody wetland types is particularly sensitive to this factor. Without clear evidence of the extent of wetted soil areas, it is very difficult to separate the woody wetlands from other uplands. Since the “other upland” category is a very large one in these studies, this is especially important for identifying locations of possible restoration projects and areas of high need.

To accurately track coastal marine habitat in its entirety will take a large commitment of funds and personnel. Future studies could utilize a wide variety of commercial and government imaging data to conduct a full ecosystem assessment for coastal areas. Satellite imagery can be used to track many areas.

Although severely limited in this study, the transect approach did prove to be quite useful, even as a pilot study. The establishment of a set of transects in locations representative of different wetland types, or representative of certain areas, would be an important part of any future study. Alternately, transects could be chosen randomly from the various CAFs. One approach would be to use some or all of the variables identified in this study, distance from coast, salinity, etc., as a “grid” of data that could be used to correlate with the conditions in randomly chosen transects. With this approach, a

relationship could be established among those variables showing significant correlation with habitat conditions. The relationship among population growth, development, and decline in wetlands acreage is an example of perhaps the strongest of these correlations. These relationships could then be used to model areas that have not been extensively surveyed. This model would also be useful in estimating future conditions of coastal habitat.

Transects, or other forms of intensive analysis, could also be used to track areas of habitat restoration. This is one way in which the long-term effects of projects could be tracked without requiring extensive visits to remote locations. Particularly beyond the five-year time span of most restoration project monitoring, remote sensing of restoration areas could help to document the effectiveness of these projects over time spans of decades and more.

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Section 11.0 Appendix A (Data Analysis Plan)

NOAA Habitat Loss Analysis
Data Analysis Plan Report

January 7, 2005
Revised January 15, 2005

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Introduction

The purpose of this report is to discuss the methods for observing historic and current trends in estuarine and coastal wetland habitats. This analysis is being developed for NOAA in support of their efforts under the Estuary Restoration Act. The analysis will provide NOAA with an overall view of the variation in the status and trends of estuarine-associated habitats throughout the U.S. coastal areas of the lower 48 states, including the Great Lakes region.

The trends analysis will be based on a non-statistical sampling method and will capture change within multiple 11.5 x 1.5 mile transects. Transects will be stratified by the Coastal Assessment Framework (CAF) regions, and if feasible the major and minor National Estuarine Reserve Regions (NERR). Figure 1 illustrates the extent of the study area including the CAF and NERR regions.

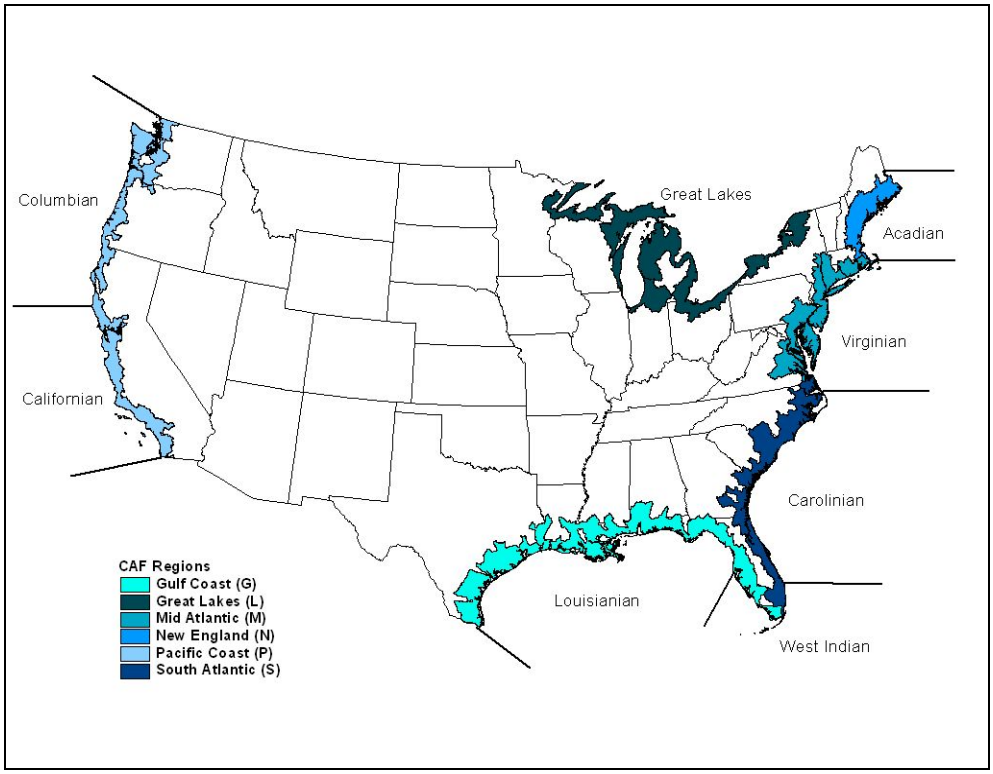


Figure 1. CAF and major NERR regions. CAF regions are depicted in shades of blue (see legend for region name) and NERR regions are depicted by solid black lines and include the region name (i.e., Columbian).

Habitat change will be captured within each transect for two time periods: current and historic. To accomplish this, Sanborn has been focusing on collecting data from three source dates: the most current data available, five to ten years prior to the most current, and historic (1940's to 1960's). In November 2004 Sanborn submitted a report to NOAA detailing a comprehensive search for national data sets to serve as data sources for both the current and historic trends analysis. This research also uncovered some regional and

localized datasets and data resources as well. In December 2004, Sanborn met with NOAA to discuss the benefits and limitations of the available data, confirm the definitions of the target habitat types, and to examine the options for the trends analysis.

Analysis Methods

Sanborn discussed with NOAA at the December 2004 meeting the three possible approaches to current and historical coastal trends:

- total enumeration (not recommended),
- statistical sampling (not feasible), and
- non-statistical sampling (only feasible approach for this project).

Total enumeration would involve producing a wall-to-wall dataset of historic and current habitats. This would be time consuming, extremely costly, inefficient, and unnecessary. Statistical sampling would be less expensive, but still quite costly. It would require a measure of variation to determine the necessary sample size. Finally, samples would need to be selected in a random fashion. Non-statistical sampling is the only solution available if the others are not possible. This method allows for the observation of trends across the datasets but does not have the powerful properties of a statistical sample.

A statistical sampling approach is not possible for this project for a number of reasons: limited budget, insufficient time, and unknown variance (needed to compute the sample size). However, the major limiting factor preventing a statistical sampling approach is the inability to select a random sample as dictated by the availability of the current and especially the historic data sets. Therefore, Sanborn will provide NOAA with a non-statistical sampling strategy to observe current and historic trends in coastal habitats. A transect methodology will be used, and two different time periods will be examined within each transect:

- Current time period: the most current data available compared to 5-10 years prior
- Historic time period: the most current data available compared to a date within the 1940's – 1960's

The key tasks in this analysis include:

- ✓ Define a classification scheme
- ✓ Compile the appropriate data layers
- ✓ Finalize the analysis methods
- ✓ Perform pilot transect
- ✓ Complete analysis transects
- ✓ Compile narrative description of each CAF region, including assessment of how representative the transect(s) in that region are to the region as a whole, in terms of habitat loss
- ✓ Present preliminary results to NOAA

Classification Scheme

A classification scheme is more than a set of labels; it is a set of rules and definitions that organizes information into useful categories. A classification scheme must be totally exhaustive (all things must fit into a category), mutually exclusive, (two different things cannot have the same name), and hierarchical (classes can be collapsed into more general classes – i.e., hardwood and conifer forests can be collapsed into forest). Without a clear set of rules, the assignment of labels to types will be arbitrary and will lack consistency.

Sanborn has worked with NOAA to develop the two critical components of a classification scheme for this project (1) a set of labels, and (2) a set of rules for assigning those labels. The labels are based on the target habitat types presented in the SOW. The hierarchical nature of the classification rules allow for collapsing of specific classes into more general classes. This is critical as it will be necessary to collapse classes when data to support mapping the classes is not available. This will be particularly true in the case of the historical data. The target habitat types discussed and agreed upon at the December 2004 meeting with NOAA are listed in Table 1. The classification key and class definitions are presented in Appendix A and Appendix B, respectively.

The classes that will most likely require being collapsed are the open water habitats, mangroves, and the woody wetland habitats. The historical data will most likely not support mapping any of the open water habitats (i.e., reefs, aquatic beds, or bottom habitats). These classes will be rolled up to the "open water" class. Also, if no data are available to identify mangroves, these habitats will be rolled up into shrub/scrub wetlands. This may be more likely in the historic data. Sanborn will evaluate the Environmental Sensitivity Index (ESI) data, as it most likely will help to identify mangroves for the current trends analysis. Finally, in some cases, there may be confusion between shrub/scrub wetland types and forested wetland types, particularly within the historical aerial photography (i.e., it may be difficult to discern what is greater than or less than 5 meters). In these cases, shrub/scrub and forested wetlands will be rolled up into woody wetlands.

Data Layers

A comprehensive data search for national datasets has already been performed and a report detailing the results has been provided to NOAA. The following datasets will be used for the current trends analysis: C-CAP, NLCD2001, NLCD92, NWI, and GAP. Table 2 compares key characteristics of each of these datasets. All of these datasets, with the exception of NWI, are raster-based datasets with a mapping scale of approximately 1:100,000. NWI is polygon-based and has a mapping scale of 1:24,000. Another variable that varies significantly from dataset to dataset is the classification scheme. Therefore it will be necessary to crosswalk the classification of each dataset to the habitat types defined for this project.

Historical aerial photography, NOAA topographical coastal survey sheets (T-sheets), and nautical charts will be used for historical data sources. Aerial photographs will be

purchased at the best available scale and they will be purchased in both digital format and as analog prints.

The primary datasets used for the current trends analysis will be C-CAP and NLCD92. NWI will be used to supplement the NLCD92 only if the source date is within five years of the NLCD92 source date. If the NWI data are used the source date will be which ever is most recent, the NWI or the NLCD92. The historical data will be primarily aerial photography acquired between 1940 and 1960, but will be supplemented by the t-sheets and nautical charts if necessary. C-CAP data for 2000 does not exists for all coastal areas in the U.S. Table 3 illustrates what dataset will be used in each CAF region for the three different dates. Date 1 refers to the most current data available, date 2 refers to data five to ten years prior to the most current, and date 3 refers to the historical data. C-CAP 2000 data for the Gulf Coast should be completed by mid-March 2005. Sanborn will confirm with NOAA before using this dataset. In addition, for each transect, Sanborn will spend a reasonable amount of time searching for more localized datasets to supplement both the current and historical data sources described in this report.

In addition to these datasets previously mentioned, Sanborn will evaluate the ESI data for use in the current trends analysis. The ESI data may provide valuable information particularly with identifying the mangroves. Since the ESI data has only been captured for one date (either in the 1990's or 2000) Sanborn will incorporate these data with the base data for either date 1 or date 2, which ever the source date is closest too. And Sanborn will assume that if a mapped feature was identified in date 1 or date 2 as mangrove, and that feature is mapped similarly in both dates, then it is mangrove in both. For example, if the NLCD92 (date 2) has mapped a feature as woody wetlands and C-CAP (date 1) has that same feature mapped and identified as a woody wetland, and the ESI has identified it as mangroves then Sanborn will assume it is mangrove in both date 1 and date 2.

Table 1. Target habitat types. Note that non-wetland classes were not in SOW. The class description was added for clarity.

Generalized Habitat Types	**Target Habitat Types**	**Classes in SOW**
Wetland Habitats		
Vegetated Habitats		
Emergent wetlands	**emergent wetlands**	salt marsh
		freshwater marsh
Woody wetlands		
	shrub-scrub wetlands	shrub swamps (non-mangrove)
	mangroves	mangroves
	estuarine forested wetlands	forested wetland (non-mangrove)
	palustrine forested wetlands	riparian forests (non-wetland)
Non-vegetated	**Natural (non-armored) shoreline**	rocky shore and beach
Open water habitats		
	palustrine aquatic beds	submerged aquatic veg
	estuarine aquatic beds	kelp beds
	coral reefs	coral reefs
	oyster reefs/shell bottom	oyster reefs/shell bottom
	hard bottom	hard (rocky) bottom
	soft bottom	soft bottom (mud and sand, intertidal and subtidal)
Non-wetland habitats	***developed***	*urban, residential, commercial*
	agriculture	*pasture, hay, row crops*
	Other upland	*upland forests (including maritime forests), shrubs, herbaceous, barren*

Table 2. Comparison of current datasets.

	C-CAP	NLCD2001	NLCD92	NWI	GAP
Content Date (years)	1986 - 2000	2001	late 1980's - early 1990's	1970's to 2000's; mostly 1980's	late 1980's to early 1990's
Mapping scale	30m pixel, approx 1:100k	30m pixel, approx 1:100k	30m pixel, approx 1:100k	1:24k or better	30m pixel, approx 1:100k
Data format	raster	raster	raster	polygon	raster
Extent Complete	2000 data for all but the East coast	only one state is complete and that is on the East Coast	complete across US	nearly complete across US	nearly complete across US
Comments regarding classification scheme	estuarine vs. palustrine wetland classes; unconsolidated shore vs. barren; aquatic beds; detailed SAV in some areas	estuarine vs. palustrine wetland classes; unconsolidated shore vs. barren; aquatic beds (basically the same as C-CAP)	only two wetland classes (woody and non-woody); barren class includes unconsolidated shoreline with other bare; no aquatic beds, etc.	most complex, includes bottom habitats (reefs, rocky and soft bottom)	varies from state-to-state
Projection	Albers - USGS standard	Albers - USGS standard	Albers - USGS standard	UTM	varies from state-to-state
Metadata available	yes - good	yes - good	yes - good	yes - good	most states have it, can generally track it down
Accuracy assessment completed	complete for Western, Great Lakes, and Gulf Coast regions – but not for localized project study datasets	varies between regions on completion of formal assessment	varies between regions on completion of formal assessment	no formal accuracy assessment	varies from state-to-state on completion of formal assessment

Table 3. Time periods and datasets for each CAF and NERR region.

CAF Regions	Major NERRS Region	Minor NERRS Region	Date 1 - most current	Date 2 - five to ten years prior to most current	Date 3 - historic
New England (N)	Acadian	Northern Gulf of Maine	1992 (NLCD/C-CAP)	1986/1980's (C-CAP/NWI)	1940-1960 (aerial photography)
		Southern Gulf of Maine	1995/1993 (C-CAP)	1986/1980's (C-CAP/NWI)	1940-1960 (aerial photography)
Mid-Atlantic (M)	Virginian	Southern New England	partial 2000 (NLCD); 1999 (RI State data); 1997 (C-CAP)	1992/1990 (NLCD/CCAP)	1940-1960 (aerial photography)
		Middle Atlantic	2000 (NLCD)	1992 (NLCD)	1940-1960 (aerial photography)
		Chesapeake Bay	2000 (NLCD)	1992 (NLCD)	1940-1960 (aerial photography)
South-Atlantic (S)	Carolinian	North Carolina	1997 (C-CAP)	1992 (NLCD)	1940-1960 (aerial photography)
		South Atlantic	1997/1995 (C-CAP)	1992/1991(NLCD/C-CAP for SC)	1940-1960 (aerial photography)
		East Florida	1995/1996 (Florida State data)	1992/1980's (NLCD/NWI)	1940-1960 (aerial photography)
Gulf Coast (G)		West Florida	1995/1996 (Florida State data)	1992/1980's (NLCD/NWI)	1940-1960 (aerial photography)
	Louisianian	Panhandle Coast	partial 2000 (C-CAP)	1992 (NLCD)	1940-1960 (aerial photography)
		Mississippi Delta	2000 (C-CAP)	1992 (NLCD)	1940-1960 (aerial photography)
		Western Gulf	2000 (C-CAP)	1992 (NLCD)	1940-1960 (aerial photography)
Pacific Coast (P)	Californian	Southern California	2000 (C-CAP)	1992 (NLCD)	1940-1960 (aerial photography)
		Central California	2000 (C-CAP)	1992 (NLCD)	1940-1960 (aerial photography)
		San Francisco Bay	2000 (C-CAP)	1992 (NLCD)	1940-1960 (aerial photography)
	Columbian	Middle Pacific	2000 (C-CAP)	1992 (NLCD)	1940-1960 (aerial photography)
		Washington Coast	2000 (C-CAP)	1992 (NLCD)	1940-1960 (aerial photography)
		Puget Sound	2000 (C-CAP)	1992 (NLCD)	1940-1960 (aerial photography)
Great Lakes (L)	Great Lakes	Lake Superior	2000 (C-CAP)	1992 (NLCD)	1940-1960 (aerial photography)
		Lakes Michigan and Huron	2000 (C-CAP)	1992 (NLCD)	1940-1960 (aerial photography)
		Lake Erie	2000 (C-CAP)	1992 (NLCD)	1940-1960 (aerial photography)
		Lake Ontario	2000 (C-CAP)	1992 (NLCD)	1940-1960 (aerial photography)

Trends Analysis

To create a model to interpolate trends requires a statistical analysis. Instead, this analysis will result in observations but not a model. These observations will allow us to state that within a certain type of environment, there was a loss or gain of a certain habitat group between the dates of interest. And that given the characteristics of this environment, we might anticipate that other areas with the same characteristics may have experienced similar losses or gains.

In each transect, the change in wetland habitat will be captured for each time period, and summarized by habitat type. Change within each transect will be reported as percent acreage lost or gained. Each transect will be the same size (11.5 by 1.5 miles) so that each is equally as important. Table 4 lists the preliminary transects and Figure 2 identifies their locations. Although some of these transects may need to be eliminated due to lack of available data and/or time and budget constraints, a minimum of one transect will be placed in each CAF region. In order to ensure that a minimum of one transect is completed for each CAF region Sanborn will prioritize the transects. For example, the first six transects to be initiated are listed in Table 5. Sanborn will confirm the availability of historical aerial photography and purchase the necessary photos for these six transects. Once this is underway, Sanborn will begin working on obtaining imagery and data for the next six transects (one from each CAF region). All aerial photography for the project will be purchased by late January or early February.

Table 4. Preliminary Transects

CAF Region	NERR Major Region	Tran-sect #	Transect
Pacific Coast	Columbian	1	Puget Sound, WA
		2	Lower Columbia River, OR
	Californian	3	San Francisco Bay, CA
		4	San Diego Bay, CA
Gulf Coast	Louisianan	5	Galveston, TX
		6	New Orleans, LA
		7	Mobile Bay, AL
		8	Tampa Bay, FL
South Atlantic Coast	Carolinian	9	North Eastern FL
		10	Charleston, SC
		11	Pamlico Sound, NC
Mid Atlantic Coast	Virginian	12	Chesapeake Bay, MD
		13	Delaware Bay, DL
		14	Long Island, NY/NJ
New England Coast	Acadian	15	Portland Harbor, ME
		16	Cape Cod, MA
Great Lakes	Great Lakes	17	Chicago, IL
		18	Lake St. Clair, Michigan

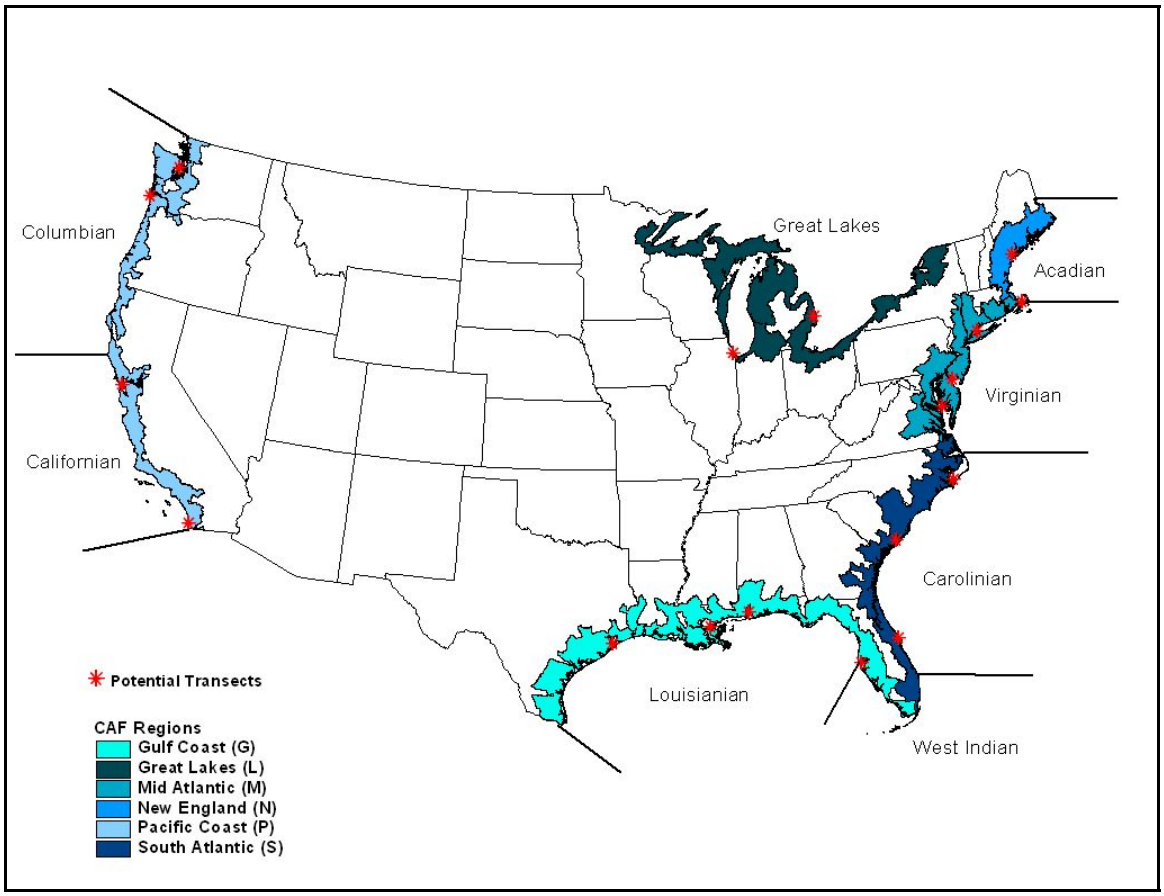


Figure 2. Preliminary sites for transects. Locations are marked with a red star.

Table 5. First six transects to be initiated.

CAF Region	NERR Major Region	Tran-sect#	Transect
Pacific Coast	Columbian	2	Lower Columbia River, OR
Gulf Coast	Louisianan	8	Tampa Bay, FL
South Atlantic Coast	Carolinian	11	Pamlico Sound, NC
Mid Atlantic Coast	Virginian	13	Delaware Bay, DL
New England Coast	Acadian	15	Portland Harbor, ME
Great Lakes	Great Lakes	18	Lake St. Clair, Michigan

The specific location of each transect will be based on the availability of historical data (i.e., it will not be a random selection). The specific location will most likely be dependent on the flight paths that provide the best available historic photo coverage.

Coastal Habitat Status Narrative

In addition to capturing change within each transect, Sanborn will work with regional experts to compile a narrative describing the overall status of coastal habitats within each CAF region. A team of the most qualified sub-consultants available will be assembled to provide the necessary information. The narrative will also include a description of the transect environment and how that environment fits into the overall CAF region. This information will provide NOAA with a regional perspective on the types and variation of coastal and estuarine-associated habitats within each CAF region.
Sanborn will work with the regional experts and NOAA to develop a specific format for the narrative so that it is consistent for each CAF region and so that provides the necessary information required by NOAA. The experts will be asked to access the relationship between the environment where the transects are located and the entire CAF region. The experts will be asked to provide their opinion as to how well the transect area represents coastal and estuarine associated habitats in the CAF region. And given that, how well the change captured in each transect or set of transects is reflective of change in the respective CAF region. They will be asked to provide their opinion of the range of change in the region for each habitat type (i.e., in their opinion between percent A and percent B of habitat type x has been lost between the source dates used in the analysis).

Pilot Transect

A pilot test was initiated on a single transect in the Columbia River basin to test our analysis methods. This was a critical step in understanding the limitation and benefits of such an analysis and in dealing with the multitude of datasets (both digital and analog). The Columbia River basin was selected based on familiarity with the area and ease of obtaining historical aerial photos.

The following points were learned based on the pilot transect:

- Exact transect location will be highly dependent on where the best aerial photography exists.
- Comparing thematic data layers has many inherent problems. The differences in interpretation can lead to false errors.
- Scanned (600 dpi), black and white, 1:12,000 scale historical photos have a lot of valuable information.
- The method of capturing change should be consistent with the primary data format – i.e., the data sources are mostly raster based so trying to digitize polygons of change would lead to too much error.
- Only one date of historical photography will be used, which may not capture seasonally or temporarily flooded wetlands.
- Different data formats and mapping scales can lead to false errors, as well as the registration of data layers.

An example of an historical aerial photography flight path from the Army Corp of Engineers is presented in Figure 3. The footprints highlighted in yellow indicate the photos that were selected for the pilot transect. These photos were selected because they provided the best coverage for a transect 11.5 miles long. This demonstrates how the flight paths will most likely determine the exact location of the transect.

Figure 3. Historical flight path with selected aerial photos highlighted (US Army Corp of Engineers, 1948).

The scale of available historical aerial photos will vary and it will most likely all be black and white photography. Photos acquired at a scale of 1:12,000 were used for the pilot transect and they were scanned at a resolution of 600 dpi. Figure 4 is an example of a close-up of one of the photos used for the pilot transect. This photo scale and scan resolution provided an adequate amount of detail to distinguish between woody wetland types and emergent wetland types. Ideally, all historical photos used for this analysis will

have a scale of 1:12,000 or larger. However, this may not always be possible. All efforts will be made to avoid using photos with a scale smaller than 1:20,000.

Figure 4. Example of one of the seven 1948 aerial photographs (Columbia River, OR-WA)

Image processing software was used to rubber sheet the digital photos to a 1:100,000 scale USGS topographical digital raster graphic (drg). The flight path used for the pilot transect can be seen in Figure 5. The rubber sheeting process required a relatively minimal amount of time and effort. It is foreseeable that photos for the analysis can be rubber sheeted in a reasonable amount of time. It would also be beneficial to have a contact copy of each photo, as the hard copy print will provide even higher resolution making it easier to distinguish between features.

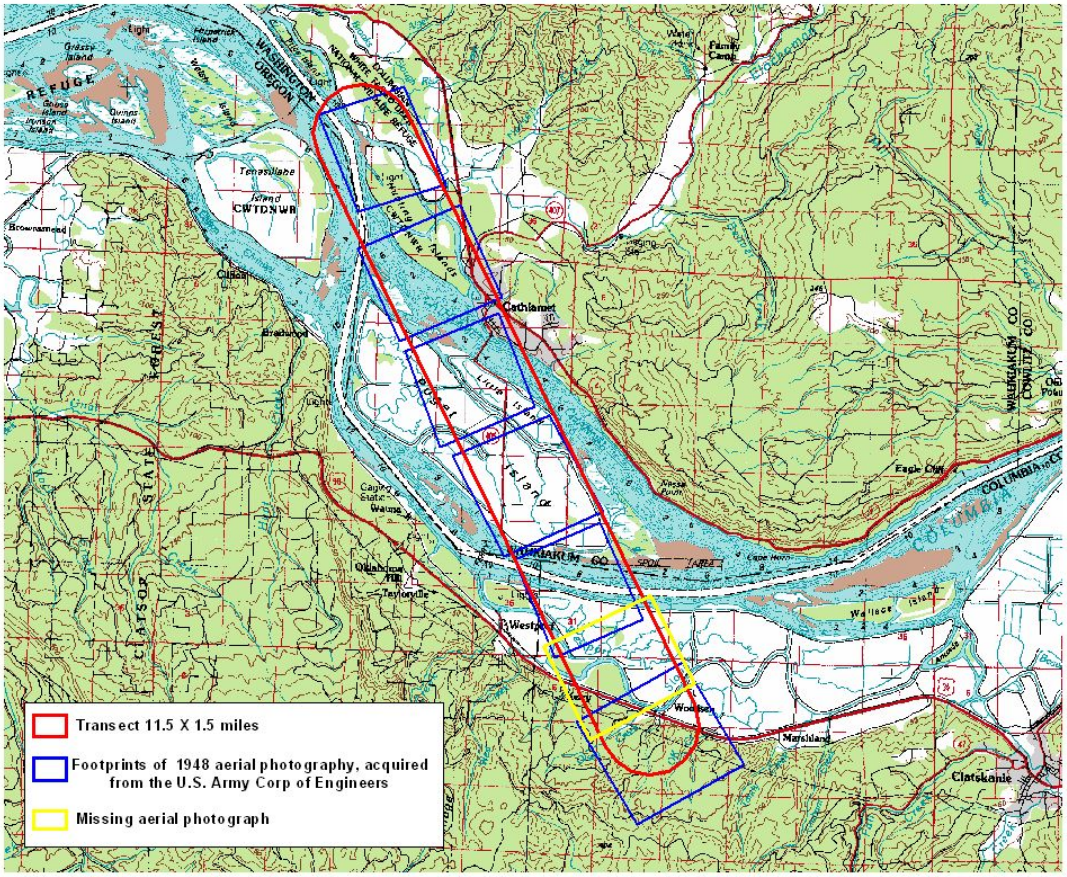
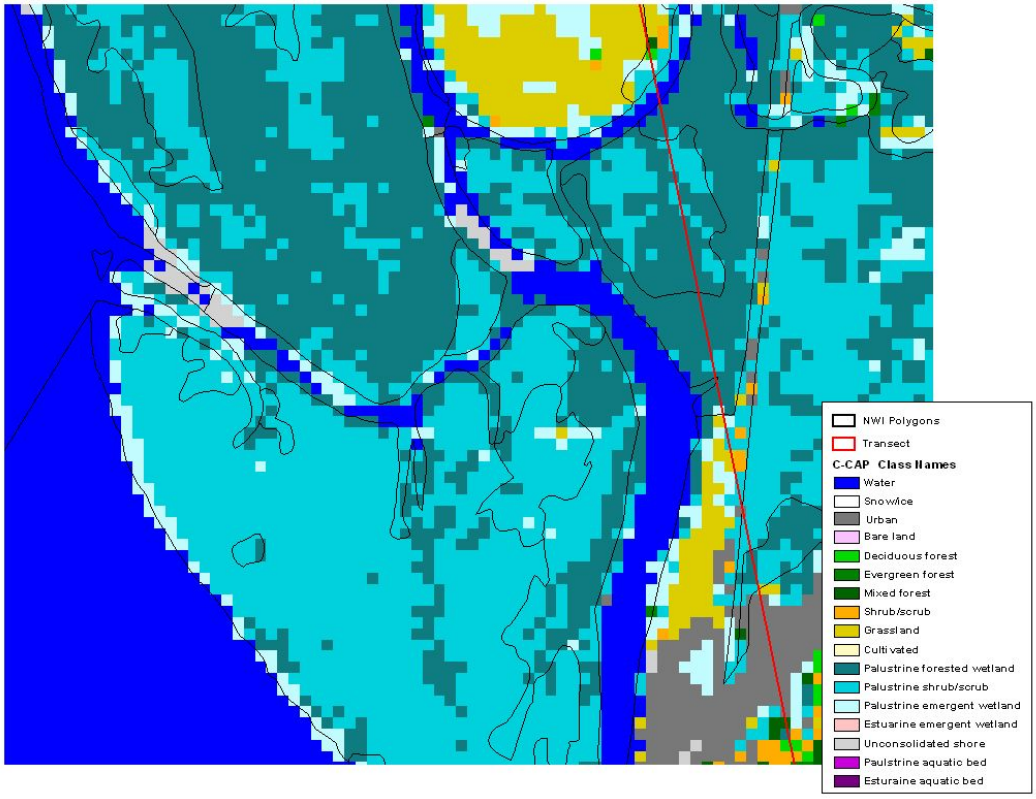
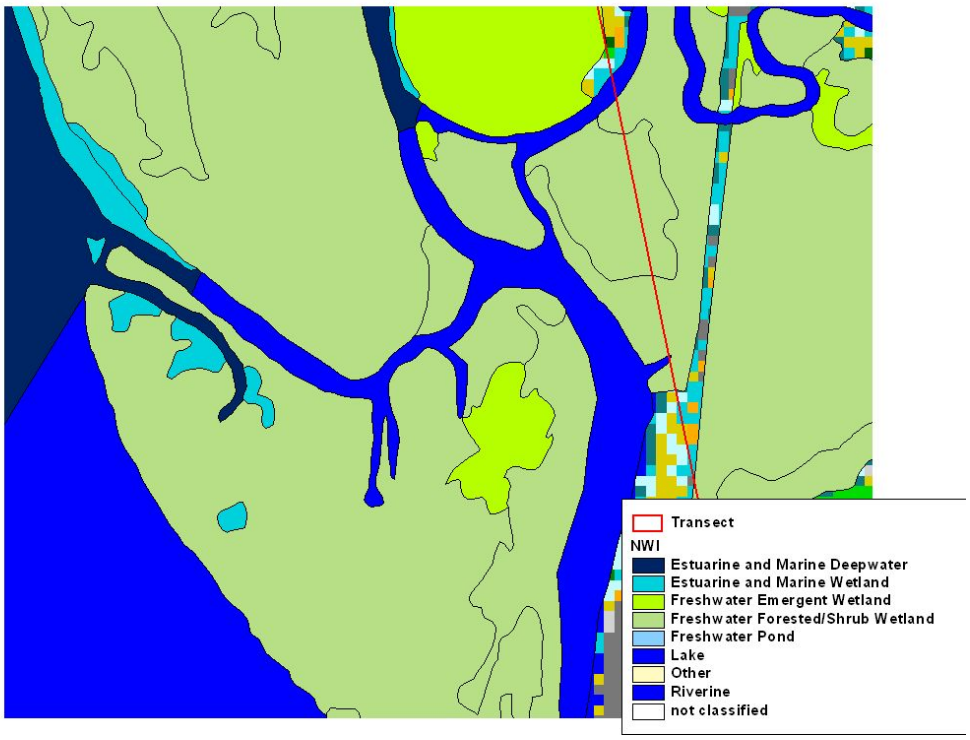


Figure 5. Pilot transect in Columbia River basin.

Comparing thematic datasets from many different sources presents a certain set of challenges. Different data formats and mapping scales can lead to false errors as can the registration between the data layers. For example, the NWI is not only a polygon layer but was also mapped at a much larger scale than the other main datasets that will be used in this analysis: C-CAP and NLCD92. Both the C-CAP and NLCD92 data are raster based data. Figure 6(a) and 6(b) illustrates the differences between these two formats and mapping scales.


NWI Polygons
Transect
C-CAP Class Names
Water
Snow/ice
Urban
Bare land
Deciduous forest
Evergreen forest
Mixed forest
Shrub/scrub
Grassland
Cultivated
Palustrine forested wetland
Palustrine shrub/scrub
Palustrine emergent wetland
Estuarine emergent wetland
Unconsolidated shore
Paulstrine aquatic bed
Esturaine aquatic bed

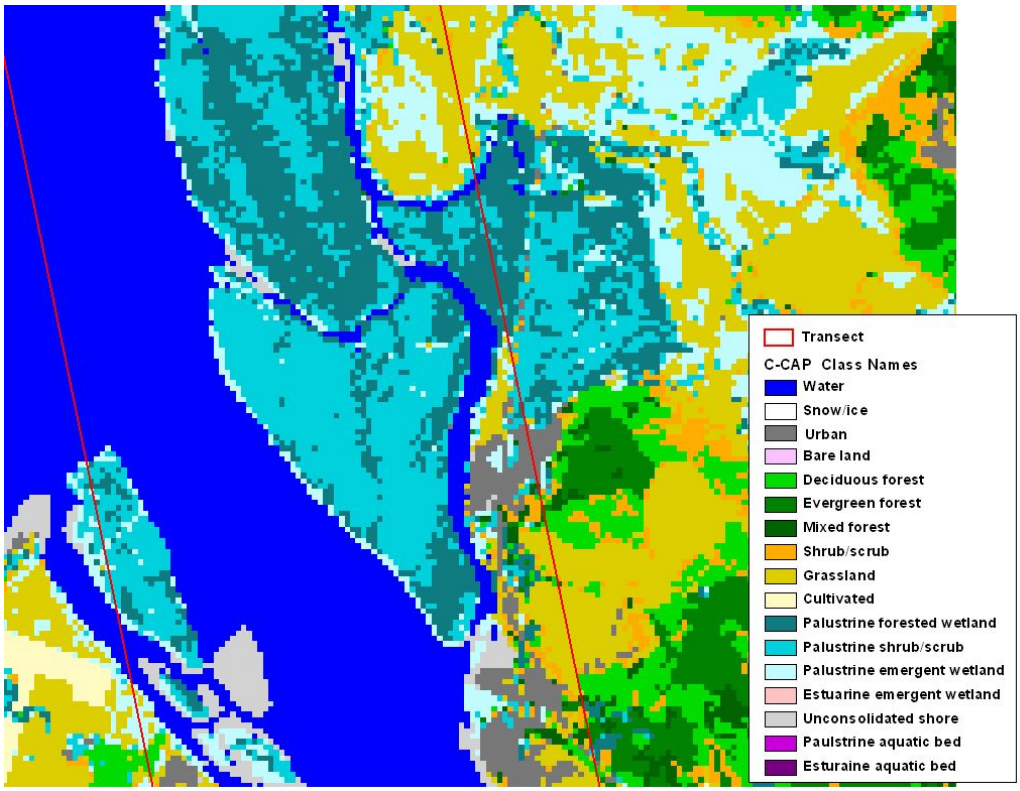
6(a)


Transect
NWI
Estuarine and Marine Deepwater
Estuarine and Marine Wetland
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Other
Riverine
not classified

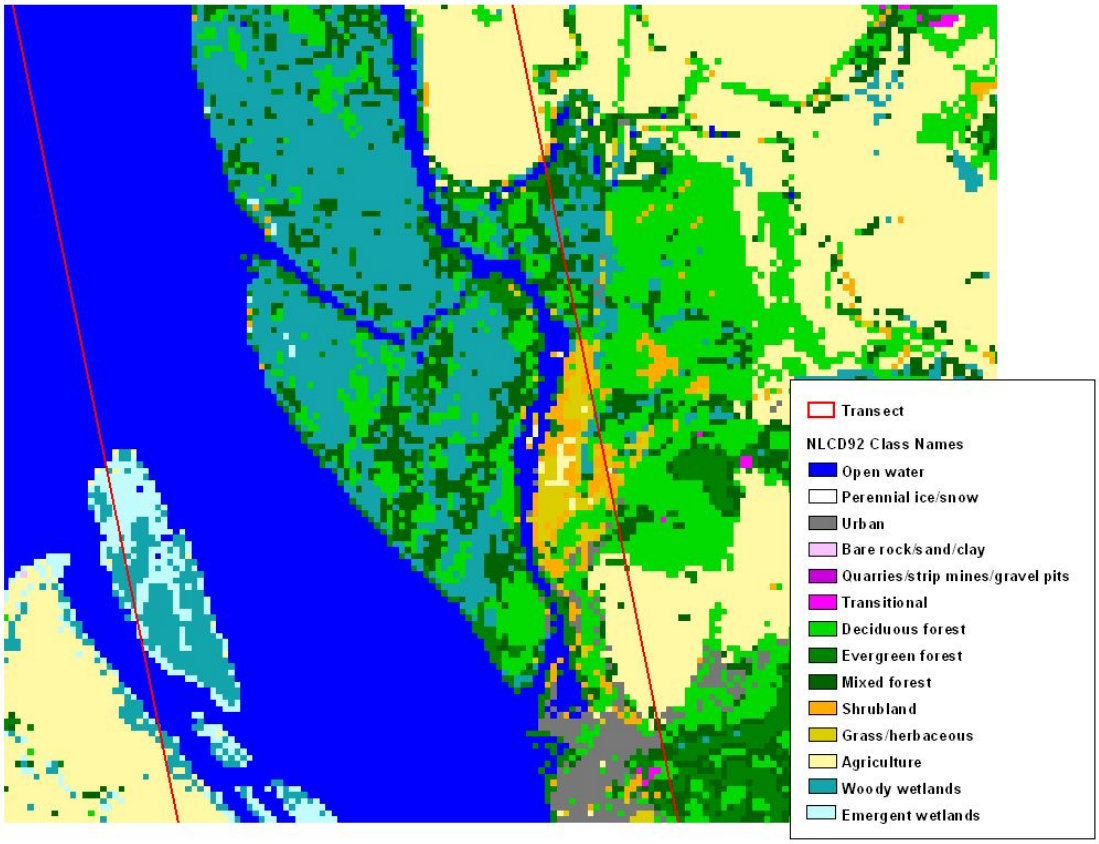
6(b)

Figure 6. (a) C-CAP raster data with NWI polygon lines, and (b) NWI polygon data

Another concern is the differences between the two raster based data layers, the C-CAP and NLCD92. These were both developed at the same mapping scale (Landsat satellite 30-m pixel data, approximately 1:100,000). However, due to the different classification schemes, image processing methods, and mapping priorities, comparing the two maps can lead to false errors. For example, Figure 7(a) and 7(b) show the same island mapped in both the C-CAP and NLCD92. The C-CAP map (Figure 7a) shows that the island is entirely a mix of shrub/scrub and forested palustrine wetlands. However, in NLCD92 (Figure 7b) it is a mix of woody wetlands and upland forested classes. This analysis would identify this as a gain in wetland habitat, however it is most likely not a true change. The apparent change is most likely due to differences in the image interpretation and methods used to develop the two datasets. For example, in developing the C-CAP data, imagery was available for multiple dates where as for the NLCD92 only one date was available. Also, mapping wetlands more accurately was a higher priority in developing the C-CAP data.



7(a)



7(b)

Figure 7. (a) C-CAP (b) NLCD92

Conclusion

In conclusion, Sanborn will provide NOAA with an overview of the status and trends of estuarine and coastal wetland habitats within the coastal areas of the lower 48 states, including the Great Lakes region. The analysis will be based on a non-statistical sampling method using transects to capture change within two time periods, current and historic. There will be a minimum of one transect per CAF region. In addition to capturing change within each transect, Sanborn will work with local experts to provide a narrative describing both the general transect environment and the CAF region that it falls in, including order-of-magnitude estimates (which may be expressed as ranges) of the amount of habitat that has been lost in each region, by habitat type.

•

Appendix A – Classification Key

1a. Vegetation or substrate is associated with permanently, temporarily, or seasonally flooded environments (wetland or open water habitats)

2a. Wetland habitat type

3a. Vegetation > 25%

4a**.** Greater than or equal to 25% of the vegetation is woody vegetation (forested or shrub land)
……..***Woody wetlands***

When appropriate data are available …

5a. Vegetation dominated by plants shorter than 5 meters
…….***Shrub/scrub wetlands***

When appropriate data are available

6a. Estuarine shrub/scrub types that grow within southern Florida - (C-CAP, Cowardin, NWI)
.....***Mangroves***

5b. Vegetation taller than 5 meters

7a. Trees, tidal and non-tidal influence, in tidal areas where ocean-derived salinity is below 0.5%
.....***Palustrine forested wetlands***

7b. Trees, tidal influence, where ocean-derived salinity is equal to or greater than 0.5%
.....***Estuarine forested wetlands***

4b. otherwise,
……..... ***Emergent wetlands***

3b. Vegetation <= 25%
.....***Natural (non-armored) shoreline***

2b. Open water habitat type

9a. Unknown bottom or surface type
.....***Open water***

9b. Known bottom or surface habitat type

10a. Water surface is dominated by plants that grow and form a continuous cover.
.....….***Aquatic bed***

When appropriate data are available …

11a**.** Tidal and non-tidal wetlands, salinity due to ocean-derived salts less than 0.5%, include algal mats, detached floating mats, and rooted vascular plants
…….***Palustrine aquatic beds***

11b. Tidal wetlands, salinity due to ocean-derived salts greater than or equal to 0.5%, include algal mats, kelp beds, and rooted vascular plants
……***Estuarine aquatic beds***

10b. Water surface is not dominated by plants and bottom is known

12a. Ridge-like or mound-like structures formed by the colonization and growth of sedentary invertebrates

13a. Found in shallow waters of warm seas, southern Florida, within marine systems
.....***Coral reefs***

13b. Found in Pacific, Atlantic, and Gulf Coasts within the estuarine system
.....***Oyster reefs***

12b. Bottom formed by rock, not sedentary invertebrates

14a. Greater than 75% cover is stones, boulders, or bedrock
.....***Hard bottom***

14b. otherwise,
.....***Soft bottom***

1b. otherwise, (non - wetland habitat types)

15a. Impervious surfaces > 20%

.....***Developed***

15B. Impervious surfaces < 20%

16a. Areas used for the production of crops, including grasses planted for livestock grazing, seed production, or hay crops account for >20% cover
…….***Agriculture/pasture***

16b. otherwise,
.....***Other upland***

Appendix B – Class Names Definitions

Wetland habitat - "lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For the purposes of this classification wetlands must have one or more of the following three attributes: 1) at least periodically, the supports predominately hydrophytes; 2) the substrate is predominantly undrained hydric soil; and 3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year." (Cowardin et al. 1979)

Open water habitat – areas of permanently flooded lands.

- Class Names and Definitions

- ***Wetland or open water habitat types:***

Emergent wetlands – Areas where perennial herbaceous vegetation accounts for 75-100% of the cover and the soil or substrate is periodically saturated with or covered with water, this includes both palustrine and estuarine emergent wetlands (NLCD92)

Woody wetlands – Areas where forest or shrubland vegetation accounts for 25-100% of the cover and the soil or substrate is periodically saturated with or covered with water. This includes shrub/scrub wetlands, mangroves, palustrine forested wetlands, and estuarine forested wetlands. (NLCD92)

Shrub/scrub wetlands - woody vegetation less than 5 meters, includes both palustrine and estuarine *except* estuarine shrub/scrub in the southern Florida "mangrove zone" (C-CAP, Cowardin et al. 1979, NWI)

Mangroves - estuarine, woody vegetation less than 5 meters, that are generally found only within the southern US, specifically in southern Florida. (C-CAP, Cowardin et al. 1979, NWI)

Palustrine forested wetlands – Includes all tidal and nontidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5%. This includes non-wetland riparian areas. (C-CAP)

Estuarine forested wetlands - Includes all tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height, and all such wetlands that

occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5%. This includes forested wetlands. (C-CAP)

Natural (non-armored) shoreline–lacks vegetation, except for pioneering plants that become established for brief periods when growing conditions are favorable. This includes unconsolidated shoreline, rocky shore, and beach.

Open water - all areas of open water, unknown bottom

•

Aquatic bed -tidal and non-tidal wetlands and deepwater habitats, both estuarine and palustrine, which are dominated by plants that grow and form a continuous cover principally on or below the surface of the water. This includes both *submerged vegetation* and *kelp beds*. (C-CAP, Cowardin et al. 1979, NWI)

Palustrine aquatic bed – tidal and nontidal wetlands, salinity due to ocean-derived salts is below 0.5%, where plants grow and form a continuous cover principally on or below the surface of the water. This includes submerged aquatic vegetation. (C-CAP)

Estuarine aquatic bed – tidal wetlands, salinity due to ocean-derived salts that are greater than or equal to 0.5%, where plants grow and form a continuous cover principally on or below the surface of the water. This includes kelp beds. (C-CAP)

Coral reefs - ridge-like or mound-like structures formed by the colonization and growth of sedentary invertebrates, found in shallow waters of warm seas – southern Florida, within marine systems (Cowardin et al. 1979, NWI)

Oyster reefs - ridge-like or mound-like structures formed by the colonization and growth of sedentary invertebrates, found in Pacific, Atlantic, and Gulf Coasts, within the estuarine system (Cowardin et al. 1979, NWI)

Hard bottom - all wetlands and deepwater habitats with substrates having 75 percent cover of stones, boulders, or bedrock and vegetative cover less than 30 percent. (Cowardin et al. 1979, NWI)

Soft bottom - all wetland and deepwater habitats with at least 25 percent cover of particles smaller than stones, and a vegetative cover less than 30 percent, i.e., cobble-gravel, sand, mud, organic. (Cowardin et al. 1979, NWI)

- ***Non-wetland habitat types:***

Developed - constructed materials, may contain some vegetation, impervious surfaces account for greater than 20 percent of total cover. includes high, medium, and low intensity developed areas. (C-CAP)

Agriculture/pasture – areas used for the production of crops or grasses for livestock or seed production or hay crops account for 20 percent of total cover. (C-CAP)

Other upland - all upland land cover/land use types, other than developed or agriculture, including barren, upland forested (including maritime forests), upland shrub, and upland herbaceous.

Note: sources for class definitions are in parentheses following the definition. The wetland habitat definition was taken from:

Classification of Wetlands and Deepwater Habitats of the United States by
Lewis M. Cowardin, USFWS, Northern Prairie Wildlife Research Center, Jamestown,ND
Virginia Carter, USGS, Reston, Virginia
Francis C. Golet, Dept. of Natural Resources Science, Univ. of Rhode Island, Kingston, RI, and
Edward T. LaRoe, U.S. NOAA, Office of Coastal Zone Management, Washington, DC
Performed for: U.S. Department of the Interior, U.S. Fish and Wildlife Service, Office of Biological Services, Washington, DC FWS/OBS-79/31 December 1979

Section 12.0 Appendix B (Data Resource Report)

NOAA Habitat Loss Analysis

Data Research Report

November 15, 2004

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Introduction

The purpose of this report is to discuss data sources for the historic and current habitat loss analysis being developed for NOAA in support of their efforts under the Estuary Restoration Act. A trends analysis will focus on collecting data from two primary time periods: current (variable depending on region, but generally 1990s to 2000's) and historic (1940's to 1960's). The geographic extent will include all U.S. coastal areas, including the Great Lakes region, of the lower 48 states. Results will be summarized by the Coastal Area Framework (CAF) regions, and if feasible the major and minor National Estuarine Reserve Regions (NERR). Figure 1 illustrates the extent of the study area including the CAF and NERR regions.

The following sections describe select datasets that provide complete, or nearly complete, national coverage. The description of the dataset includes the methods, time period, and classification scheme. In addition, the general advantages and disadvantages are described in the summary for each dataset. At the end of both sections there is a discussion on existing data gaps. The conclusion provides information on the overall project concept, how the reported data sources will be used, and what types of data need further research and acquisition.

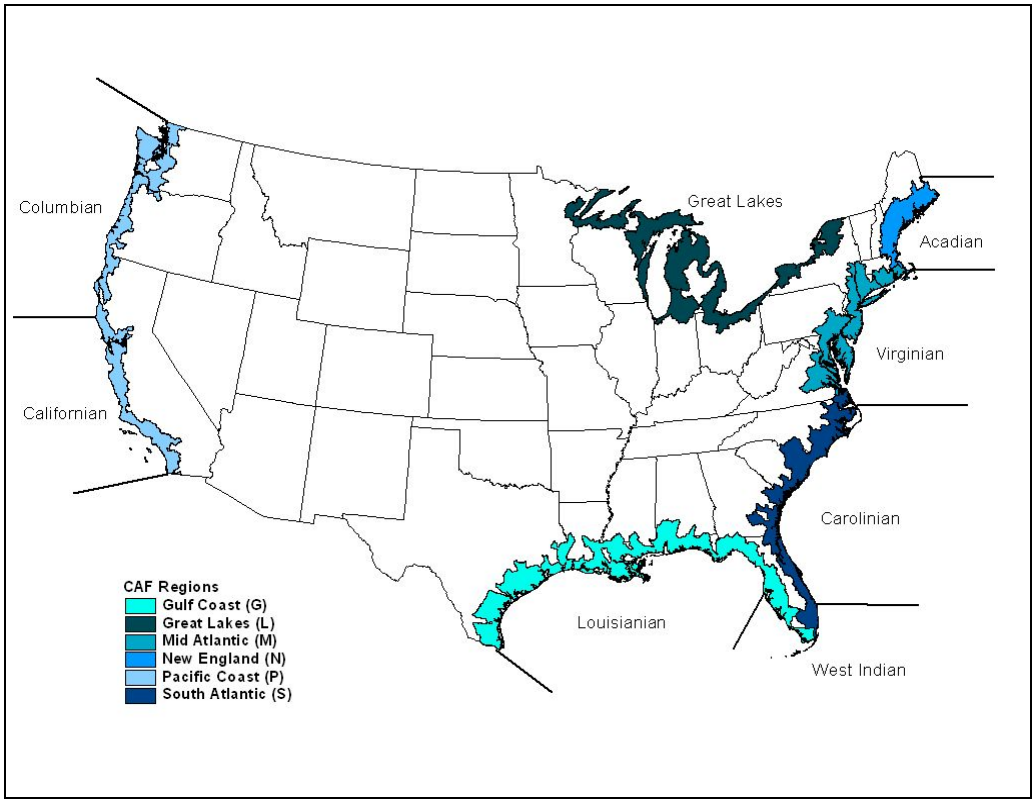

Figure 1. CAF and major NERR regions. CAF regions are depicted in shades of blue (see legend for region name) and NERR regions are depicted by solid black lines and include the region name (i.e., Columbian).

Current Data (1970's to 2000's) NOTE: "current" data used for each area should be the most recent possible; in most cases 5- to 10-year comparisons (based on 1992 NLCD data) will provide the basis for "current rate of loss" analysis.

NOAA Coastal Change Analysis Program

Methods - C-CAP provides a national baseline of land cover and change data. This includes land cover data for two dates, approximately five years apart and a change detection analysis illustrating the differences between the two dates. The land cover data is derived from Landsat Thematic Mapper (TM) satellite imagery, with a 30m-pixel resolution, in conjunction with many ancillary datasets. Methods involve a spectral analysis along with image processing and GIS modeling techniques.

Time period – The time period varies depending on the region. Digital maps based on satellite imagery from 2000 exist for most of the U.S. coastal areas and the Great Lakes. The exception is the East Coast. C-CAP maps do exist in spots along the East Coast, however the time periods range from 1986 to 1997. Appendix A lists C-CAP availability by region.

Classification Scheme – Appendix B lists the habitat classes for all current data sets, including the C-CAP wetland classes.

Summary – Although not complete, the C-CAP maps provide the most current data available for most of the U.S. coastal areas as well as the Great Lakes region. They also provide one of the more extensive wetland classification schemes. Benthic habitats were originally going to be mapped as part of CCAP, however that mapping is now being done separately. The C-CAP maps include nearly all of the wetland/estuary habitats identified by NOAA in the Statement of Work with the exception of the deep water habitats such as coral reefs, and rocky and unconsolidated bottoms.

USGS National Landcover Database

Methods - The NLCD project was created in 1995 and identifies twenty-one classes of land cover, using consistent procedures for the entire U.S, and includes a subsequent accuracy assessment. The NLCD maps were derived from Landsat TM satellite imagery, with a 30m-pixel resolution, using spectral analysis and GIS modeling techniques. The USGS has completed the initial land cover mapping (NLCD 92), which encompasses the entire conterminous United States. Using enhanced image processing methods, the USGS is currently developing an updated land cover map (NLCD2001) for all 50 states and Puerto Rico.

Time period – The original NLCD was based on data from the late 1980's to the early 1990's, depending on location. This dataset is complete. The updated NLCD, which is currently being developed, is based on data from 2000 – 2001. There are only two

datasets available within the coastal/Great Lakes area. Appendix A lists availability of NLCD2001 and NLCD92 datasets by region.

Classification Scheme - The wetland classes mapped in the initial land cover mapping effort are woody wetlands and emergent herbaceous wetlands. In the more current land cover mapping effort (NLCD 2001) wetland habitat types are broken out into palustrine and estuarine wetland habitats. USGS and NOAA are working together to combine efforts between the C-CAP and NLCD. Where applicable, the NLCD2001 is implementing the C-CAP wetland habitat types. Appendix B lists the NLCD92 and NLCD2001 wetland classes.

Summary – The NLCD92 provides complete coverage for wetlands within the study area. The classification scheme is general though and deep water habitats were not mapped. Unconsolidated shoreline was not mapped separately from the sand/bare rock/clay land cover type. However, GIS modeling techniques may allow for extracting this type along the coastline, particularly in conjunction with NOAA's medium resolution vectorized shoreline. NLCD2001 has more detailed wetland/estuary classes, however it is not complete. There are only two zones completed within the coastal and Great Lakes regions.

USFWS, National Wetlands Inventory

Methods - The US Fish and Wildlife Service has mapped wetlands and deepwater habitats (streams, lakes, estuaries, etc.) for most of the US. The maps are available by USGS 1:24,000 scale quad maps. The primary source of data collection is high altitude aerial photographs. Digital data is complete for the entire East Coast and Great Lakes regions. Digital data for the Gulf Coast, including Florida, is nearly complete, and most of the West Coast is complete.

- *Time period* – Dates for the source data ranges from the 1970's through 2000, however data is predominately from the 1980's.
- *Classification Scheme* – The classification is fairly extensive and is based on the Classification of Wetlands and Deepwater Habitats of the US (Cowardin et.al, 1979). Appendix B lists the general NWI classes.
- *Summary* - The NWI is an extensive wetlands mapping project, and nearly complete for the entire US coastal areas and Great Lakes region. It includes deepwater habitats such as reefs and unconsolidated bottoms. However, the majority of the data is from the 1980's. Fortunately, in areas where the more current C-CAP or NLCD is lacking, NWI is more current. For example, in areas of the New England coast the NWI is from the 1990's and 2000's.

USGS Gap Analysis Program

- *Methods* - The purpose of the GAP is to develop a comprehensive assessment of the conservation status of native vertebrate species and natural land cover types. It is a state-run program that is coordinated by the USGS. In addition to developing species occurrence databases, the GAP has mapped land cover and vegetation types on a state-by-state basis. The maps are derived from Landsat TM satellite imagery, with a 30m-pixel size. Although based on a spectral analysis, mapping also involves using ancillary datasets and GIS modeling techniques. Although there is a current effort to update the GAP land cover maps, the initial versions of the GAP maps are complete for nearly all states within the Great Lakes region and coastal areas of the U.S.

- *Time period* – The completed GAP land cover maps are predominately from the early 1990's. Efforts are currently underway to update most GAP land cover maps.

- *Classification Scheme* – The classification schemes of the GAP land cover maps vary from state to state. Some states are much more generalized, such as Louisiana. Other states have more detailed classification schemes such as North Carolina. All have included wetlands at some level.

- *Summary* - The GAP land cover maps provide additional wetland information for each state from the early 1990's, which coincides with the NLCD92. This could possibly help to expand on the two NLCD92 wetland classes, depending on the complexity of the state's GAP classification scheme.

<u>NOAA Submerged Aquatic Vegetation (SAV) Maps</u>

- *Methods* – NOAA uses a combination of satellite imagery, aerial photography, and shipboard acoustic surveys, in addition to shipboard imaging and sediment sampling to map benthic habitats. In conjunction with local, state, and federal agencies, NOAA has completed several SAV mapping and change detection analyses. Project study areas are located in Maine, Massachusetts, New York/New Jersey, Rhode Island, North Carolina, Florida, Washington, and Texas.

- *Time period* - The time period varies depending on the project. Most projects were developed using data from the early to mid 1990's. However, a few projects were more recent than that such as Long Island Shoreline (2002), Narragansett Bay in Rhode Island (1999), and Estero Bay in Florida (2000).
-
- *Classification scheme*- Benthic habitat types include seagrass beds, coral reefs, and mangrove forests.

- *Summary* – Mapped SAV data is limited, so these projects will provide extra data that can supplement either the NLCD92 or C-CAP/NLCD2001 era data sets. The Maine and Massachusetts SAV mapping project included the entire coastal areas of both states. The other SAV projects focused on specific estuaries or bays of particular interest, such as Willapa Bay in Washington and the southern boundary of the Everglades National Park in Florida. Overall, the data is limited in geographic extent.

USGS Digital Line Graphs

Methods – The USGS has developed DLGs based on their different scale topographic quadrangle maps. DLGs exist for 1:24,000, 1:100,000, and 1:2,000,000 scale quad maps. These are vectorized datasets that represent the different feature types on the quad maps, such as roads and streams. The hydrology component includes lakes, rivers, ponds, marshes, etc. The only DLGs that would be somewhat applicable to use as an historical data set for this project would be the 1:2,000,000 scale DLGs because they date back to 1973.

Time period – The 1:2,000,000 scale DLGs date from 1973 – 1994.
Classification scheme – The hydrology component includes basic line and polygon features such as lakes, ponds, rivers, and streams.

Summary – The DLG's might provide be a good supplemental source for current data. The early DLGs (i.e., from 1973) may be a reference source, particularly in conjunction with other historical data. However, 1973 is more recent than the target historical dates (1940-1960).

Significant Data Gaps in the Current Data Sets

Temporal gaps – Wetlands data from 2000/2001 exists for nearly all of the lower 48 states coastal and Great Lakes areas. The exception is the East Coast region. Most of the Southern New England, Middle Atlantic, and Chesapeake Bay regions have data mapped from 2000/2001. However, the most current data from the remaining areas – Northern and Southern Gulf of Maine, North Carolina, South Atlantic, and East and West Florida – is from the early to late 1990's. The most significant gaps are Maine, the most current data being from 1993, and Florida where the most current data is from 1996.

Geographic gaps – There are few to no gaps geographically in the current datasets. At some point in the last ten years, almost every part of the coastal or Great Lakes regions has been mapped.

Habitat gaps – The classification schemes of the CCAP, NLCD2001, NWI, and some GAP data all include palustrine and estuarine habitat types. NLCD92 is limited to woody versus emergent wetlands. C-CAP and NWI include the unconsolidated shoreline and benthic habitats. However, C-CAP is limited only to submerged aquatic vegetation. NWI includes reefs and bottom habitats. NOAA SAV maps include more data covering benthic habitats, but these maps are spotty and coverage is not consistent in all regions.

The most extensive classification scheme is NWI, but NWI is predominately from the 1980's. Very little mapping exists for deepwater habitats such as coral reefs and bottom habitats.

Historical Data (1940's to 1960's)

NOAA Historical Shoreline and Shoreline Data

- *Methods* - NOAA has extracted shoreline data for most of the coastal regions in the contiguous U.S. The Great Lakes region has not been complete, nor has Washington state. However individual shoreline vectorization projects for these two areas exist on the NOAA shoreline data explorer website. Historical nautical charts were used to develop these shoreline products. Dates vary from state to state, depending on availability.

- *Time period* – The time period varies from state to state. For example, California shoreline data is from 1909 – 1988 and Alabama shoreline data is from 1978 – 1986.

- *Classification scheme* – The shoreline data includes the following attributes: approximate shoreline; apparent shoreline; dike/levee; jetty; pier/ramp/dock; man-made structures like wharves/seawalls/locks etc.

- *Summary* - This data may not be applicable to this study. It is possible, that in conjunction with other historical data, this shoreline data could help to identify the historical unconsolidated shoreline. However, more investigation is needed.

NOAA Historical Nautical Charts

Methods – NOAA has many scanned and geo-referenced historical nautical charts. The collection is extensive. At this point, very few vectorized coverages have been discovered that were derived from the historical nautical charts. The NOAA historical shoreline project utilizes the historical nautical charts. NOAA does provide an ArcView 3.x extension that extracts shoreline data from nautical charts. However, its applicability to this project requires more investigation.

Time period – The time period varies from state to state.

Classification scheme – Information available on these maps would include shoreline location as well as location of dikes, levees, jetties, piers, etc. It may be possible to derive mangrove forests from nautical charts.

Summary – In general the historical nautical charts will not supply a lot of information about historical locations of different coastal wetland habitat types such as emergents, forested wetlands, shrub/scrub wetlands, submerged aquatics,etc. Also, nautical charts cover a limited extent along the shoreline of waters available for navigation. However, they may be useful in mapping some unconsolidated shorelines as well as some mangrove habitats.

USGS Digital Raster Graphics

Method – The USGS has scanned many of their topographic quadrangles maps. The DRGs are available in digital, geo-referenced format at different scales (i.e., 1:24,000, etc.). There are some collections of historical topo quads that have been scanned, but are *not* geo-referenced. The collections include 7.5 and 15-minute quads of San Francisco Bay in California as well as many in the New England states. The USGS also sells replications of historical USGS maps. It may be possible to obtain, through the USGS, hard copy topo maps of various historical quad maps.

Time Period – The San Francisco Bay collection dates back to 1895 for the 15-minute quads, but most of the 7.5-minute quads are from the 1940's and 1950's to present. The time period for the New England collection is approximately the same.

Classification scheme – There is no classification scheme for DRGs. These are scanned images of the original topo quads.

Summary – The DRGs would provide a great reference source, especially in conjunction with other historic datasets. Unfortunately, they do not differentiate between different types of wetlands, such as emergent, shrub/scrub, or forested. They would provide more general information, such as the presence of a wetland or swamp.

Historical aerial photography

Method – Aerial photography dates back to the 1930's and has been heavily utilized in many different fields of land and resource management. NOAA has an extensive archive of historic aerial photos of the U.S. Exclusive Economic Zone – approximately 5 to 8 miles inland – and that date back to 1943. The USDA, Aerial Photography Field Office, also has an extensive historic aerial photo archive that dates back to 1955. While an index to the NOAA aerial photo archive is not online, a research analyst is available to provide information on what exists in a specific area. The USDA provides an online index to their archive. Photos are organized by state, and then by county. For both agencies, a fee is required to purchase photos and requires approximately one month for delivery. Also, geo-referenced photos are not necessarily available.

Several historic trends analysis projects have been completed for specific estuaries, particularly those belonging to the National Estuary Program. These analyses have utilized historic photos from the 1940's and 50's. It may be possible to obtain historic digital aerial photos from these or other sources in geo-referenced format. Other sources of historic aerial photos include the USGS EROS Data center, Army Corp of Engineers, National Archives, state agencies, and local historical societies. Exact coverage and time periods available from these sources would have to be researched.

- *Time period* – Aerial photos are available back to the early to mid -1940's.

- *Classification scheme* - NA

- *Summary* - Aerial photos are ideal for mapping most historic wetlands. They are available as far back as the early 1940's, and provide detailed mapping information. However, in most cases, they are not already geo-referenced, so bringing them into a spatial format would require either referencing the scanned photo or translating the information using another data source as a back drop (possibly a DRG). Also, aerial photos would not provide a reliable method to collect historic information on benthic habitats such as aquatic beds or coral reefs.

Significant Data Gaps in the Historical Data Sets

Temporal gaps – Historical data exists back to the 1940's in some format, such as aerial photos or old USGS topographic quadrangles. However, it may not be possible to obtain complete historical coverage from one source, during one time period, for all regions. It may be necessary to obtain data from different sources over several dates for each region.

Geographic gaps – Geographical gaps vary depending on the source data. For example, the NOAA coastal aerial photographs are limited to within 5 to 8 miles of the coastline. This is generally true of the historical nautical charts as well. The USDA aerial photos may fill in gaps that exist with the NOAA photos. Historical USGS topographic quadrangle maps should exist for the entire U.S., but finding readily available quads may be difficult.

- *Habitat gaps* – Habitat types are the most limiting in the historical data sources, especially benthic habitats. Aerial photos will provide the most detailed information, particularly regarding wetland cover type (i.e., emergents, shrubs, forested) as well as shoreline information. However, they will most likely not provide information regarding benthic habitats such as coral reefs or submerged vegetation. DRGs or USGS topo quads will provide very general information such as approximate shoreline location and marsh versus upland. Historical nautical charts may provide information regarding mangrove forests and shoreline location.

Methods

Current data provides a much more comprehensive coverage of estuarine habitats across the U.S. than historical data. The historical data still requires more data digging through localized datasets to try to fill in data gaps. This has already been started and several sources have been located for further investigation, see Appendix C for a list of additional sources that may provide more detailed datasets.

The overall concept for the analysis will be to select areas within each CAF region where there appears to be more detailed data available and place a transect through these areas. Figure 2 illustrates the general location for potential transects. Current data sources, such as the NWI, will be used to help locate the exact location of the transects, preferably in areas of high habitat diversity. The current data sources will provide the baseline for the target habitats, and then along each transect the change in habitat will be mapped. As the data research continues and more historical datasets are uncovered, their use in the analysis will be discussed with NOAA during our weekly project meetings. Specific methods for extrapolating from these transects to the remainder of each region will be detailed in the data analysis plan.

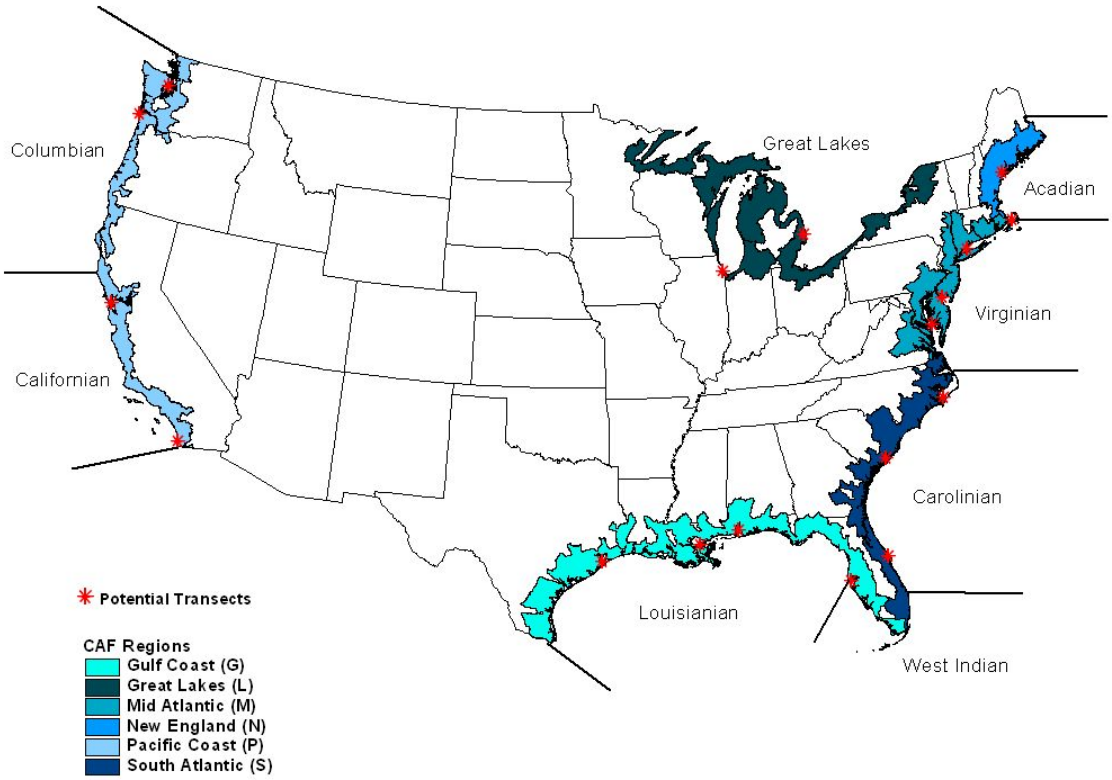

Figure 2. Preliminary sites for transects are marked with a red star.

Initially, there will be two to four transects per CAF region. Depending on the availability of historical data, it may be necessary to eliminate transects. However, a minimum of one

transect per CAF region will be maintained. Since the CAF regions correspond closely to the NERR major regions, the distribution of the transects will likely also provide one to two per NERR major region. The following table lists the general location of the preliminary transect sites.

Table 1. Preliminary Transect Sites

CAF Region	NERR Major Region	Tran-sect #	Transect
Pacific Coast	Columbian	1	Puget Sound, WA
		2	Lower Columbia River, OR
	Californian	3	San Francisco Bay, CA
		4	San Diego Bay, CA
Gulf Coast	Louisianan	5	Galveston, TX
		6	New Orleans, LA
		7	Mobile Bay, AL
		8	Tampa Bay, FL
South Atlantic Coast	Carolinian	9	North Eastern FL
		10	Charleston, SC
		11	Pamlico Sound, NC
Mid Atlantic Coast	Virginian	12	Chesapeake Bay, MD
		13	Delaware Bay, DL
		14	Long Island, NY/NJ
New England Coast	Acadian	15	Portland Harbor, ME
		16	Cape Cod, MA
Great Lakes	Great Lakes	17	Chicago, IL
		18	Lake St. Clair, Canada

In addition to summarizing the results by CAF and/or NERR region, the results will also be summarized by target habitat groups, as best as possible. The target habitat groups that NOAA identified in the SOW are:

- Salt marsh
- Freshwater marsh
- Forested wetland (non-mangrove)
- Shrub swamps (non-mangrove)
- Mangroves
- Riparian forests (non-wetland)
- Submerged aquatic vegetation
- Kelp beds
- Oyster reefs/shell bottom
- Natural (non-armored) shoreline (rocky shore and beach)
- Maritime forest
- Soft bottom (mud and sand; inter-tidal and sub-tidal)
- Hard (rocky) bottom
- Coral reef

NWI is the only data source that maps these individual classes. However other datasets will also be required which have more generalized classification schemes. As discussed previously with NOAA the target habitat types will need to be collapsed into target habitat groups to account for the more generalized classification schemes. The following are the proposed groupings:

- Emergent wetlands (salt marsh, freshwater marsh)
- Shrub/scrub wetlands (shrub swamps, mangroves)
- Forested wetlands (forested wetlands, riparian forests, maritime forests, mangroves)
- Aquatic beds (submerged aquatic vegetation, kelp beds)
- Reefs (coral reefs, oyster reefs/shell bottom)
- Unconsolidated shoreline (Natural (non-armored) shoreline (rocky shore and beach)
- Bottom habitats (soft bottom, hard rocky bottom)

Where possible, these groupings will be split as follows (in general order of priority):

Non-wetland riparian and maritime forests versus forested wetlands (i.e., swamps)
Mangroves versus other shrub swamps and forested wetlands
Coral reefs versus oyster reefs
Soft bottom versus hard rocky bottom

If due to source data limitations it is not possible to split the groupings as suggested above for the historical analysis, these categories may be split (where possible) only for the current coverage and current loss rate analyses.
Even within these groupings it may be difficult to find data to support all groups. The current datasets will most likely capture all habitat types, with the possible exception of bottom habitats. In the historical datasets there are many more habitat gaps. Aerial photos, where available, would most likely allow emergent, shrub/scrub, and forested wetlands to be differentiated. However, aquatic beds, reefs, and bottom habitats may not be possible to map from historical maps at all. Unconsolidated shorelines should be attainable from aerial photos, and/or in conjunction with historical nautical charts.

Appendix A – Availability of Current Datasets by Region

CAF Regions	Major NERRS Region	Minor NERRS Region	2000/2001	1999	1997	1995/1996	1993/1994	1992	1991/1990	1988	1986	1980's
New England (N)	Acadian	Northern Gulf of Maine					ME GAP	NLCD/C-CAP			C-CAP	NWI
		Southern Gulf of Maine				partial C-CAP	partial C-CAP; ME GAP	NLCD			partial C-CAP	
Mid-Atlantic (M)	Virginian	Southern New England	partial NLCD2001 (zone 60)	RI coastal habitat s	partial C-CAP (MA-RI-E.CN)	partial C-CAP (So. NJ); RI coastal habitats	partial C-CAP (NY)	NLCD	partial C-CAP (MA-RI-E.CN)	RI wetlan ds		
		Middle Atlantic	NLCD2001 (zone 60)					NLCD				
		Chesapeake Bay	NLCD2001 (zone 60)		C-CAP			NLCD				
South Atlantic (S)	Carolinian	North Carolina			C-CAP			NLCD	C-CAP			
		South Atlantic			partial C-CAP (GA)	partial C-CAP (all SC)		NLCD; partial C-CAP (GA)	partial C-CAP (all SC)			
		East Florida				wetlands from DLGs (FLDEP)		NLCD				NWI
	West Indian	~~Caribbean~~						NLCD				
Gulf Coast (G)		West Florida				wetlands from DLGs (FLDEP)		NLCD				NWI

	Louisianan	Panhandle Coast	partial C-CAP					NLCD				
		Mississippi Delta	C-CAP			partial C-CAP		NLCD			partial C-CAP	
		Western Gulf	C-CAP					NLCD				
Pacific Coast (P)	Californian	Southern California	C-CAP					NLCD				
		Central California	C-CAP					NLCD				
		San Francisco Bay	C-CAP					NLCD				
	Columbian	Middle Pacific	C-CAP					NLCD				
		Washington Coast	C-CAP					NLCD				
		Puget Sound	C-CAP					NLCD				
Great Lakes (L)	Great Lakes	Lake Superior	C-CAP/partial - NLCD2001 (zone 41)					NLCD				
		Lakes Michigan and Huron	C-CAP					NLCD				
		Lake Erie	C-CAP					NLCD				
		Lake Ontario	C-CAP					NLCD				

Appendix B – Habitat Classes for Current Datasets

Proposed Target Habitat Groups	Classes in SOW	Cowardin, et al 1979	C-CAP Wetland Classes	NLCD2001 Wetland Classes	NLCD92 Wetland Classes	NWI Generalized Classification
			1986 - 2000	2001	late 80's - early 90's	1970's to 2000's
emergent wetlands	salt marsh	emergents	estuarine emergent wetlands	estuarine emergent wetlands	emergent herbaceous wetlands	estuarine emergent
	freshwater marsh	emergents	palustrine emergent wetlands	palustrine emergent wetlands	emergent herbaceous wetlands	palustrine emergent
shrub-scrub wetlands	shrub swamps (non-mangrove)	shrub-scrub	palustrine shrub-scrub	palustrine shrub-scrub	woody wetlands	palustrine scrub-shrub
	mangroves	shrub-scrub (when < 6m)	estuarine shrub-scrub	estuarine shrub-scrub	woody wetlands	estuarine scrub-shrub
forested wetlands	forested wetland (non-mangrove)	forests	palustrine forested wetland	palustrine forested wetland	woody wetlands	palustrine forested
	riparian forests (non-wetland)	forests	palustrine forested wetland	palustrine forested wetland	woody wetlands	palustrine forested
	maritime forest	forests	estuarine forested wetland	estuarine forested wetland	woody wetlands	estuarine forested
	mangroves	forests (when GE 6m, i.e., Florida)	estuarine forested wetland	estuarine forested wetland	woody wetlands	estuarine forested
aquatic beds	submerged aquatic veg.	aquatic bed	palustrine aquatic bed	palustrine aquatic bed		palustrine aquatic bed
	kelp beds	aquatic bed	estuarine aquatic bed	estuarine aquatic bed		estuarine aquatic bed
reefs	coral reefs	reefs				marine reef

	oyster reefs/shell bottom	reefs				marine reef and/or marine and estuarine unconsolidated bottom
unconsolidated shoreline	natural (non-armored) shoreline (rocky shore and beach)	unconsolidated shoreline	unconsolidated shoreline	unconsolidated shoreline	bare rock/sand/clay	marine and estuarine rocky shore and unconsolidated shore
bottom habitats	hard (rocky) bottom	rock bottom				marine and estuarine rock bottom
	soft bottom (mud and sand, inter-tidal and sub-tidal)	unconsolidated bottom				marine and estuarine unconsolidated bottom

Appendix C – Additional Data Sources for Historical and Current Datasets

State or Region	Data Layer	Source - url	SI comments
California			
	NOAA - Central and Northern CA biographic assessment	http://biogeo.nos.noaa.gov/products/canms_cd/htm/data.htm	has 1999 offshore rocks/islands/substrate/kelp beds coverages
	CA Spatial Information Library		
	Wetlands - NWI	http://gis.ca.gov	
	DLG Hydrology	http://gis.ca.gov	DLG-3 1:100k
	NHD	http://gis.ca.gov	
	CDF-FRAP	http://frap.cdf.ca.gov/projects/frap_veg/index.html	best available land use for 2002 - includes wetlands, this should provide good information on current wetlands
	DOQQs	http://gis.ca.gov	most current version of DOQQs plus archive of DOQQs - archive looks like it is from late 90's
	DRGs	http://gis.ca.gov	all drgs are available on line for CA - 250k, 100k, and 24k
			Example date: from Crescent City, CA 250k topo - from 1942-52, field checked 1958, updated 1975/1977
	ICEMAPS2	http://icemaps.des.ucdavis.edu/icemaps2/ICEMapInit.html	NOTHING

	San Francisco Estuary Institute	http://www.sfei.org/index.html and http://www.ecoatlas.org/	historical mapping projects - they have done a comprehensive look at SF Bay habitats back to pre-European settlement
	CA Central Valley Wetlands and Riparian GIS - Wetlands Inventory and Conservation	from Ceres website : http://www.ceres.ca.gov	Wetlands for SFBAY and Central Valley - early 1992-1993 - from Landsat
	UC Berkley - Earth Sciences and Map Library	http://sunsite.berkeley.edu/histopo/#	historic topos for greater SF BAY - Nice but looks like jpgs and NOT REFERENCED
Florida			
	Florida Fish and Wildlife Research Institute	http://ocean.floridamarine.org/mrgis/viewer.htm	lots of Florida projects, one complete seagrasss coverage for entire state 1987-1999
	Library of Congress	http://lcweb2.loc.gov/cgi-bin/query/D?gmd:475:./temp/~ammem_vhVU::	paper map of Florida - 1940 - topographic
New England and New York	USGS Historic Topos	http://docs.unh.edu/nhtopos/nhtopos.htm	good collection of scanned BUT NOT REFERENCED historic topo quads (15minute) from USGS
	Long Island Sound Study	http://www.longislandsoundstudy.net/research_data.htm	huge database with lots of potential for New York and New Jersey wetland/coastal habitats
	Rhode Island - RIGIS	http://www.edc.uri.edu/rigis-spf/statewide/state.html#wetlands	digital aerial photos back to 1939
	NY/NJ Harbor	http://www.csc.noaa.gov/lcr/nyharbor/index.html	historical bathymetric grids; also some current station data for benthic habitats like mussel beds, etc.
Washington State			

	WADNR - Nearshore Habitat Program - Shorezone Inventory	http://www2.wadnr.gov/nearshore/research/index.asp?sp=y&id=9	characterizes 3000 miles along WA coast line - 1994 - 2000 - used aerial photography
	WADNR - Nearshore Habitat Program - Eelgrass surveys and Kelp bed monitoring	http://www2.wadnr.gov/nearshore/research/index.asp?sP=y&id=17	inventory of kelp beds and eelgrass - current data only
	WADFW	http://wdfw.wa.gov/hab/sshiap/index.htm	salmon habitat inventory
	WADNR	http://www.dnr.wa.gov/dataandmaps/maps/photo_january.htm	historic aerial photos
Maryland			
	Maryland Merlin	http://www.mdmerlin.net/	
Louisiana			
	USGS - Louisiana Coastal land loss	http://www.nwrc.usgs.gov/special/landloss.htm	historical habitat loss for entire coastal habitat area in state - referenced 1950's NWI data
Oregon			
	Tillamook Bay NEP	http://www.co.tillamook.or.us/gov/estuary/tbnep/maps.html	info on Tillamook Bay Estuary - GIS data - doesn't look like historic data
	Lower Columbia River Estuary Partnership	http://www.lcrep.org/main_links.htm	info/links on Lower Columbia - not necessarily GIS data but links to other estuary projects from around the country
Texas			
	Texas General Land Office	http://www.glo.state.tx.us/gisdata/gisdata.html	may contain helpful info for Texas, many base layers
Federal Programs for Coastal Management/Research			
	CWAP: Coastal Research and Monitoring Strategy	http://water.usgs.gov/owq/cleanwater/coastalresearch/index.html	research and monitoring strategy

	EPA - EMAP	http://www.epa.gov/emap/html/data.html	station data -in estuaries- water quality, etc. - can obtain station locations and station data since 1990
	EPA - National Coastal Assessment - Coastal 2000	http://www.epa.gov/emfjulte/nca/	Designed coastal monitoring - data is on EMAP
	Coastal Zone Management Program	http://www.ocrm.nos.noaa.gov/czm/	partnership with states and feds - has a list of each states coastal program - might lead to state data
	National Marine Sanctuaries	http://www.sanctuaries.nos.noaa.gov/	13 sanctuaries - should look at each one for specific studies - some seabed mapping has been done
	National Estuary Program	http://www.anep-usa.org/techtransfer/index.htm	many estuaries part of the program, many of which have done research and mapping including historical trends analysis
	NERRS	http://nerrs.noaa.gov/welcome.html	25 reserves, links to each reserve, some have research info, some may lead to links for that state - like South Carolina
	Center for Coastal Monitoring and Assessment	http://ccma.nos.noaa.gov/	looks like could be links to efforts for different habitat types - I.e., coral reef mapping, etc.
	USFWS - Coastal Habitat Program	http://www.fws.gov/cep/cepcode.html	working with communities to conserve habitat - couldn't find any real research but provides contact info
Misc. Collections			
	Library of Congress - American Memory	http://lcweb2.loc.gov/ammem/gmdhtml/gmdhome.html	Map collection from 1500 - 2004 - but mostly maps are from 1800's - and not vectorized

	Duke University, Old Maps in Perkins Library	http://docs.lib.duke.edu/maps/guides/old.html	Has most of the pre-1972 topographic maps on microfilm for the southeastern states
	Association of National Estuary Programs	http://www.anep-usa.org/publications/habitat_loss.htm	list of estuaries that have completed trends analysis
	EPA - wetland restoration	http://www.epa.gov/owow/wetlands/restore/links/	this is by state - have not investigated each states site but could lead to more state info
	USGS - NWRC	http://www.nwrc.usgs.gov/	could not access data page - NWRC has done historical research projects, such as in Louisiana
	Perry-Castaneda Library - Historical Map websites - U of Texas at Austin	http://www.lib.utexas.edu/maps/map_sites/hist_sites.html#US	historical map site - have not looked through everything - looks like mostly historical atlases
	Army Corp.	http://www.usace.army.mil/estuary.html	provides contacts/links to info - by region
	NRCS - National Resource Conservation Service	http://www.nrcs.usda.gov/technical/maps.html	links to data for soils, plants, etc.
	NALC	http://www.csc.noaa.gov/crs/lca/datasources.html	imagery back to 1970's

Section 13.0 Appendix C (Data Resource Tables)

Table 13-01. Time periods and land cover datasets for each transect.

CAF Region	NERR Major Region	Transect	Date 1 most recent	Date 2 five to ten years prior to most recent	Date 3 historic (roughly 1940-1960)
Pacific Coast	Columbian	Lower Columbia River, OR	C-CAP 2000	C-CAP 1992	Aerial Photo 1948
	Californian	San Pablo Bay, CA	C-CAP 2000	C-CAP 1993	Aerial Photo 1958
Gulf Coast	Louisianan	Tampa Bay, FL	NLCD 1992 - Seagrass Mapping - Florida Fish and Wildlife Conservation Commission (1987-1999)	NWI 1982	Aerial Photo 1957
South Atlantic Coast	Carolinian	Pamlico Sound, NC	C-CAP 1997	C-CAP 1991 - NOAA Benthic Mapping 1992	Aerial Photo 1953
Mid Atlantic Coast	Virginian	Block Island Sound, RI	C-CAP 1997 - NWI 1999	NLCD 1992	Aerial Photo 1939
New England Coast	Acadian	Portland Harbor, ME	Gulf of Maine Habitat Mapping Project (GOMLC7 1997)	C-CAP 1986 - NWI 1987	Aerial Photo 1947
Great Lakes	Great Lakes	Chicago, IL	C-CAP 2001	NLCD 1992	Aerial Photo 1938

Table 13-02. Historical aerial photos citation for each transect (Date 3)

CAF Region	NERR Major Region	Transect	Date	Scale	Flight Line Photo #'s	Source	Link
Pacific Coast	Columbian	Lower Columbia River, OR	Sept 18 & 25, 1948	1:10,000	48 - 4502, 4412, 4498, 4495, 4492, 4489, 4486	US Army Corps of Engineers - PO Box 2946 Portland, OR 97208 (503)808-4820	
	Californian	San Pablo Bay, CA	Sept 20, 1958	1:26,000	58 S - 9797A, 9799A, 9801A, 9803A, 9805A, 9807A, 9809A, 9811A	National Geodetic Services 1315 East West Highway Station 932 Silver Spring, MD 20910	http://geodesy.noaa.gov/PC_PROD/Catalog/aerial_photos.htm
Gulf Coast	Louisianan	Tampa Bay, FL	1957		57 L - 1540, 1542, 1544, 1546, 1548, 1550, 1552	National Geodetic Services 1315 East West Highway Station 932 Silver Spring, MD 20910	http://geodesy.noaa.gov/PC_PROD/Catalog/aerial_photos.htm
South Atlantic Coast	Carolinian	Pamlico Sound, NC	June 10, 1953	1:20,000	53 O - 249, 251, 253, 255, 257, 259, 261, 263	National Geodetic Services 1315 East West Highway Station 932 Silver Spring, MD 20910	http://geodesy.noaa.gov/PC_PROD/Catalog/aerial_photos.htm
Mid Atlantic Coast	Virginian	Block Island Sound, RI	May 14-16, 1939		39 - 432, 619, 725, 728a, 796, 798, 799, 801, 1053, 1056, 1158, 1168, 1172	University Rhode Island	http://www.edc.uri.edu/aerialse/aerial1939/South39index.htm
New England Coast	Acadian	Portland Harbor, ME	May 31,1947	1:24,000	47 C - 2117, 2119, 2121, 2123	National Geodetic Services 1315 East West Highway Station 932 Silver Spring, MD 20910	http://geodesy.noaa.gov/PC_PROD/Catalog/aerial_photos.htm
Great Lakes	Great Lakes	Chicago, IL	November 14 & 20, 1938 & April 4, 1939	1:20,000	BWQ (3 - 28, 30), (5 - 7, 8, 10, 66, 68), (10 - 70, 71)	Illinois Department of Natural Resources	http://www.isgs.uiuc.edu/nsdihome/webdocs/ilhap/county/cook.html

Table 13-03. Crosswalk of C-CAP, NLCD, and NWI classes to Land Cover Classes

Generalized Target Habitat Groups and Non-wet Land Cover	Classes	Classes in SOW	C-CAP Classes	NLCD2001 Classes	NLCD92 Classes	NWI Generalized Classification
Wetland Habitats						
Vegetated Habitats						
Emergent wetlands	***emergent wetlands***	salt marsh	estuarine emergent wetlands	emergent herbaceous wetlands	emergent herbaceous wetlands	estuarine emergent
		freshwater marsh	palustrine emergent wetlands			palustrine emergent
Woody wetlands	***woody wetlands***			woody wetlands	woody wetlands	
	shrub-scrub wetlands	shrub swamps (non-mangrove)	palustrine shrub/scrub wetlands			palustrine scrub/shrub
			estuarine shrub/scrub wetlands			estuarine shrub/scrub
	mangroves	mangroves	*estuarine shrub/scrub wetlands			*estuarine shrub/scrub
	estuarine forested wetlands	forested wetland (non-mangrove)	estuarine forested wetlands			estuarine forested
	palustrine forested wetlands	riparian forests (non-wetland)	palustrine forested wetlands			palustrine forested
Non-Vegetated Habitats	***natural (non-armored) shoreline***	rocky shore and beach	unconsolidated shore	** unconsolidated shore	bare rock/sand /clay	marine and estuarine unconsolidated shore
Open Water Habitats	***open water***		water	open water	open water	
	aquatic bed					
	palustrine aquatic beds	submerged aquatic vegetation	palustrine aquatic bed			palustrine aquatic bed
	estuarine aquatic beds	kelp beds	estuarine aquatic bed			estuarine aquatic bed
	coral reefs	coral reefs				marine reef - Southern Florida
	oyster reefs/shell bottom	oyster reefs/shell bottom				estuarine reef - Pacific, Atlantic, Gulf Coast

Table 13-03 (cont.).

Generalized Target Habitat Groups and Non-wet Land Cover	Classes	Classes in SOW	C-CAP Classes	NLCD2001 Classes	NLCD92 Classes	NWI Generalized Classification
Open Water Habitats (cont.)	***hard bottom***	hard (rocky) bottom				marine and estuarine rock bottom
	soft bottom	soft bottom (mud and sand, intertidal and subtidal)				marine and estuarine unconsolidated bottom
Non-wet Land Cover	***developed***	*urban, residential, commercial*	developed high intensity	developed, low intensity	low intensity residential	
			developed medium intensity	developed, medium intensity	high intensity residential	
			developed low intensity	developed, high intensity	commercial / industrial / transportation	
	agriculture	*pasture, hay, row crops*	cultivated land	pasture/hay	pasture/hay	
			pasture/hay	cultivated crops	row crops	
					small grains	
					fallow	
					orchards/vineyards/other	
	other upland	*upland forests (including maritime forest), shrubs, herbaceous, barren*	tundra	developed, open space	deciduous forest	
			deciduous forest	barren land(rock, sand, clay)	evergreen forest	
			evergreen forest	deciduous forest	mixed forest	
			mixed forest	evergreen forest	shrub land	
			scrub/shrub	mixed forest	grasslands/herbaceous	
			bare land		urban/recreational grasses	

Table 13-03 (cont.).

Generalized Target Habitat Groups and Non-wet Land Cover	Classes	Classes in SOW	C-CAP Classes	NLCD2001 Classes	NLCD92 Classes	NWI Generalized Classification
Non-wet Land Cover(cont.)	***other upland (cont.)***		tundra		quarries/strip-mines/gravel pits	
			snow/ice		transitional	
					perennial ice/snow	

* Only in southern Florida "mangrove zone"

** Unconsolidated Shore not mapped for Mid Atlantic CAF

Table 13-04. Introductory Notation to Tables 13-04a thru 13-04l.

The following tables 13-04a through 13-04l contain the base acreages for the low and high percent ranges of change estimated by local experts for each CAF region. Local experts provided a percent estimate of change for the historic period and the recent period. The 1992 NLCD acreage is a rough calculation of acreage by land cover class based on each CAF region's boundaries and the 1992 NLCD geospatial raster data.

The known and/or estimated values by land cover class are:

- 1992 NLCD Acreage
- Historic % of 19xx ~ *Percent Change from Historic (19xx) Acreage up to 2004(estimated by local experts)*
- Recent % of 1992 ~ *Percent Change from Recent (1992) Acreage up to 2004 (estimated by local experts)*

The calculated values by land cover class are:

- 1992 – 2004 Recent Loss/Gain Acres ~ *Acres change based on estimated percent change over recent time period*
- 2004 Acreage
- 19xx (Historic) Acreage
- 19xx – 2004 Historic Loss/Gain Acres ~ *Acres change based on estimated percent change over historic time period*
- 1992 – 2004 Recent % of 19xx (Historic) ~ *Percent Change of Recent Acres Change compared to Historic Acreage*

Below is an example of the calculations with sample data. The historic (19xx) date in this example is 1938.

Known:

- 1992 NLCD Acreage = 100 acres
- 1938 – 2004 Historic % of 1938 = -10% (given by expert)
- 1992 – 2004 Recent % of 1992 = -5% (given by expert)

Calculated:

- 1992 – 2004 Recent Loss/Gain Acres = (100 acres)(-5%) = -5 acres lost
- 2004 Acreage = 100 acres – 5 acres = 95 acres
- 1938 Acreage = 95 acres / 90% = 105.5555 ~ 106 acres
- 1938 – 2004 Historic Loss/Gain Acres = 95 acres – 106 acres = -11 acres lost
- 1992 – 2004 Recent % of 1938 = -5 acres lost / 106 acres = -4.72% ~ -5%

Table 13-04a. Great Lakes CAF region low range acreages and percentages based on low percent ranges of change estimated by local experts. Further description and calculation details provided in Table 13-04 Introductory Notation.

Great Lakes CAF Region - Low Range Estimates									
		Acreage by Year			Historic Change		Recent Change		
		1938 Acreage Low Range	1992 NLCD Acreage	2004 Acreage Low Range	1938 - 2004 Historic Loss/Gain Acres Low Range	1938 - 2004 Historic % of 1938 Low Range *(estimated)*	1992 - 2004 Recent Loss/Gain Acres Low Range	1992 - 2004 Recent % of 1992 Low Range *(estimated)*	1992 - 2004 Recent % of 1938 Low Range
Wetland Habitats	***Wetlands Total***	***8,047,447***	***7,793,317***	***7,403,651***	***-643,796***	***-8%***	***-389,666***		***-5%***
	Emergent Wetlands	992,843	940,588	893,559	-99,284	-10%	-47,029	-5%	-5%
	Woody Wetlands Total	6,976,470	6,829,597	6,488,117	-488,353	-7%	-341,480	-5%	-5%
	Woody Wetlands (undetermined)	no data	no data	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data	5%	no data	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data	-5%	no data	no data	no data
	Natural (non-armored) Shoreline	23,629	23,131	21,975	-1,654	-7%	-1,157	-5%	-5%
Open Water Habitats	***Open Water Total***	***1,498,752***	***1,467,199***	***1,393,839***	***-104,913***	***-7%***	***-73,360***	***-5%***	***-5%***
	Open Water	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed (undetermined)	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***1,838,200***	***2,162,589***	***2,205,840***	***367,640***	***20%***	***43,252***	***2%***	***2%***
	Agriculture	***17,524,354***	***18,039,776***	***18,400,571***	***876,218***	***5%***	***360,796***	***2%***	***2%***
	Other Upland	***25,733,191***	***25,191,440***	***23,931,868***	***-1,801,323***	***-7%***	***-1,259,572***	***-5%***	***-5%***

Table 13-04b. Great Lakes CAF region low range acreages and percentages based on high percent ranges of change estimated by local experts. Further description and calculation details provided in Table 13-04 Introductory Notation.

Great Lakes CAF Region - High Range Estimates									
		Acreage by Year			Historic Change		Recent Change		
		1938 Acreage High Range	1992 NLCD Acreage	2004 Acreage High Range	1938 - 2004 Historic Loss/Gain Acreage High Range	1938 - 2004 Historic % of 1938 Low Range *(estimated)*	1992 - 2004 Recent Loss/Gain Acreage High Range	1992 - 2004 Recent % of 1992 High Range *(estimated)*	1992 - 2004 Recent % of 1938 High Range
Wetland Habitats	***Wetlands Total[1]***	***8,196,418***	***7,793,317***	***6,966,956***	***-1,229,463***	***-15%***	***-826,361***		***-10%***
	Emergent Wetlands	999,375	940,588	799,500	-199,875	-20%	-141,088	-15%	-14%
	Woody Wetlands Total[2]	7,231,338	6,829,597	6,146,637	-1,084,701	-15%	-682,960	-10%	-9%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data	-5%	no data	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data	-10%	no data	no data	no data
	Natural (non-armored) Shoreline	24,492	23,131	20,818	-3,674	-15%	-2,313	-10%	-9%
Open Water Habitats	***Open Water Total[3]***	***1,588,027***	***1,467,199***	***1,349,823***	***-238,204***	***-15%***	***-117,376***	***-8%***	***-7%***
	Open Water	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total[4]	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed (undetermined)**	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***1,913,059***	***2,162,589***	***2,486,977***	***573,918***	***30%***	***324,388***	***15%***	***17%***
	Agriculture	***17,255,438***	***18,039,776***	***19,843,753***	***2,588,316***	***15%***	***1,803,978***	***10%***	***10%***
	Other Upland	***26,673,289***	***25,191,440***	***22,672,296***	***-4,000,993***	***-15%***	***-2,519,144***	***-10%***	***-9%***

Table 13-04c. New England CAF region low range acreages and percentages based on low percent ranges of change estimated by local experts. Further description and calculation details provided in Table 13-04 Introductory Notation.

New England CAF Region – Low Range Estimates									
		Acreage by Year			**Historic Change**		**Recent Change**		
		1947 Acreage Low Range	**1992 NLCD Acreage**	**2004 Acreage Low Range**	**1947 – 2004 Historic Loss/Gain Acreage Low Range**	**1947 - 2004 Historic % of 1947 Low Range** *(estimated)*	**1992 - 2004 Recent Loss/Gain Acreage Low Range**	**1992 - 2004 Recent % 1992 Low Range** *(estimated)*	**1992 - 2004 Recent % of 1947 Low Range**
Wetland Habitats	***Wetlands Total[1]***	***916,606***	***884,706***	***769,949***	***-146,657***	***-16%***	***-114,757***		***-13%***
	Emergent Wetlands	267,474	255,717	232,702	-34,772	-13%	-23,015	-9%	-9%
	Woody Wetlands Total[2]	610,785	596,414	506,952	-103,833	-17%	-89,462	-15%	-15%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data	-10%	no data	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data	-2%	no data	no data	no data
	Natural (non-armored) Shoreline	33,661	32,575	30,295	-3,366	-10%	-2,280	-7%	-7%
Open Water Habitats	***Open Water Total[3]***	***736,156***	***720,153***	***662,541***	***-73,616***	***-10%***	***-57,612***	***-8%***	***-8%***
	Open Water	no data	no data	no data	no data	-10%	no data	no data	no data
	Aquatic Bed Total[4]	no data	no data	no data	no data	-5%	no data	no data	no data
	Aquatic Bed (undetermined)**	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	-3%	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***703,908***	***831,892***	***915,081***	***211,173***	***30%***	***83,189***	***10%***	***12%***
	Agriculture	***1,071,657***	***816,501***	***857,326***	***-214,331***	***-20%***	***40,825***	***5%***	***4%***
	Other Upland	***10,324,719***	***10,324,719***	***10,324,719***	***0***	***0%***	***0***	***0%***	***0%***

Table 13-04d. New England CAF region low range acreages and percentages based on high percent ranges of change estimated by local experts. Further description and calculation details provided in Table 13-04 Introductory Notation.

New England CAF Region – High Range Estimates									
		Acreage by Year			Historic Change		Recent Change		
		1947 Acreage High Range	1992 NLCD Acreage	2004 Acreage High Range	1947 – 2004 Historic Loss/Gain Acreage High Range	1947 - 2004 Historic % of 1947 High Range *(estimated)*	1992 - 2004 Recent Loss/Gain Acreage High Range	1992 - 2004 Recent % of 1992 High Range *(estimated)*	1992 - 2004 Recent % of 1947 High Range
Wetland Habitats	***Wetlands Total[1]***	***945,119***	***884,706***	***585,973***	***-359,145***	***-38%***	***-298,732***		***-32%***
	Emergent Wetlands	277,026	255,717	199,459	-77,567	-28%	-56,258	-22%	-20%
	Woody Wetlands Total[2]	627,804	596,414	357,848	-269,956	-43%	-238,565	-40%	-38%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data	-15%	no data	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data	-5%	no data	no data	no data
	Natural (non-armored) Shoreline	34,538	32,575	28,666	-5,871	-17%	-3,909	-12%	-11%
Open Water Habitats	***Open Water Total[3]***	***784,782***	***720,153***	***612,130***	***-172,652***	***-22%***	***-108,023***	***-15%***	***-14%***
	Open Water	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total[4]	no data	no data	no data	no data	-10%	no data	no data	no data
	Aquatic Bed (undetermined)**	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	-10%	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***688,462***	***831,892***	***998,270***	***309,808***	***45%***	***166,378***	***20%***	***24%***
	Agriculture	***1,108,108***	***816,501***	***775,676***	***-332,432***	***-30%***	***-40,825***	***-5%***	***-4%***
	Other Upland	***11,411,532***	***10,324,719***	***10,840,955***	***-570,577***	***-5%***	***516,236***	***5%***	***5%***

Table 13-04e. Mid Atlantic CAF region low range acreages and percentages based on low percent ranges of change estimated by local experts. Further description and calculation details provided in Table 13-04 Introductory Notation.

Mid Atlantic CAF Region – Low Range Estimates									
		Acreage by Year			**Historic Change**		**Recent Change**		
		1939 Acreage Low Range	**1992 NLCD Acreage**	**2004 Acreage Low Range**	**1939 – 2004 Historic Loss/Gain Acreage Low Range**	**1939 - 2004 Historic % of 1939 Low Range** *(estimated)*	**1992 – 2004 Recent Loss/Gain Acreage Low Range**	**1992 - 2004 Recent % 1992 Low Range** *(estimated)*	**1992 - 2004 Recent % of 1939 Low Range**
Wetland Habitats	***Wetlands Total[1]***	***2,313,319***	***2,229,742***	***1,920,055***	***-393,264***	***-17%***	***-309,688***		***-13%***
	Emergent Wetlands	839,697	791,987	696,948	-142,748	-17%	-95,038	-12%	-11%
	Woody Wetlands Total[2]	1,437,778	1,403,948	1,193,356	-244,422	-17%	-210,592	-15%	-15%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data	5%	no data	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data	-10%	no data	no data	no data
	Natural (non-armored) Shoreline	35,844	33,807	29,750	-6,093	-17%	-4,057	-12%	-11%
Open Water Habitats	***Open Water Total[3]***	***712,101***	***696,277***	***626,649***	***-85,452***	***-12%***	***-69,628***	***-10%***	***-10%***
	Open Water	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total[4]	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed (undetermined)**	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	0%	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	0%	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***3,484,362***	***4,090,337***	***4,703,888***	***1,219,527***	***35%***	***613,551***	***15%***	***18%***
	Agriculture	***9,024,446***	***7,124,563***	***6,768,335***	***-2,256,112***	***-25%***	***-356,228***	***-5%***	***-4%***
	Other Upland	***16,915,099***	***15,223,589***	***15,223,589***	***-1,691,510***	***-10%***	***0***	***0%***	***0%***

Table 13-04f. Mid Atlantic CAF region low range acreages and percentages based on high percent ranges of change estimated by local experts. Further description and calculation details provided in Table 13-04 Introductory Notation.

Mid Atlantic CAF Region – High Range Estimates									
		Acreage by Year			Historic Change		Recent Change		
		1939 Acreage High Range	1992 NLCD Acreage	2004 Acreage High Range	1939 - 2004 Historic Loss/Gain Acreage High Range	1939 - 2004 Historic % of 1938 High Range *(estimated)*	1992 – 2004 Recent Loss/Gain Acreage High Range	1992 - 2004 Recent % of 1992 High Range *(estimated)*	1992 - 2004 Recent % of 1938 High Range
Wetland Habitats	***Wetlands Total[1]***	***2,661,410***	***2,229,742***	***1,543,618***	***-1,117,792***	***-42%***	***-686,125***		***-26%***
	Emergent Wetlands	852,137	791,987	673,189	-178,949	-21%	-118,798	-15%	-14%
	Woody Wetlands Total[2]	1,754,935	1,403,948	842,369	-912,566	-52%	-561,579	-40%	-32%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data	-5%	no data	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data	-20%	no data	no data	no data
	Natural (non-armored) Shoreline	36,921	33,807	28,060	-8,861	-24%	-5,747	-17%	-16%
Open Water Habitats	***Open Water Total[3]***	***740,910***	***696,277***	***577,910***	***-163,000***	***-22%***	***-118,367***	***-17%***	***-16%***
	Open Water	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total[4]	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed (undetermined)**	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	-10%	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	-5%	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***3,408,615***	***4,090,337***	***5,112,922***	***1,704,307***	***50%***	***1,022,584***	***25%***	***30%***
	Agriculture	***8,768,693***	***7,124,563***	***5,699,650***	***-3,069,043***	***-35%***	***-1,424,913***	***-20%***	***-16%***
	Other Upland	***20,932,435***	***15,223,589***	***16,745,948***	***-4,186,487***	***-20%***	***1,522,359***	***10%***	***7%***

Table 13-04g. South Atlantic CAF region low range acreages and percentages based on low percent ranges of change estimated by local experts. Further description and calculation details provided in Table 13-04 Introductory Notation.

South Atlantic Coast CAF Region – Low Range Estimates									
		Acreage by Year			**Historic Change**		**Recent Change**		
		1953 Acreage Low Range	**1992 NLCD Acreage**	**2004 Acreage Low Range**	**1953 – 2004 Historic Loss/Gain Acreage Low Range**	**1953 - 2004 Historic % of 1953 Low Range** *(estimated)*	**1992 - 2004 Recent Loss/Gain Acreage Low Range**	**1992 - 2004 Recent % 1992 Low Range** *(estimated)*	**1992 - 2004 Recent % of 1953 Low Range**
Wetland Habitats	***Wetlands Total[1]***	***10,523,489***	***10,191,168***	***9,681,610***	***-841,879***	***-8%***	***-509,558***		***-5%***
	Emergent Wetlands	2,514,901	2,435,483	2,313,709	-201,192	-8%	-121,774	-5%	-5%
	Woody Wetlands Total[2]	7,849,184	7,683,938	7,299,741	-549,443	-7%	-384,197	-5%	-5%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data	-5%	no data	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data	5%	no data	no data	no data
	Natural (non-armored) Shoreline	75,732	71,747	68,159	-7,573	-10%	-3,587	-5%	-5%
Open Water Habitats	***Open Water Total[3]***	***1,076,134***	***1,076,134***	***1,076,134***	***0***	***0%***	***0***	***0%***	***0%***
	Open Water	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total[4]	no data	no data	no data	no data	0%	no data	no data	no data
	Aquatic Bed (undetermined)**	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***1,714,991***	***1,938,686***	***2,229,489***	***514,497***	***30%***	***290,803***	***15%***	***17%***
	Agriculture	***8,278,603***	***7,358,759***	***6,622,883***	***-1,655,721***	***-20%***	***-735,876***	***-10%***	***-9%***
	Other Upland	***14,274,459***	***13,980,141***	***13,560,736***	***-713,723***	***-5%***	***-419,404***	***-3%***	***-3%***

Table 13-04h. South Atlantic CAF region low range acreages and percentages based on high percent ranges of change estimated by local experts. Further description and calculation details provided in Table 13-04 Introductory Notation.

South Atlantic Coast CAF Region – High Range Estimates									
		Acreage by Year			Historic Change		Recent Change		
		1953 Acreage High Range	1992 NLCD Acreage	2004 Acreage High Range	1953 – 2004 Historic Loss/Gain Acreage High Range	1953 - 2004 Historic % of 1953 High Range *(estimated)*	1992 - 2004 Recent Loss/Gain Acreage High Range	1992 - 2004 Recent % of 1992 High Range *(estimated)*	1992 - 2004 Recent % of 1953 High Range
Wetland Habitats	***Wetlands Total[1]***	***10,840,345***	***10,191,168***	***8,780,680***	***-2,059,666***	***-19%***	***-1,410,488***		***-13%***
	Emergent Wetlands	2,462,848	2,435,483	2,191,935	-270,913	-11%	-243,548	-10%	-10%
	Woody Wetlands Total[2]	8,267,528	7,683,938	6,531,347	-1,736,181	-21%	-1,152,591	-15%	-14%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data	-15%	no data	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data	-5%	no data	no data	no data
	Natural (non-armored) Shoreline	79,718	71,747	57,397	-22,321	-28%	-14,349	-20%	-18%
Open Water Habitats	***Open Water Total[3]***	***1,099,277***	***1,076,134***	***1,022,327***	***-76,949***	***-7%***	***-53,807***	***-5%***	***-5%***
	Open Water	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total[4]	no data	no data	no data	no data	-3%	no data	no data	no data
	Aquatic Bed (undetermined)**	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***1,604,430***	***1,938,686***	***2,326,423***	***721,993***	***45%***	***387,737***	***20%***	***24%***
	Agriculture	***9,056,934***	***7,358,759***	***5,887,007***	***-3,169,927***	***-35%***	***-1,471,752***	***-20%***	***-16%***
	Other Upland	***14,290,810***	***13,980,141***	***12,861,729***	***-1,429,081***	***-10%***	***-1,118,411***	***-8%***	***-8%***

Table 13-04i. Gulf Coast CAF region low range acreages and percentages based on low percent ranges of change estimated by local experts. Further description and calculation details provided in Table 13-04 Introductory Notation.

Gulf Coast CAF Region – Low Range Estimates									
		Acreage by Year			**Historic Change**		**Recent Change**		
		1957 Acreage Low Range	**1992 NLCD Acreage**	**2004 Acreage Low Range**	**1957 - 2004 Historic Loss/Gain Acreage Low Range**	**1957 - 2004 Historic % of 1957 Low Range** *(estimated)*	**1992 - 2004 Recent Loss/Gain Acreage Low Range**	**1992 - 2004 Recent % 1992 Low Range** *(estimated)*	**1992 - 2004 Recent % of 1957 Low Range**
Wetland Habitats	***Wetlands Total[1]***	***15,539,782***	***14,001,984***	***12,742,621***	***-2,797,161***	***-18%***	***-1,259,362***		***-8%***
	Emergent Wetlands	7,596,607	6,853,460	6,305,184	-1,291,423	-17%	-548,277	-8%	-7%
	Woody Wetlands Total[2]	7,733,521	6,960,169	6,264,152	-1,469,369	-19%	-696,017	-10%	-9%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Mangroves	no data	no data	no data	no data	-5%	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Natural (non-armored) Shoreline	201,495	188,354	173,286	-28,209	-14%	-15,068	-8%	-7%
Open Water Habitats	***Open Water Total[3]***	***2,132,063***	***2,192,979***	***2,302,628***	***170,565***	***8%***	***109,649***	***5%***	***5%***
	Open Water	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total[4]	no data	no data	no data	no data	-5%	no data	no data	no data
	Aquatic Bed (undetermined)**	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***2,339,900***	***2,807,880***	***3,650,244***	***1,310,344***	***56%***	***842,364***	***30%***	***36%***
	Agriculture	***13,957,285***	***14,356,065***	***15,073,868***	***1,116,583***	***8%***	***717,803***	***5%***	***5%***
	Other Upland	***25,143,186***	***25,861,563***	***27,154,641***	***2,011,455***	***8%***	***1,293,078***	***5%***	***5%***

Table 13-04j. Gulf Coast CAF region low range acreages and percentages based on high percent ranges of change estimated by local experts. Further description and calculation details provided in Table 13-04 Introductory Notation.

Gulf Coast CAF Region – High Range Estimates									
		Acreage by Year			Historic Change		Recent Change		
		1957 Acreage High Range	1992 NLCD Acreage	2004 Acreage High Range	1957 - 2004 Historic Loss/Gain Acreage High Range	1957 - 2004 Historic % of 1957 High Range *(estimated)*	1992 - 2004 Recent Loss/Gain Acreage High Range	1992 - 2004 Recent % of 1992 High Range *(estimated)*	1992 - 2004 Recent % of 1957 High Range
Wetland Habitats	***Wetlands Total[1]***	***18,067,076***	***14,001,984***	***11,201,587***	***-6,865,489***	***-38%***	***-2,800,397***		***-16%***
	Emergent Wetlands	9,137,947	6,853,460	5,482,768	-3,655,179	-40%	-1,370,692	-20%	-15%
	Woody Wetlands Total[2]	8,700,211	6,960,169	5,568,135	-3,132,076	-36%	-1,392,034	-20%	-16%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	no data	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Mangroves	no data	no data	no data	no data	-10%	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Natural (non-armored) Shoreline	221,593	188,354	150,683	-70,910	-32%	-37,671	-20%	-17%
Open Water Habitats	***Open Water Total[3]***	***2,871,758***	***2,192,979***	***2,412,277***	***-459,481***	***-16%***	***219,298***	***10%***	***8%***
	Open Water	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total[4]	no data	no data	no data	no data	-10%	no data	no data	no data
	Aquatic Bed (undetermined)**	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***2,249,407***	***2,807,880***	***4,071,427***	***1,822,020***	***81%***	***1,263,546***	***45%***	***56%***
	Agriculture	***13,422,337***	***14,356,065***	***16,509,475***	***3,087,138***	***23%***	***2,153,410***	***15%***	***16%***
	Other Upland	***26,417,725***	***25,861,563***	***24,568,484***	***-1,849,241***	***-7%***	***-1,293,078***	***-5%***	***-5%***

Table 13-04k. Pacific CAF region low range acreages and percentages based on low percent ranges of change estimated by local experts. Further description and calculation details provided in Table 13-04 Introductory Notation.

Pacific CAF Region – Low Range Estimates									
		Acreage by Year			Historic Change		Recent Change		
		1948 Acreage Low Range	1992 NLCD Acreage	2004 Acreage Low Range	1948 - 2004 Historic Loss/Gain Acreage Low Range	1948 - 2004 Historic % of 1948 Low Range *(estimated)*	1992 - 2004 Recent Loss/Gain Acreage Low Range	1992 - 2004 Recent % 1992 Low Range *(estimated)*	1992 - 2004 Recent % of 1948 Low Range
Wetland Habitats	***Wetlands Total[1]***	***660,802***	***713,637***	***594,722***	***-66,080***	***-10%***	***-118,915***		***-18%***
	Emergent Wetlands	104,116	101,924	96,828	-7,288	-7%	-5,096	-5%	-5%
	Woody Wetlands Total[2]	73,759	85,233	76,710	2,950	4%	-8,523	-10%	-12%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	5%	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data	10%	no data	no data	no data
	Natural (non-armored) Shoreline	478,618	526,480	421,184	-57,434	-12%	-105,296	-20%	-22%
Open Water Habitats	***Open Water Total[3]***	***415,070***	***399,257***	***419,220***	***4,151***	***1%***	***19,963***	***5%***	***5%***
	Open Water	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total[4]	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed (undetermined)**	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***2,229,865***	***2,675,838***	***3,344,797***	***1,114,932***	***50%***	***668,959***	***25%***	***30%***
	Agriculture	***3,314,205***	***3,314,205***	***3,148,495***	***-165,710***	***-5%***	***-165,710***	***-5%***	***-5%***
	Other Upland	***34,972,842***	***33,383,167***	***36,721,484***	***1,748,642***	***5%***	***3,338,317***	***10%***	***10%***

Table 13-04l. Pacific CAF region low range acreages and percentages based on high percent ranges of change estimated by local experts. Further description and calculation details provided in Table 13-04 Introductory Notation.

Pacific CAF Region – High Range Estimates									
		Acreage by Year			**Historic Change**		**Recent Change**		
		1948 Acreage High Range	**1992 NLCD Acreage**	**2004 Acreage High Range**	**1948 - 2004 Historic Loss/Gain Acreage High Range**	**1948 - 2004 Historic % of 1948 High Range** *(estimated)*	**1992 - 2004 Recent Loss/Gain Acreage High Range**	**1992 - 2004 Recent % of 1992 High Range** *(estimated)*	**1992 - 2004 Recent % of 1938 High Range**
Wetland Habitats	***Wetlands Total[1]***	***548,805***	***713,637***	***466,484***	***-82,321***	***-15%***	***-247,153***		***-45%***
	Emergent Wetlands	127,406	101,924	76,443	-50,962	-40%	-25,481	-25%	-20%
	Woody Wetlands Total[2]	74,902	85,233	74,153	-749	-1%	-11,080	-13%	-15%
	Woody Wetlands (undetermined)*	no data	no data	no data	no data	10%	no data	no data	no data
	Shrub-scrub Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Mangroves	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Forested Wetlands	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Forested Wetlands	no data	no data	no data	no data	15%	no data	no data	no data
	Natural (non-armored) Shoreline	350,986	526,480	315,888	-35,099	-10%	-210,592	-40%	-60%
Open Water Habitats	***Open Water Total[3]***	***444,534***	***399,257***	***431,198***	***-13,336***	***-3%***	***31,941***	***8%***	***7%***
	Open Water	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed Total[4]	no data	no data	no data	no data	no data	no data	no data	no data
	Aquatic Bed (undetermined)**	no data	no data	no data	no data	no data	no data	no data	no data
	Palustrine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Estuarine Aquatic Beds	no data	no data	no data	no data	no data	no data	no data	no data
	Coral Reefs	no data	no data	no data	no data	no data	no data	no data	no data
	Oyster Reefs/Shell Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Hard Bottom	no data	no data	no data	no data	no data	no data	no data	no data
	Soft Bottom	no data	no data	no data	no data	no data	no data	no data	no data
Non Wet	***Developed***	***1,293,322***	***2,675,838***	***3,879,965***	***2,586,643***	***200%***	***1,204,127***	***45%***	***93%***
	Agriculture	***3,389,528***	***3,314,205***	***2,982,785***	***-406,743***	***-12%***	***-331,421***	***-10%***	***-10%***
	Other Upland	***32,534,443***	***33,383,167***	***38,390,642***	***5,856,200***	***18%***	***5,007,475***	***15%***	***15%***