Wetland Condition of the Inland Bays Watershed

Volume 1: Nontidal Wetlands

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Executive Summary

The Delaware Department of Natural Resources and Environmental Control (DE DNREC) and The Center for the Inland Bays assessed the condition of freshwater nontidal wetlands in the Inland Bays watershed. The goal of this project was to report on the condition of these wetlands across the watershed and identify the stressors that are impacting wetland condition in order to guide wetland protection and restoration activities. Tidal wetlands (meso- to polyhaline tidal fringe) were assessed in 2008 and will be included in Volume II of this report in 2009.

Wetlands perform a variety of functions related to hydrology, nutrient cycling and storage, and the plants and wildlife that inhabit these areas. These functions support ecosystem services to the watershed such as reducing flooding, maintaining stream flows, preventing erosion, improving water quality by removing nutrients and pollutants, providing habitat for wildlife, and sustaining globally rare plant species. Large portions of historic nontidal wetlands in the Inland Bays have been lost to date, over 60% in several subwatersheds, which makes existing wetlands even more important. Understanding the condition of wetlands on a local scale and how this affects the functions and services that they provide is needed to better direct the State and its conservation partners to allocate resources for wetland restoration and protection efforts across the Inland Bays watershed.

We assessed the condition of nontidal wetlands in the Inland Bays watershed using a probabilistic sampling design developed by EPA Ecological Monitoring and Assessment Program (EMAP). This approach allowed us to correct for biases due to site access and allowed us extrapolate the sample results to represent the entire population of wetlands in the watershed. We reported on the two most prevalent nontidal wetland subclasses (flats and riverine) in the Inland Bays. Riverine wetlands adjacent to natural streams provide storage for overbank flow, subsurface water, and precipitation. Interactions with surface water improve water quality and reduce downstream flooding (DE DNREC 2001, NRCS 2008). Flat wetlands, are typically located at the headwaters of the watershed and the interfluvs between streams, have poor vertical drainage and are fed by precipitation and groundwater. In the Inland Bays watershed, the majority of flats are in the poorly drained southern portion. These wetlands can absorb heavy precipitation and filter water slowly to surface and groundwaters, prevent flooding downstream, improve water quality, and provide wildlife habitat in large forested areas (DE DNREC 2001, NRCS 2008).

From a pool of randomly selected wetlands across the watershed we attempted to access 386 riverine and flat nontidal wetland sites on public or private land in 2005 and 2006. Overall, we had a 66% rate of success for gaining access to the wetlands in the watershed. From 137 privately owned riverine sites we attempted to access, 9% were denied by the landowner, 41% of landowners did not respond to our request, and 50% granted access. Of our 50 sampled riverine sites, 84% were on private land and 16% were on public land. From 101 privately owned flats sites, 32% were denied by the landowner, 29% did not respond and 40% granted access. Of the 49 sampled flats sites, 51% were on private land, 37% were in a private conservation area known as the Cypress Swamp and 12% were on public land.

We sampled 50 nontidal riverine sites and 49 nontidal flats wetlands using the Delaware Rapid Assessment Protocol (DERAP). The DERAP takes a field crew of 2-4 people 30 minutes to 2 hours to complete and collects data on the presence and intensity of 41 stressors related to habitat, hydrology and buffer features (Jacobs 2007a). We also sampled 25 of the riverine sites and 24 of the flats sites with the Delaware Comprehensive Assessment Protocol (DECAP). The DECAP requires a field crew of 4-5 people and 3-6 hours of field work and collects more detailed, quantitative data on 20 variables related to vegetation, soils, hydrology, topography, and surrounding landuse (Jacobs et al. 2008). We summarized the condition of wetlands by subclass, using wetland functions and an Index of Wetland Condition (IWC) which ranged from 0 to 100 with 100 being closest to reference standard. We also isolated the common stressors affecting each wetland subclass in the watershed.

Hydrogeomorphic (HGM) models were used to assess 5 wetland functions for flats and riverine wetlands: maintenance of characteristic hydrology, biogeochemical cycling and storage, plant community integrity, wildlife habitat integrity, and buffer integrity. HGM functions are composed of DECAP variables that were scaled to reference conditions in the Nanticoke River and Inland Bays watershed and surrounding areas. Additionally, an index of wetland condition (IWC) was produced that combined the strongest variables to produce an overall score of condition for each subclass.

Flats wetlands in the Inland Bays watershed scored an average IWC value of 80.7±15; 18% were classified as highly stressed, 40% moderately stressed and 42% minimally or not stressed. Plant Community Integrity had the highest functioning average of 85.8%±13 and the highest scoring composition due to a low occurrence of invasive plants, high shrub species richness, and a high occurrence of wetland indicator tree species. Buffer Integrity was functioning well with an average of 82%±18 but had some channelized streams and ditches (30%), and trails (34%) present. The Wildlife Habitat Integrity function averaged 77%±14 due to high scoring tree density, as well as shrub density and tree basal area, but had habitat stressors such as forestry activities within 50 years (34% of flats), and garbage and isolated dumping (26% of flats) present. The Maintenance of Characteristic Hydrology averaged 71%±34 and the scoring distribution highlighted that severe alterations to hydrology (e.g. ditching for agriculture or forestry) have been concentrated to a portion of flats wetlands, leaving other portions largely intact and few in the middle. The Biogeochemical Cycling and Storage function is based on the hydrology FCI and tree components, and averaged only 55%±29 which reflected low hydrology functioning in combination with low occurrence of deadwood.

Because the Cypress Swamp was owned by a conservation partner we considered if the condition of these wetlands would be different. We separated data for the Cypress Swamp flats sites and compared their condition scores and stressors to privately and publicly owned sites. We found that the average IWC ($F_{23,1}$=9.34, P=0.044), Plant Community ($F_{18,1}$=6.42, P=0.002) and Buffer Integrity ($F_{16,1}$=9.34, P=0.001) function averages were greater in the Cypress Swamp. Also, on average sites in the Cypress Swamp had fewer stressors present (2.6) compared to the other flats sites (6.4). Common stressors found in both types were found less frequently at Cypress Swamp sites as well.

The IWC for riverine wetlands in the Inland Bays averaged 64.3±24. Based on the IWC, 32% of nontidal riverine wetlands were minimally or not stressed, 32% were moderately stressed and 36% were severely stressed. The presence of channelized streams in the assessment area and in the buffer, invasive plant species, garbage and isolated dumping, and fill or excavation in the wetland were the stressors most commonly affecting riverine wetlands in the Inland Bays watershed. Due to the pervasive hydrologic alterations through ditching and channelization, Hydrology and Biogeochemistry had the lowest functioning averages of 33.7±35 and 28.7±31, respectively. The Plant Community function averaged 67.6±23 and was affected by the presence of invasive species and shifted plant species composition. Buffer Integrity performed well with an average of 70.8±25, but was still affected by the presence of channelized streams and ditches, septic systems and row crops or nurseries within 100m of the wetland. Wildlife Habitat had the highest functioning average of 73.2±22.

An overall evaluation of all nontidal wetlands in the watershed including flats, riverine, ponds, and farmed wetlands found that 38% of the nontidal wetlands were minimally or not stressed, 37% were moderately stressed, and 25% were highly stressed. This perspective gives a simple view of nontidal wetland condition in the Inland Bays watershed; over a third of the nontidal wetlands are minimally stressed and are functioning relatively well, but one quarter have been severely altered and, as a result, are not able to function well and provide the caliber of ecological benefits to the residents of the State of Delaware.

Prioritizing wetland protection and restoration efforts on the watershed level will encourage a proactive approach to improving the condition of wetlands and provide direction for stakeholders performing restoration activities. This will ensure that projects are strategically targeted to maximize wetland performance and that resources and funding are effectively utilized. Protecting the condition and acreage of wetlands in the Inland Bays is critical. Because we have lost over 60% of the wetland resources and degraded many of those that remain, the functions and services that the remaining wetlands provide are essential to maintaining the ecological integrity of the Inland Bays watershed and the Bays. All wetlands need to be protected from conversion to other land uses or degradation to a lower condition due to activities within and surrounding the wetland. Funds for protection should be used for high condition wetlands and wetlands that are part of large intact areas first. We recommend that restoration focus first on improving the condition of existing wetlands by eliminating stressors and protecting healthy areas. Working with existing wetlands is more cost-effective, returns greater function improvements, and has a greater likelihood of success. Re-establishing wetlands is the only way to increase our wetlands acreage, but should be performed with funds that are designated for wetland re-establishment only and cannot be used for protection or enhancement of existing wetlands. We recommend the following specific objectives:

- Improve protection of nontidal wetlands through state and local regulations, fee simple acquisitions and conservation easements, and outreach and community involvement.
- Ensure that wetland functions are replaced before permitting the destruction or degradation of wetlands.
- Prioritize restoring hydrology to riverine wetlands by removing stream channelization and reconnecting surface water flow to wetlands.
- Encourage the use of best management practices to protect flats wetlands from additional stressors.
- Focus protection and re-establishment of flats with the goal of increasing large forested wetlands.
- Develop a watershed restoration plan based on the best available science to prioritize areas for protection, enhancement, and re-establishment of wetlands.
- Use outreach within the watershed to better inform the general public about the status and value of their local wetland resources and ways in which they can reduce indirect wetland impacts.

INTRODUCTION

Wetlands provide essential benefits and play a crucial role as part of the natural systems of the watershed. Wetlands can minimize flooding from storms, control erosion, and improve and maintain water quality by sequestering and excessive nutrients and other pollutants. Wetlands are some of the most productive ecosystems in the world and they play an important role by transitioning between terrestrial and aquatic habitats. As such, they are biologically rich and provide habitat and resources for wildlife and wetland adapted plants. They also have substantial value as a source of recreation (hunting, fishing etc.) and livelihood. Coastal wetlands especially provide nurseries for commercial fish and shellfish species. Wetlands are also valued for their aesthetics and rich history across the region. The State of Delaware is dedicated to improving wetland habitat and waters of the State through restoration and protection efforts, research, and effective planning that encourages the benefits of wetlands to persist and flourish.

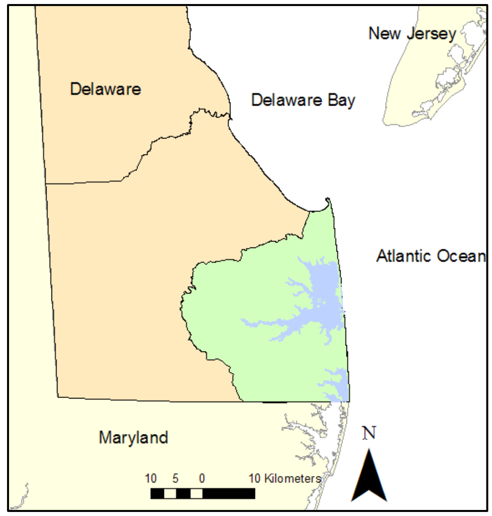
Wetland research has begun to report on the condition of the wetlands that remain on the landscape, not just on the status of wetlands in terms of losses and gains in wetland acreage (Tiner 2001). In order to make effective and efficient progress protecting and improving our existing wetlands, we need to know not only the acreage of the resource but also the condition and the causes of degradation. Evaluating wetland condition and performance on a watershed scale compiles useful information that watershed organizations, planning and regulatory agencies, and other stakeholders in Delaware can incorporate into their water quality and landuse planning strategies. Determining the performance of existing wetland functions and services in the Inland Bays watershed will allow the State and other conservation partners to best allocate resources for protection and restoration. Protection efforts can be directed toward wetlands in good condition and restoration efforts can target wetlands that have been altered and are providing reduced functions and services. Wetland assessment information also identifies the specific stressors that are commonly altering wetlands. This will better direct the form of restoration that is needed for each type of wetland in each portion of the watershed.

The Delaware Department of Natural Resources and Environmental Control (DE DNREC) has developed methods to assess the condition of wetlands on a watershed scale. This data helps resource managers and land use officials make informed decisions about wetland resources. We summarize the condition of wetlands by functional types, estimate their performance of functions and isolate the common threats facing each wetland subclass in the watershed. We report on the two most prevalent nontidal wetland subclasses (flats and riverine) in the Inland Bays. The remaining nontidal wetlands are depressions including vernal pools, coastal plain ponds, and interdunal swales and are not included in this report. Because depressions comprise 4% of the wetland acreage in the watershed, there were not enough respective sites selected in our probabilistic survey for a statistically valid sample to report on their condition on a watershed scale. Tidal wetlands (meso- to polyhaline tidal fringe) were assessed in 2008 and will be included in Volume II of this report in 2009.

INLAND BAYS WATERSHED

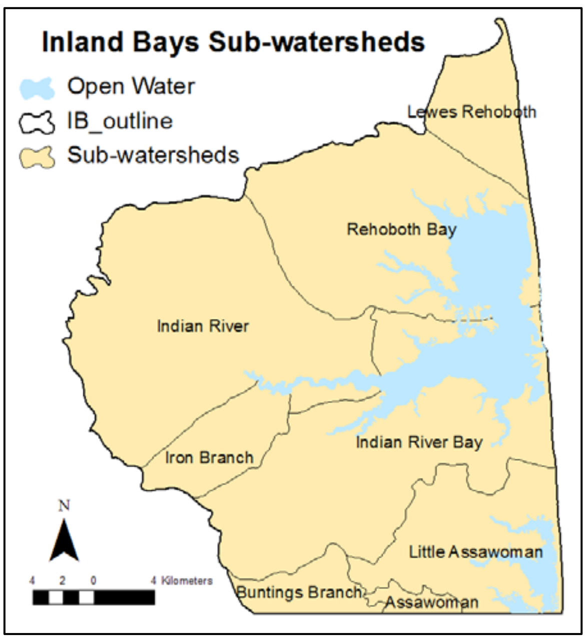
2.1 Watershed Characterization

The Inland Bays watershed in southeastern Delaware drains over 200,000 acres into the Atlantic Ocean. Part of the Atlantic Coastal Plain ecoregion, the watershed has a flat landscape with muted topography (Map 1; DE DNREC 2001). Wetlands cover 39% of the watershed (DE DNREC 2001). Unique and rare wetland communities including Atlantic White Cedar swamps, sea-level fens, and innerdunal swales provide habitat for numerous rare plants and animals.

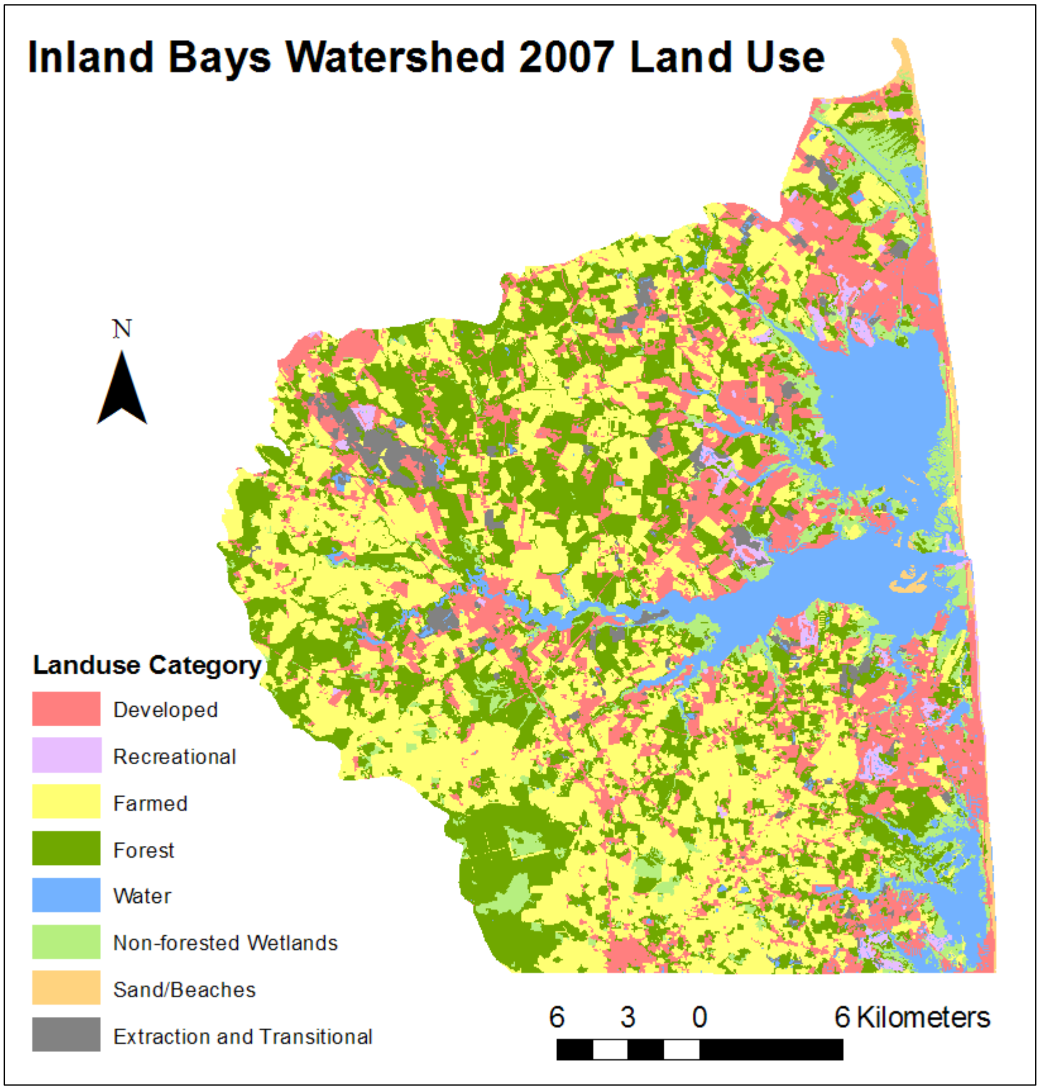


Map 1. Inland Bays watershed in southeastern Delaware.

The watershed's landuse is mixed agriculture, forest, and urban which are all positioned around three shallow, interconnected coastal lagoons; from north to south: Rehoboth Bay, Indian River Bay and Little Assawoman Bay (Map 2). Historically, this area was dominated by farming communities, however with improved access and popularity among vacationers and retirees, residential and resort communities have been increasing. Recreational opportunities along the coasts have encouraged seasonal and permanent populations to concentrate along the oceanfront and bays. Although between 1992 and 1997 the acreage of wetlands in the Inland Bays was stable, it is likely that surrounding land use changes decreased wetland condition. More recently, urban land uses have increased in acreage but several others have decreased. Between 1997 and 2007, the acreage of agriculture (4%), forest (2%) and wetlands (3%) decreased while developed land increased 5% (DOSPC 2008). Map 3 shows recent land use distribution across the watershed. Pockets of forested and agriculture habitat remain in the western portion and development dominates along the coastline and bays.



Map 2. The subwatersheds of the Inland Bays.



Map 3. Land cover in the Inland Bays watershed in 2007 based on NLCD land use categories.

The abundant coastal resources support a vibrant tourism industry with activities including fishing, hunting, boating, clamming, crabbing, hiking, and water sports. The natural richness of the region contributed to the designation of parts of the Inland Bays as Waters of Exceptional Recreational or Ecological Significance (ERES Waters) by the State of Delaware and the US Environmental Protection Agency (Weston 1993).

These highly productive bays also provide critical habitat for migratory birds, finfish, and shellfish. Thirty-nine neotropical songbird species nest in the watershed and a number of important migratory waterfowl and nesting waterbirds use the coastal habitats for nesting, foraging and overwintering. The Bays support thriving hard clam and blue crab fisheries. A strong recreational fin-fishery is also supported with summer flounder, striped bass, and blue fish.

2.2 Hydrogeomorphology and Wetlands in the Watershed

The Atlantic Coastal Plain consists of layers of unconsolidated sediments eroded from the early Appalachian Mountains, which first formed in the Permian period around 240 million years before present. Much of the current soil on the Delmarva Peninsula was deposited from runoff from the retreating glaciers of the Pleistocene flowing down the Susquehanna River. These sediments were re-worked by marine processes and have mixed with patches of marine clays (Denver et al. 2004). The flat landscape lacked much natural drainage and an abundance of wetlands were formed because of the ideal geomorphic and hydrologic conditions. Freshwater, brackish and saltwater wetland communities cover 39% of the Inland Bays area (DE DNREC 2001). Although the saline and brackish estuaries may be the most recognizable for the area, there is 4 times the acreage of nontidal, freshwater wetlands in the Inland Bays.

The interaction of wetlands and groundwater in the Inland Bays basin is complex and dependant on the characteristics of local soils. Poorly drained soils occupy a large portion of the Inland Bays (35%) and have limited use for residential development and septic suitability (DE DNREC 2001) if they have not been drained. Instead, many of these areas remain as wooded wetlands and are associated with the floodplains of creeks and rivers (DE DNREC 2001). Riverine wetlands adjacent to natural streams provide storage for overbank flow, subsurface water, and precipitation. Interactions with surface water improve water quality and reduce downstream flooding (DE DNREC 2001, NRCS 2008). Flat wetlands which are typically located at the headwaters of the watershed and the interfluvs between streams have poor vertical drainage and are fed by precipitation and groundwater. These wetlands retain heavy precipitation and filter slowly to surface and groundwaters. Flats are able to prevent flooding downstream, improve water quality by filtering precipitation and runoff from surrounding land uses, and provide valuable wildlife habitat in large forested areas (DE DNREC 2001, NRCS 2008).

Many aspects of the Inland Bays watershed are ideal for agriculture including the flat topography, temperate climate, well distributed rainfall and soils of unconsolidated sands and clays that contain little surface rock. However, the slow draining, saturated soils were problematic for large scale farming and were managed heavily via drainage networks and channels. These networks of ditches water from the soils to facilitate agricultural production and prevent farm flooding. As a result of these efforts, 26% of the basin was artificially drained through tax ditches (DE DNREC 2001). Additionally, natural stream channels were straightened and deepened to remove water from the land as rapidly as possible. Channelization and ditching impacts natural hydrology patterns by draining wetlands and isolating them from surface waters by depositing excavated fill along waterways. In the Inland Bays watershed, 87% of waterways (i.e. canals, ditches, streams, rivers or natural channels) are either ditched or channelized.

Wetland Function- Biological, chemical and hydrologic processes performed in wetlands such as nitrogen cycling
Wetland Condition- the degree to which a wetland has been altered, generally by human activity
Wetland Values- societal importance attached to wetland functions
Wetland Services- Components provided by wetland functions such as floodwater control and storage, erosion control, wildlife habitat, nutrient sequestration, fish and shellfish production and water quality and supply

2.3 Water Quality in the Inland Bays Watershed

In recent years, Inland Bays land cover has shifted from being dominated by agriculture toward more urban uses, especially near the Atlantic Ocean. The focus of water management has also turned from drainage ditches for agriculture to storm-water for residential development (DE DNREC 2001). On-site waste water treatment systems (i.e. septic systems) contribute up to 220,000 kg of nitrogen and 115,000 kg of phosphorous to the watershed each year (DE DNREC 2000). The increase of impervious surfaces without protection of riparian zones has lead to diminished water quality (Jennings 2003). The remaining portions of the watershed are still heavily used for farming and poultry production (Map 3). The application of animal waste as fertilizer to cropland has contributed nutrients to surface waters. This problem is exacerbated by drainage ditches and channelized streams which circumvent wetlands, thereby allowing water to bypass nutrient processing and enabling excessive nutrients to be discharged directly into water bodies.

In 1998 and 2004 DNREC developed total maximum daily load (TMDLs) for the Indian River, Indian River Bay, and Rehoboth Bay watersheds (DE DNREC 1998) and the Little Assawoman Bay watershed including surrounding tributaries and ponds (DE DNREC 2004). Surface waters in the Inland Bays were highly enriched with the nutrients nitrogen and phosphorus, and were oxygen depleted (DE DNREC 1998, 2004). A Pollution Control Strategy for the Inland Bays watershed was adopted in October 2008 that recommended a 40-85% reduction of nitrogen and phosphorus over the next several years. This estimate would restore healthy levels of dissolved oxygen and bay grass habitat within the Inland Bays and their tributaries (DE DNREC 2008). DNREC is working to reduce nutrient inputs, manage and control the effects of population growth, and protect natural habitats. The natural functions of freshwater wetlands contribute to improving surface and ground water quality, and their management is an important part of meeting nutrient reduction goals.

METHODS

We assessed the condition of wetlands in the Inland Bays watershed by assessing changes in wetland acreage from pre-settlement times as well as the present condition of the remaining nontidal flats and riverine wetlands. We determined the condition of nontidal wetlands and associated stressors that were impacting condition in the Inland Bays watershed using the Delaware Rapid Assessment Protocol (DERAP) and the Delaware Comprehensive Assessment Protocol (DECAP). The methods used in this study were adapted from the Nanticoke Watershed Wetland Study (Jacobs and Bleil 2007). A probabilistic survey was used to sample sites on both private and public lands and then assessment models were used to calculate condition indices.

3.1 Determining Changes in Wetland Acreage

Historic wetland acreage was determined using U.S. Department of Agriculture Natural Resource Conservation Service soil maps (Tiner 2005). Hydric soil map units from soil survey data were identified as historic wetlands. Changes in wetland acreage from pre-settlement to 1992 were determined by comparing the acreage of wetlands from the historic coverage with the 1992 State Wetland Mapping Project (SWMP) maps (Pomato 1994).

3.2 Assessment Model Development

Two assessment methods were developed or refined for use in the Inland Bays watershed: The Delaware Comprehensive Assessment Protocol (DECAP) and associated hydrogeomorphic (HGM) models and the Delaware Rapid Assessment Protocol (DERAP). Both methods were used to evaluate wetland condition by HGM subclasses of flats and riverine, which are defined using landscape position, landform, and the water flow dynamics of the wetlands. HGM models that are based on data collected using the DECAP were initially developed for the Nanticoke Watershed by an expert team led by Smithsonian Environmental Research Center including scientists from East Carolina University, EPA, The Nature Conservancy (TNC), U.S. Fish and Wildlife Service, and Virginia Institute of Marine Science (VIMS). Functional models using ecological data collected from reference sites within the Nanticoke River watershed and Delmarva Coastal Plain were developed using data from wetlands that spanned the range of severe to minimal anthropogenic alterations. One assumption of the HGM approach is that anthropogenic disturbance reduces ecological condition. Therefore, sites that represented the least altered state were considered reference standard sites and all variables were scaled to these sites.

The Nanticoke HGM models were then updated by incorporating 12 flat and 13 riverine wetlands into the reference dataset and were combined with the reference sites from the Nanticoke. From those, 6 riverine and 6 flats wetland sites met the definition for reference standard for the Inland Bays watershed. Ecological variation between watersheds was assessed by comparing metric mean values and the range of metric values between reference standard sites in the Nanticoke and Inland Bays. If the means were significantly different or the ranges were different, the scaling was adjusted to represent the range of values in the both the Nanticoke and Inland Bays. We then compared the adjusted scores for the Nanticoke sites with the original scores on the Nanticoke assessment sites (n=89 for flats and n=54 for riverine). If it changed the outcome by >10%, we developed separate scoring criteria for each watershed. If the scores did not change by >10% then one updated scoring criteria was developed for use in both watersheds.

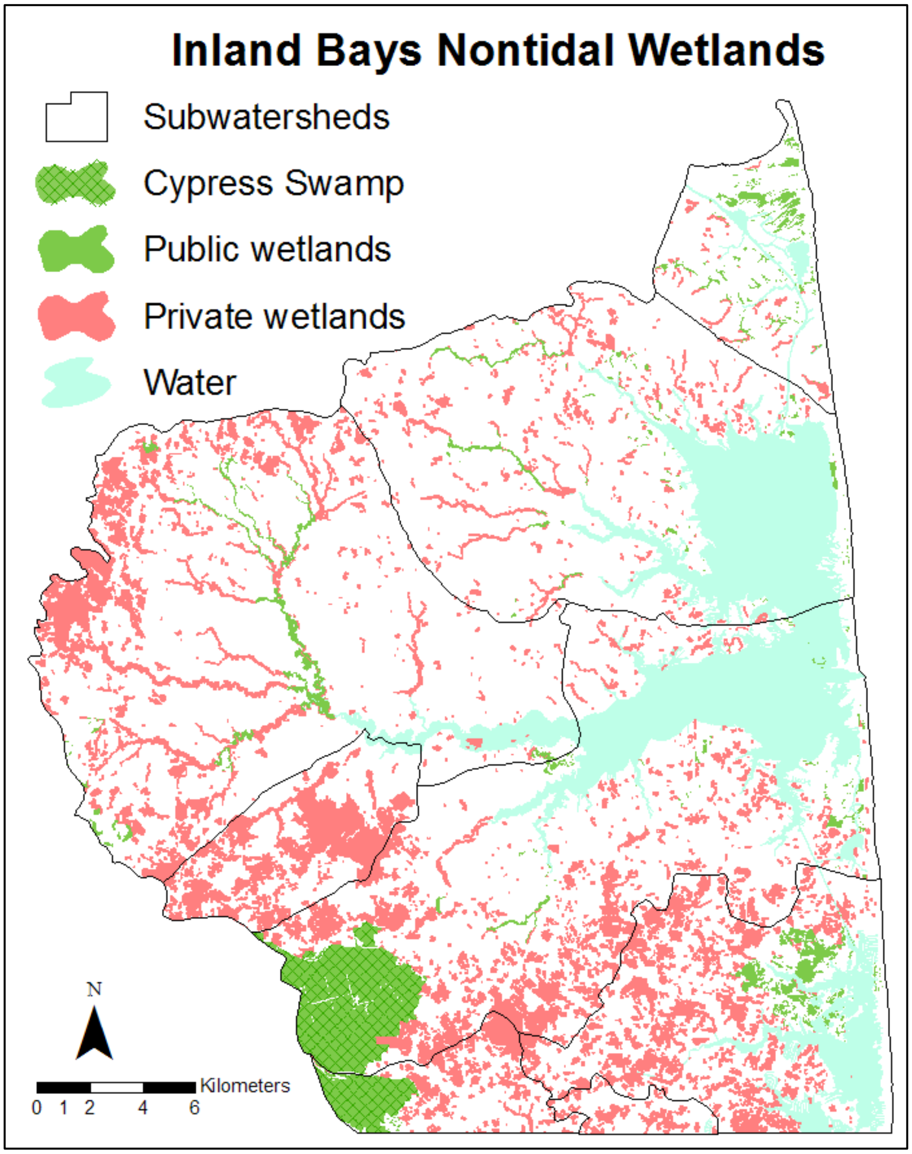
The Delaware Rapid Assessment Protocol was developed to be used in conjunction with comprehensive data (DECAP) to determine the general condition of wetlands on a watershed scale. DERAP collects data on the presence and intensity of stressors that are correlated with DECAP to assess and report on the condition of wetlands by watershed and to assess status and trends over time. DERAP is applicable to all nontidal wetlands in the Outer Coastal Plain regions of Maryland and Delaware and was developed to meet the needs of users that require a rapid assessment of the general condition of a wetland site. By using a combination of the DERAP and DECAP we were able to sample many more sites and increase our statistical power for estimating watershed level condition. Step-wise multiple regression analysis was used to select the stressors that best defined differences in sites based on the DECAP Index of Wetland Condition. Multiple linear regression (MLR) was then used to assign weights to the stressors for each class of nontidal wetlands. An overall score for a site is calculated by summing the weights for all the stressors that are present. During development we found the weighted DERAP score to be significantly correlated with the DECAP IWC scores with r^2 values of 0.82 for flats, and 0.88 for riverine wetlands.

3.3 Site Selection

EPA's Ecological Monitoring and Assessment Program (EMAP) in Corvallis, Oregon assisted with selecting 1200 sites in the target sample population using a generalized random tessellation stratified (GRTS) design (Stevens and Olsen 1999, 2000). The target population was mapped nontidal wetlands in the Inland Bays watershed from the Delaware state wetland maps (SWMP; Pomato 1994) which were based on 1992 aerial photography. Test and assessment sites were randomly selected from wetland polygons to give each point an equal probability of being selected and to allow more than one point to fall in a wetland polygon.

We reviewed maps of each site and assigned a wetland class to each (flat, riverine, depression, or non-target) using aerial photography, topographic, and hydrologic GIS data layers. Landscape position, landform, water flow path, and waterbody type (LLWW) descriptors (Tiner 2005) were added to the most recent SWMP maps which were used for the basis of present wetland acreage based on 1992 aerial photograph. Non-target areas were open water, ponds or tidal wetlands that were missed from being removed from the target sample frame. We sampled sites in each of the 2 dominant wetland types (flat and riverine) in the order the sites were selected (lowest to highest EMAP design number) with the goal of sampling 50 of each. We sampled 4 depression sites to assist with future HGM model updates but were not able to report on the condition of depressional wetlands for the watershed.

The majority of freshwater wetlands in the Inland Bays watershed are privately owned (Map 4). The largest block of public freshwater wetland habitat is in the Great Cypress Swamp in the southwestern corner and is owned by a conservation partner. We were permitted access to all sites in the Great Cypress Swamp. Because of the potential that this area was in a higher condition than other wetlands in the watershed, we compensated for a disproportionate rate of access to the Cypress Swamps by stratifying by area prior to sampling. The cypress swamp is approximately 36% of the nontidal wetland area for the watershed. Since we had a 100% rate of site access, we limited the number of flat sites we sampled in the Cypress Swamp to 18 (36% of 50) to avoid biasing our sample. Once 18 sites were sampled in numerical order, others in the cypress swamp were dropped and recorded as "locational extra."



Map 4. Distribution of nontidal wetlands across the Inland Bays subwatersheds by ownership from DE SWMP maps.

3.4 Landowner Contact and Site Access

Landowner permission was obtained prior to accessing private and Cypress Swamp study sites. Landowners were identified using county tax records and were contacted by DE DNREC agency staff for riverine wetland sites or by the Center for the Inland Bays staff for flat wetland sites. Initial landowner contact was attempted by mailing a post card or letter providing a brief description of the study goals, methods, and anticipated benefits. If a phone number could be found, the mailing was followed with a phone call to secure permission and discuss details of the sampling visit.

Once landowner permission was secured, we field validated potential study sites to confirm that the site met the required criteria (e.g. correct wetland classification) and to determine the best access for future sampling. Overall, we had a 66% rate of success for gaining access to the wetlands in the watershed. Sampling access to wetlands varied between riverine and flat sites (Figure 1). Of the 137 riverine sites that we attempted to access, 56 (41%) did not respond to our request, 68 (50%) granted access and 13 (9%) denied access. Of the 68 sites that we field validated, 50 were sampled, 2 were dropped because they were not wetlands, 15 were dropped because they were a different subclass of wetland, and 1 was not sampled because it fell within an already sampled site.

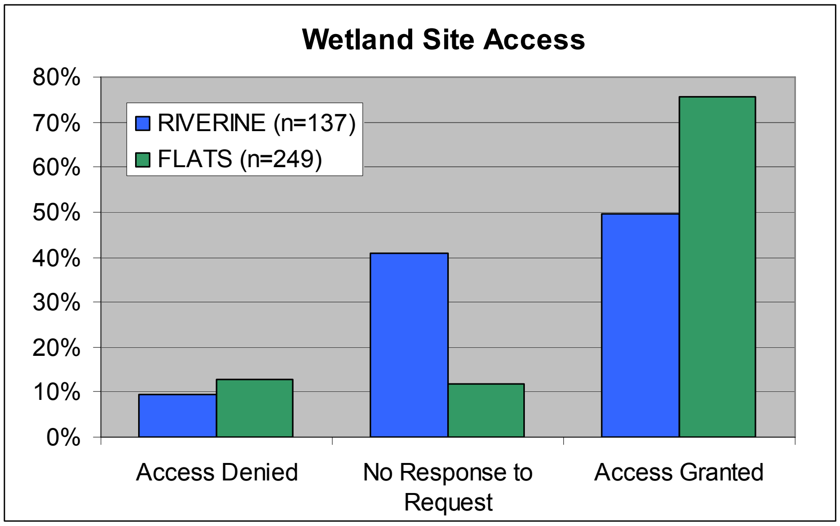


Figure 1. Success rate for accessing all wetland sites in the Inland Bays by wetland subclass. Flats sites include Cypress Swamp locations.

Of the 249 flat sites that we attempted to access, all 142 (57%) in the Cypress Swamp were granted, 46 private sites (18%) allowed access, 32 (13%) denied access, and 29 (11%) did not respond to our request. Of the 86 flat sites that were field validated, 49 were sampled, 9 were dropped because they were not wetlands, 6 were dropped because they were determined to be a different subclass, and 22 were marked as extra Cypress Swamp sites.

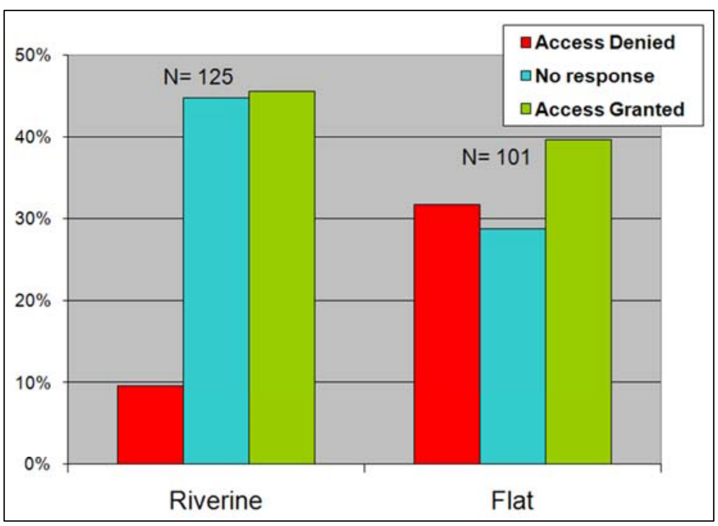


Figure 2. Site access to private wetland sites by wetland subclass.

Access specifically for private property also differed between wetland subclass (Figure 2). Of the flats private landowners that we contacted

32% denied sampling access, 29% did not respond to our request, and 40% accepted. A total of 49 flats wetlands were sampled; 24 (49%) between public and conservation partner lands and 25 (51%) on private lands. Responses from private landowners of riverine sites were much different, with only 10% denying access, 45% not responding to us, and 46% accepting our request. We sampled 50 riverine sites, 42 (84%) on private land and 8 (16%) on public property.

3.5 Data Collection

We sampled 99 sites in the Inland Bays watershed with the DE Rapid Assessment Protocol (DERAP; N_{FLAT}=49 in 2005, N_{RIV}=50 in 2006). The DERAP takes a field crew of 2-4 people 30 minutes to 2 hours to complete and collects data on the presence and intensity of stressors related to habitat, hydrology and buffer features (Jacobs 2007a). A brief list of wetland stressors is found in Table 1. A complete list of stressors and abbreviations is found in Appendix A. The stressor checklist dataset for DERAP riverine and flats sites is found in Appendices B and C, respectively. We also sampled half of those sites with the DE Comprehensive Assessment Protocol (DECAP; N_{FLAT}=24 in 2005, N_{RIV}=25 in 2006; Jacobs et al. 2008). The sampling time for a field crew of 4-5 people using the DECAP ranges between 3-6 hours of field work and collects more detailed, quantitative data. At each site, metric information on the vegetative structure and species composition, soils, hydrology, topography, and surrounding landuse was collected to score variables (Table 2) that were responsive to disturbance.

Table 1. Stressors used in DERAP in the Inland Bays watershed for flats and riverine wetlands. Habitat and Hydrology Stressors pertained to within the wetland site. Buffer Stressors related to the habitat surrounding the wetland.

Habitat Stressors	Hydrology Stressors	Buffer Stressors
Mowing in AA	Density of ditches	Development-commercial/industrial /residential
Farming activity in AA	Ditching in floodplain (not including main channel)	Waste water disposal method
Grazing in AA	Channelized stream not maintained	Landfill/Waste Disposal
Forestry activity (time since last activity)	Channel incision	Channelized Streams or Ditches
Cleared land not recovering	WeirDamRoad	Roads
Excessive Herbivory/ Pinebark Beetle /Gypsy Moth	Stormwater Inputs	Trails
Invasive species	Point Source (non-stormwater)	Row crops/Nursery
Chemical defoliation	Filling, Excavation	Orchard
Managed or converted to pine	Microtopo alterations	Poultry/Livestock
Burned	Excessive sedimentation	Forest Harvesting within 15 Yrs
Trails	Soil Subsidence/Root Exposure	Slips/Docks
Roads in site	Tidal Restriction	Boat moorings
Garbage/Isolated dumping		Golf course
Excessive nutrients indicators		Mowing
		Sand/Gravel Operation

Table 2. Variables from the DECAP data used in FCI and IWC scores for flat and riverine wetlands in the Inland Bays watershed. Variable name and abbreviation, definition, and field methods to collect the data that were used to score the variable are provided. An

Variable	Definition	Method	Scoring	Flats	Riverine
Drainage V_{DRAIN*}	% of AA impacted by ditching	Uses ditch dimensions, soil type and van Schilfgaarde equation	Continuous	X	
Vegetation Disturbance $V_{(VEG)DISTURB*}$	Timing and intensity of anthropogenic vegetation disturbance	Visual identification of vegetation disturbance within ranges of years	Categorical	X	X
Tree density V_{TDEN}	Trees with diameters of ≥ 15 cm dbh/ha	Trees measured and counted within vegetation plots	Continuous	X	
Tree species composition $V_{TREESPP\ or\ TREECOMP}$	Presence of indicator tree species in canopy	Visual identification of tree species in vegetation plots (flats) OR importance value (IV) of FACU or upland species in the canopy (riv)	Categorical	X	X
Tree Basal area V_{TBA}	Sum of BA of all trees ≥ 15 cm dbh.	Uses tree measurements in vegetation plots	Continuous	X	X
Microtopographic Disturbance V_{MICRO*}	Presence of windrows, logging trails, skidder tracks and bedding	Visual assessment of the soil surface conditions within AA	Categorical	X	
Microtopographic Relief $V_{MICROTOPO}$	Frequency of tip-ups and hummocks in AA	Measure of natural microtopographic relief	Continuous		X
Herbaceous Vegetation Composition V_{HERB}	Identification of all understory species	Visual survey in four subplots (2x0.5m) within each vegetation plot	Categorical	X	
Presence of *Rubus* species V_{RUBUS*}	Presence of blackberry (*Rubus spp*) in vegetation plots	Presence recorded	Categorical	X	X
Shrub density $V_{SHRUBDEN}$	Shrubs/ha ≥ 0.5 m high	Uses number of shrubs within vegetation plots	Continuous	X	X
Anthropogenic sediment input V_{FILL*}	Percent of AA covered by fill	Visual estimation of fill cover	Categorical	X	
Standing dead trees $V_{DEADWOOD}$	Dead trees/ha ≥15 cm dbh and ≥3 meters in height.	Uses counts of dead trees in AA	Categorical	X	
Buffer vegetation near assessment area $V_{BUFFERBA}$	Tree BA of forested buffer	Uses basal area measurements in buffer plots	Continuous	X	X
$V_{BUFFUSE200}$	% high impact landuse in the AA 200m buffer	Measured in GIS	Continuous	X	X
Floodplain condition $V_{FLOODPLAIN}$	Presence of ditching, filling or excavation within floodplain.	Visual determination	Categorical		X
Invasive species $V_{INVASIVE(HERBS)}$	% cover of invasive species in the herbaceous layer	Percent cover of invasive herbs in understory plots	Categorical		X
Channelization outside assessment area $V_{CHANNELOUT}$	Channelization within 500m of AA	Frequency of channelization within 500m of AA	Categorical		X
Stream condition inside assessment area $V_{INSTREAM}$	Condition of stream channel within the AA	Channel incision ratio combined with visual determination of severe alterations	Categorical		X
Adjusted Floristic Quality Assessment Index V_{FQAI}	Presence of high quality vegetation species	Uses presence of indicator species within AA	Continuous		X
Distance to nearest road from wetland center $V_{DISTto\ ROADS}$	Straight line distance from wetland edge to nearest mapped road.	Measured in GIS	Continuous		X

* Variables that are based on alterations to a wetland. When scaling these variables, higher amounts of alteration or disturbance are scored lower.

3.6 HGM Function and DECAP IWC Scoring

The status of wetlands in the watershed was assessed using HGM functional categories and an overall IWC. Function and IWC scores range from 0 to 100, with 100 being equal to our reference standard sites and 0 denoting a highly disturbed condition. Reference standard is defined as sites that have minimal anthropogenic disturbance and represent least altered examples of a wetland class within a region Scores between 0 and 100 can be interpreted as functioning at that percent of a reference standard site (i.e. a site with a score of 80 is functioning at 80% of the reference standard).

Using scientific literature and professional knowledge of wetland systems, variables (Table 2) were combined by expert teams to form Functional Condition Index (FCI) scores that represent 5 functional categories (Table 3). Both the raw metric and scored variable data from DECAP flats and riverine sites used to compute the FCI and IWC values are listed in Appendices E and F, respectively. Each functional category represents an integral component of wetland communities

Table 3. Functional Capacity Index (FCI) categories and formulas used to score functions of flat and riverine assessment wetlands in the Inland Bays watershed.

FCI Category	Formula
Flats	
Maintenance of Characteristic Hydrologic Regime (Hydrology)	$(0.25*V_{FILL)} + (0.75*V_{DRAIN)}$
Wildlife Habitat Integrity	$(V_{DISTURB} + ((V_{TBA}+V_{TDEN})/2) + V_{SHRUB} + V_{SNAG})/4$
Plant Community Integrity	$((V_{TREESPP}+V_{HERB}+V_{RUBUS}+V_{SHRUBSPP})/4)$
Biogeochemical Cycling & Storage	$((V_{MICRO} + V_{DEADWOOD}+ ((V_{TBA}+V_{TREEDEN})/2) /3)$ Hydrology FCI
Buffer Integrity	$((2*V_{LANDUSE200}+V_{BUFFBA}+V_{BUFFRD200})/4)*V_{BUFFIMP200}$
Riverine	
Maintenance of Characteristic Hydrologic Regime (Hydrology)	$\sqrt{}(((V_{INSTREAM}+(2*V_{FLOODPLAIN}))/3))*(V_{CHANNEL\_OUT}*V_{HYDROALT\_OUT})$
Wildlife Habitat Integrity	$(V_{TBA}+ V_{MICRO}+ V_{SHRUBDEN}+ V_{VEG\_DISTRUB})/4$
Plant Community Integrity	$0.8((V_{INVASIVE}+V_{FQAI}'+ V_{TREECOMP})/3) + 0.2(V_{RUBUS})$
Biogeochemical Cycling & Storage	$0.5((V_{TBA}+ V_{MICRO})/2) * 0.5$(Hydrology FCI)
Buffer Integrity	$0.5(V_{DISTANCE\_TO\_ROADS}) + 0.5(V_{BUFFUSE200}+V_{BUFFERBA})/2)$

and encompasses various wetland attributes as seen in the formulas (Jacobs 2006, 2007b). Functional categories allow us to generate a general rating for a group of variables or attributes to estimate how these functions are performing relative to reference standard sites. This approach avoids modeling functions very specifically which is difficult or impossible using rapid assessment methods (Cole 2006, Jordan et al. 2007). Variables that comprise the five functional categories are scaled to reference standard conditions. Data that is outside the range of reference standard condition are scored lower. Therefore, wetland site scores are lower if their data fall higher or lower than the range of reference standard condition for that wetland type. A site that is performing all functions at a high level will indicate high ecological integrity (Fennessy et al. 2004).

The HGM approach provides simple methods to determine what components of the wetland are altered or exhibiting signs of stress. For example, if the IWC score is lower than reference standard, the function models can be used to evaluate which functions are scoring lower. More specific information can also be obtained by examining the variables that compose the IWC or function. Because variables are directly linked to field data, the variable scores will identify field metrics that are deviating from reference standard conditions and causing lower function and condition scores. For example, if a site has a low Wildlife Habitat Integrity FCI score, an examination of the variables may show that the tree density and tree basal area variable scores are low, and reviewing the field metrics may reveal a recent forestry operation.

In addition to the FCI scores, variables were also used to compute an Index of Wetland Condition (IWC; Table 4). The IWC is a single composite score that represents the overall condition of the site. Comprehensive variables were screened and scored in a manner analogous to that used in developing macroinvertebrate and fish indicators of biotic integrity (IBI) in EMAP stream surveys. This included screening for signal:noise ratio, range test, responsiveness and redundancy. Variables that passed each of these tests were used in the final IWC, and variables that did not were dropped (Herlihy et al. 2006). Variables within the IWC were weighted based on their contribution to three categories: Hydrology, Vegetation, and Landscape. Habitat has the weighting of 50% of the total IWC score for both wetland types because plant communities typically respond predictably to a wide range of impacts that alter wetland condition. Hydrology was given the next highest weighting of 40%. Although hydrology was an integral component of

Table 4. Index of wetland condition (IWC) formulas for flats and riverine wetlands in the Inland Bays watershed. Variable names and definitions are listed in Table 3.

Wetland Type	IWC
Flats	50/7 * (Vdisturb + Vherb + Vrubus + Vtba + Vtreeden + Vtreespp + Vshrubden) + 40/3 * (Vmicro + Vfill + Vdrain) + 10/1 * (Vlanduse200)
Riverine	50/4 * (Vrubus+Vinvasive+Vtree+Vtba) + 40/2 * (Vfloodplain+Vchannelout) + 10/1* Vbuffuse200

wetland condition it was difficult to model with rapid assessment variables. Therefore, it has a slightly lower weight than habitat. Landscape was given the lowest weighting of 10% because previous experience has shown that it is difficult to reliably predict the condition of individual wetlands based on surrounding landscape. Additionally, landscape variables for flats and riverine wetlands were unresponsive to wetland condition but were added to the IWC because they may become more responsive in the future as the landscape changes.

3.7 DERAP IWC Scoring

The DERAP collects information on the presence and intensity of more than 40 wetland stressors related to habitat, hydrology and buffer quality. To formulate a DERAP IWC we selected stressors using multiple linear regression and model importance values, and quantified a scoring coefficient associated with each stressor (Herlihy et al. 2006; Appendix D). For flats wetlands, 15 stressors were selected to be included in the DERAP IWC calculation; 6 habitat stressors, 5 hydrology and 3 landscape or buffer stressors. For riverine wetlands, 17 stressors were selected; including 7 habitat stressors and 10 hydrology stressors. The DERAP IWC score for each site was calculated by summing the stressor coefficients for each of the selected stressors that were present and subtracting the sum from a baseline intercept score.

3.8 Assigning Condition Categories

Wetlands can be assigned to a descriptive condition category based on the DECAP or DERAP IWC to simplify interpretation. The IWC category breakpoints were set based on 115 assessment sites in the Nanticoke and Inland Bays watersheds. Each site had been given a best professional judgment (BPJ) rating during the site visit that roughly separated sites into a high, medium or low condition group. We used the IWC scores of the sites in each condition group to calculate percentile distribution values. We applied key percentile values to the all of the Inland Bays sites as our category breakpoints. Category breakpoints for rapid and comprehensive data as well as the overall IWC are found in Table 5.

Condition category definitions:

- <u>Minimally or not stressed</u> – Sites with an IWC ≥25th percentile of the IWC range for sites with a 'high condition' BPJ rating; exhibiting soil and/or vegetative structure and function similar to natural communities of the same wetland type; no or incidental anomalies; ecosystem level functions are highly maintained
- <u>Moderately stressed</u> – Sites in between minimally and highly stressed; evident changes in soil and/or vegetative structure such as shifts in size, relative abundance, presence of more tolerant taxa, and absence of characteristic taxa; ecosystem level functions largely maintained
- <u>Highly stressed</u> – Sites with an IWC ≤75th percentile of the IWC range for sites with a 'low' BPJ rating; large changes in soil and/or vegetative structure including changes in dominant taxa; ecosystem functions are altered and exhibit reduced complexity and redundancy

Table 5. Condition categories and breakpoint values for flats and riverine nontidal wetlands in the Inland Bays watershed as determined by index of wetland condition (IWC) scores.

Wetland Type	Method	Minimally or Not Stressed	Moderately Stressed	Severely stressed
Riverine	DERAP	≥84.93	<84.93 and ≥44.45	<44.45
	DECAP	≥84.40	<84.40 and ≥49.9	<49.9
Flats	DERAP	≥87.04	<87.04 and ≥64.2	<64.2
	DECAP	≥88.06	<88.06 and ≥61.33	<61.33

3.9 Presenting Wetland Condition

Our results are presented at the site and population level. Site level results are discussed by summarizing the range of scores that were found in sampled sites of a wetland subclass (e.g. Habitat Integrity FCI scores for flats wetlands ranged from 22 to 98). Population level results are presented using weighted means and standard deviations (e.g. Habitat Integrity for flats wetlands averaged 87±13) or weighted percentages (e.g. 20% of the area of flats had garbage present). Population results were determined using the random site data, weighted for sampling bias, and extrapolated to the watershed level.

Population level results have incorporated weights that corrected for any bias due to different rates of access on private and public lands. The cumulative results represent the total area of the respective wetland subclass for the entire watershed.

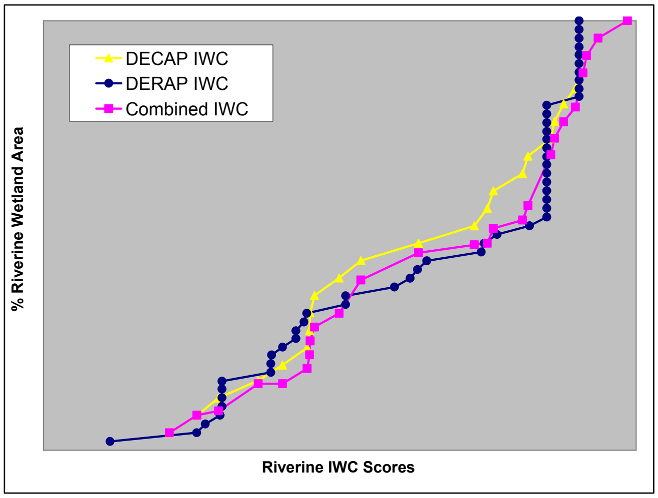
HGM models use variables and scored metrics to develop functional condition indices (FCI). We defined these as:

<u>Metric</u> - a field measure that facilitates the quantification of a particular site characteristic (e.g. tree basal area or species diversity)

<u>Variable</u> - a metric normalized on a scale of 0 to 1.0 reflecting the disturbance gradient. A zero reflects the most disturbed site in the watershed and 1.0 reflects the best obtainable condition as defined by reference standard sites. Variables can be scaled categorically or continuously based on the nature of the data.

<u>Functional Condition Index (FCI)</u> – a mathematical formula constructed of variables that represent the capacity of a wetland to perform a function. FCI scores range from 0–1.0.

The overall condition of each wetland subclass was determined by integrating the DECAP IWC on 25 sites with the DERAP IWC on 50 sites using a two-sample design. Since we sampled 25 sites in each subclass with both the DECAP and DERAP we were able to incorporate the more detailed data collected from the DECAP with the larger sample from the DERAP to best determine the condition of the entire population. The DECAP IWC, DERAP IWC and the Combined IWC using the two-sample design are illustrated in Figure. The 3-line graph demonstrates that the DERAP and DECAP estimates are similar to each



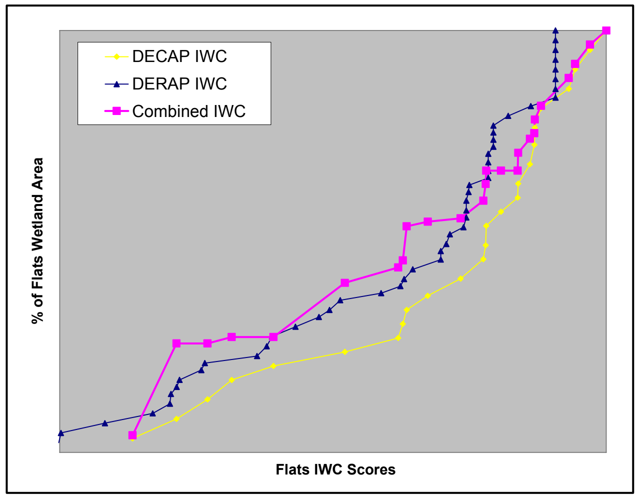


Figure 3. The two-sample design graphs for riverine (left) and flats (right) wetlands. For each subclass, the DECAP IWC (yellow line ▲) is calibrated with the DERAP IWC (blue line ●) to create a combined IWC (pink line ■). The x-axis represents increasing scores and the y-axis shows cumulative subclass wetland area.

other and the combined IWC estimate integrates the two well.

We use a (CDF) to display the population level results. A CDF can be interpreted by drawing a horizontal line anywhere on the graph and reading that as: 'z' proportion of the area of wetlands in the watershed is above (or below) the score of 'w'. The advantage of these types of graphs is that they can be interpreted based on individual user goals, and break points can be placed anywhere on the graph to determine the percent of the population that is functioning within the selected conditions. In Figure 4, roughly 60% of the wetland area was falling below 80% of reference standard condition. Another interpretation is that almost 40% of the population was >80% of reference standard condition.

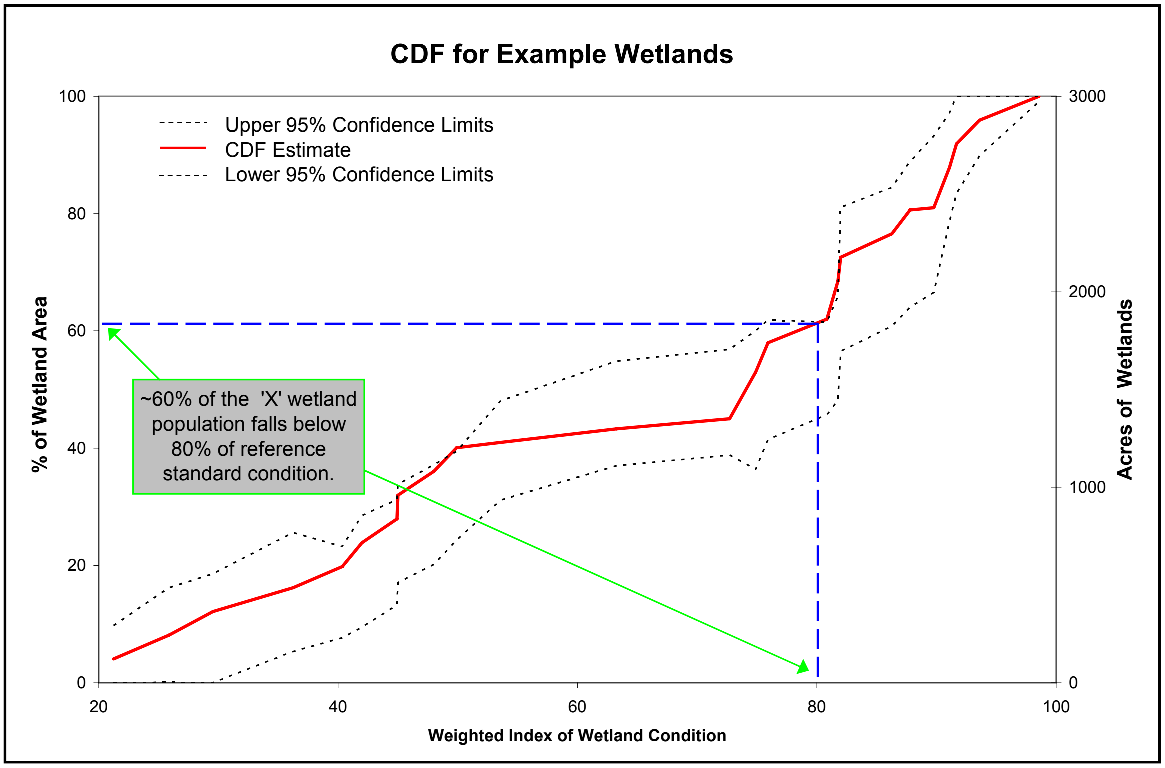


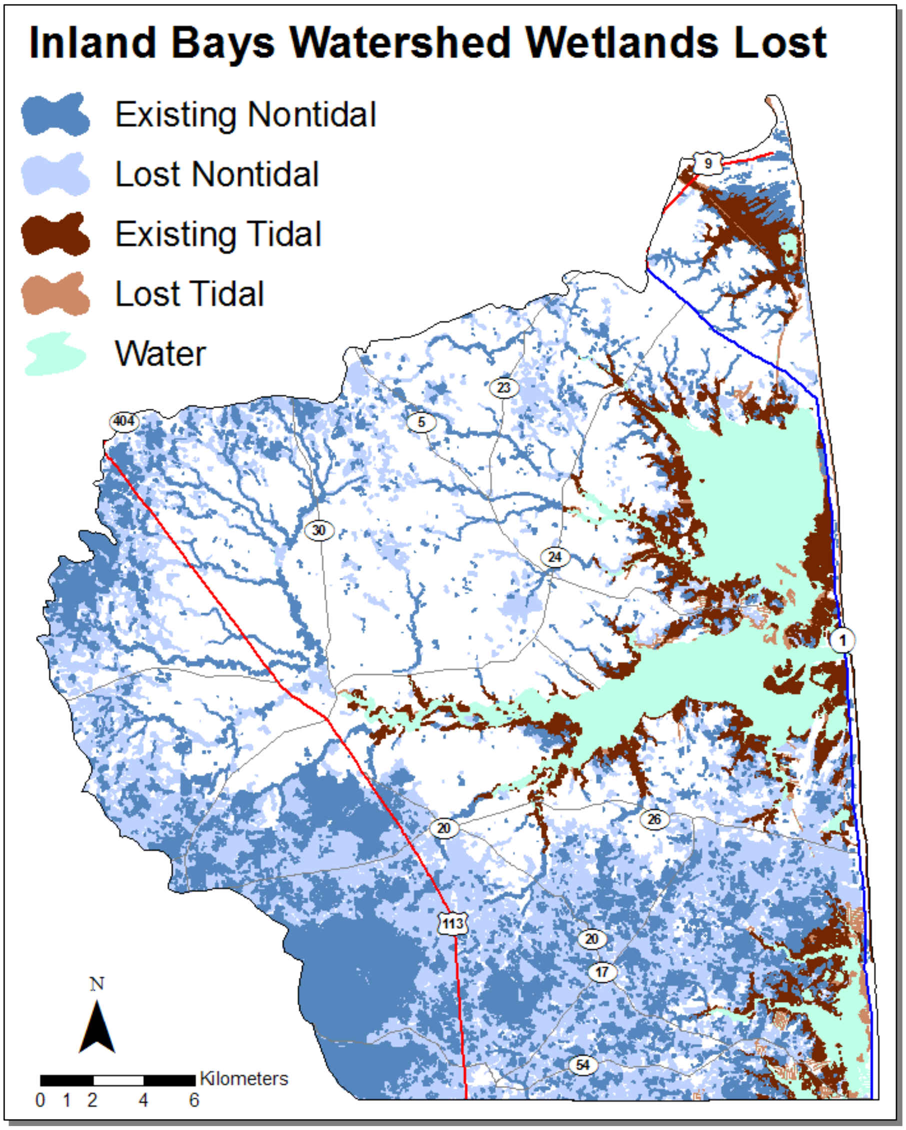
Figure 4. An example of a CDF showing wetland condition. The combined IWC population estimate (red line) is flanked by upper and lower 95% confidence intervals (black dashed lines). A reading or population interpretation (blue dashed line) extends from a point on the population line to the axes.

We also report on the overall condition of nontidal wetlands for the entire watershed. We calculated an overall condition rating of nontidal wetlands in the Inland Bays watershed using the proportion and condition of several wetland subclasses. In addition to flat, and riverine, we also included farmed wetlands and ponds or excavated wetlands. For each of the 4 mentioned subclasses we determined the proportion of each to total wetland area in the watershed (e.g. flats=74% of wetlands in Inland Bays). For condition, we used the previously determined condition proportions by subclass (e.g. 60% of flats were minimally stressed). For the condition of farmed wetland and ponds we referred to the results of the Nanticoke watershed report (Jacobs and Bleil 2008). We combined the proportions and conditions to summarize overall nontidal wetland condition.

RESULTS AND DISCUSSION

4.1 Historic Wetland Acreage

The Inland Bays watershed historically had over 75,000 acres of wetlands (Map 5). Presently, the Inland Bays watershed has about 28,000 acres of wetlands, which represents a loss of 60% of the wetland acreage since pre-European settlement and exceeds the national average for wetland loss of 53% (Dahl 1990). Ninety-eight percent of the 46,000 acres of wetlands lost in the watershed was nontidal wetlands. Loss of nontidal wetlands since the 1950's has been attributed mostly to channelization and ditching, agriculture development, urban development and the creation of ponds (Tiner and Finn 1986, DE DNREC 2001). The majority of forested wetland loss has been in the southwestern part of the watershed, where wetlands have been systematically ditched since the 1950s to improve drainage for agriculture.



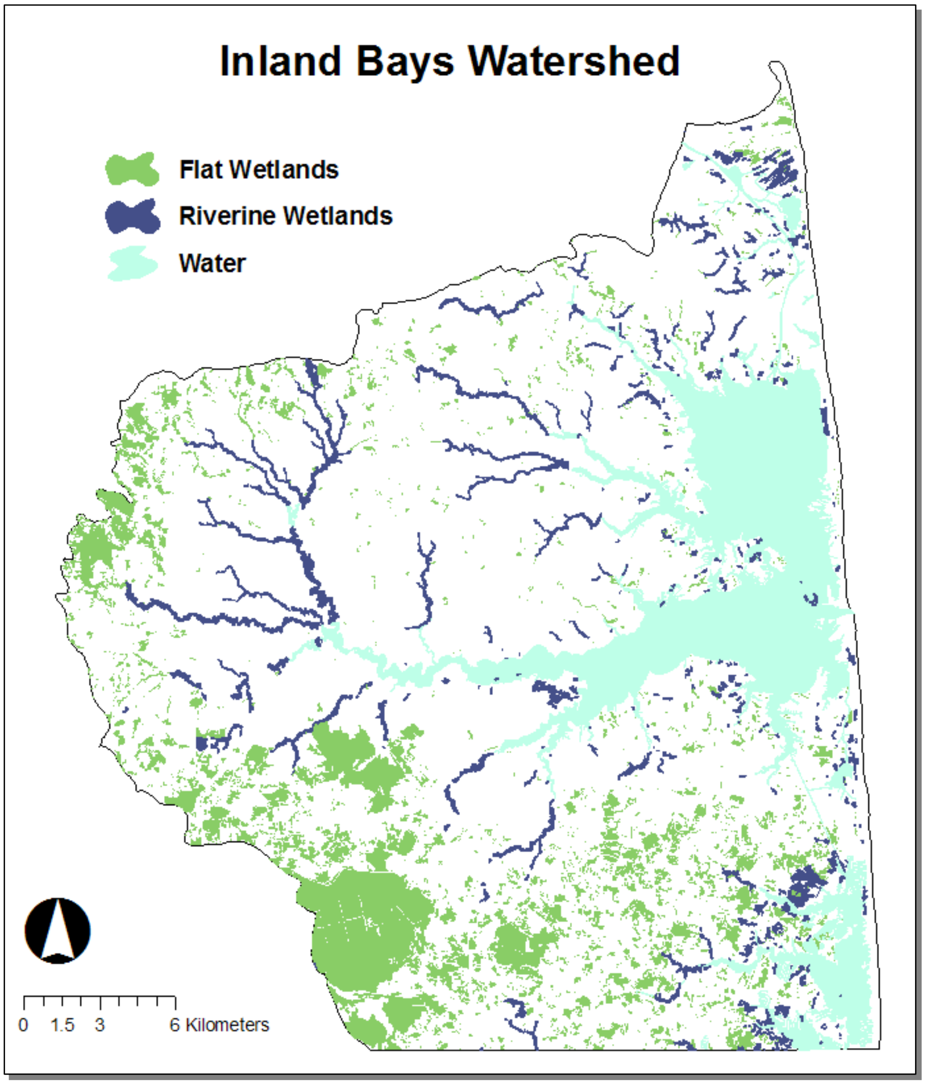
Map 5. Distribution of present day wetlands and wetlands lost since European settlement by HGM subclass in the Inland Bays watershed.

Tidal wetlands loss was due primarily to urban development, sea level rise, dredging, coastal pond and impoundment creation, and natural impacts from storms (Tiner and Finn 1986, DE DNREC 2001). Also, significant amounts of tidal marshes have been converted to open water due to multiple interacting stressors such as sea level rise, snow goose herbivory, and ditching. Tidal wetland loss has been concentrated around the southernmost bay (Little Assawoman) in the southeastern part of the watershed.

4.2 Present Wetland Condition

4.2.1 Flat Wetland Condition

Flats are the dominant wetland type in the Inland Bays watershed, comprising 78% of the nontidal wetlands and occurring in areas where there is little slope over an extended area. Wetland hydrology comes from a contribution of ground water that rises close to the surface during early winter to late spring, and precipitation that accumulates on the soil surface until it is evapotranspired or infiltrates into the soil. Layers of finer textured soils beneath the typically sandy soils retard the vertical movement of water causing saturated soils for extended periods although there may only be standing water on the surface for brief time periods. Flat wetlands are found on the periphery of the watershed and are prevalent in poorly drained southern portion of the watershed (Map 6).



Map 6. Layout of flat and riverine wetlands in the Inland Bays watershed.

Flats spanned the range of condition from highly disturbed to minimally disturbed with an average IWC of 80.7±15 that ranged from 48 to 100. Based on the IWC, 18% of flats in the watershed were highly stressed, 40% moderately stressed and 42% minimally or not stressed (Figure 5). Minimally stressed flats wetlands averaged 1 stressor each and were affected by trails in the buffer area (16%) and 28% had experienced forestry activity 30-50 years ago. None had channelized streams in the assessment site, but channelized streams and ditches did occur in the buffer (8%). Moderately stressed flats, on average, had 5 stressors present such as channelized streams and ditches present in the buffer (33%), and fill in the assessment area (56%). Many of the moderately stressed sites also had trails (50%) or roads (56%) in the assessment area, or roads in the buffer (44%). Severely stressed wetlands averaged 10 stressors and most often had channelized streams and ditches present in the buffer area (62%), ditches (77%) and roads in the site (46%) or buffer (69%). Most sites had had fill or excavation present (77%).

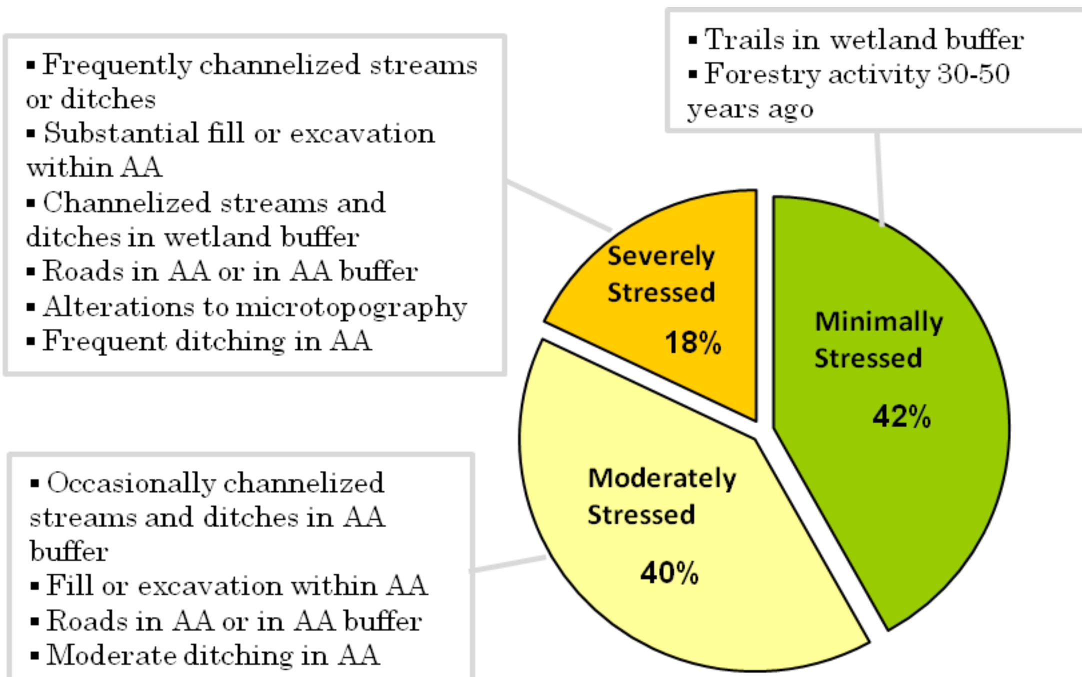


Figure 5. Proportion of Flats wetlands by condition category with common stressors for each for the Inland Bays Watershed in 2005-6 based on the Index of Wetland Condition (IWC). Percentages represent percent of flats wetland area in the watershed.

The weighted two-sample population estimate for flats is shown in red as a CDF in Figure 6 with confidence limits in black. The CDF indicates an even distribution of scores throughout the range of wetland conditions without clumps.

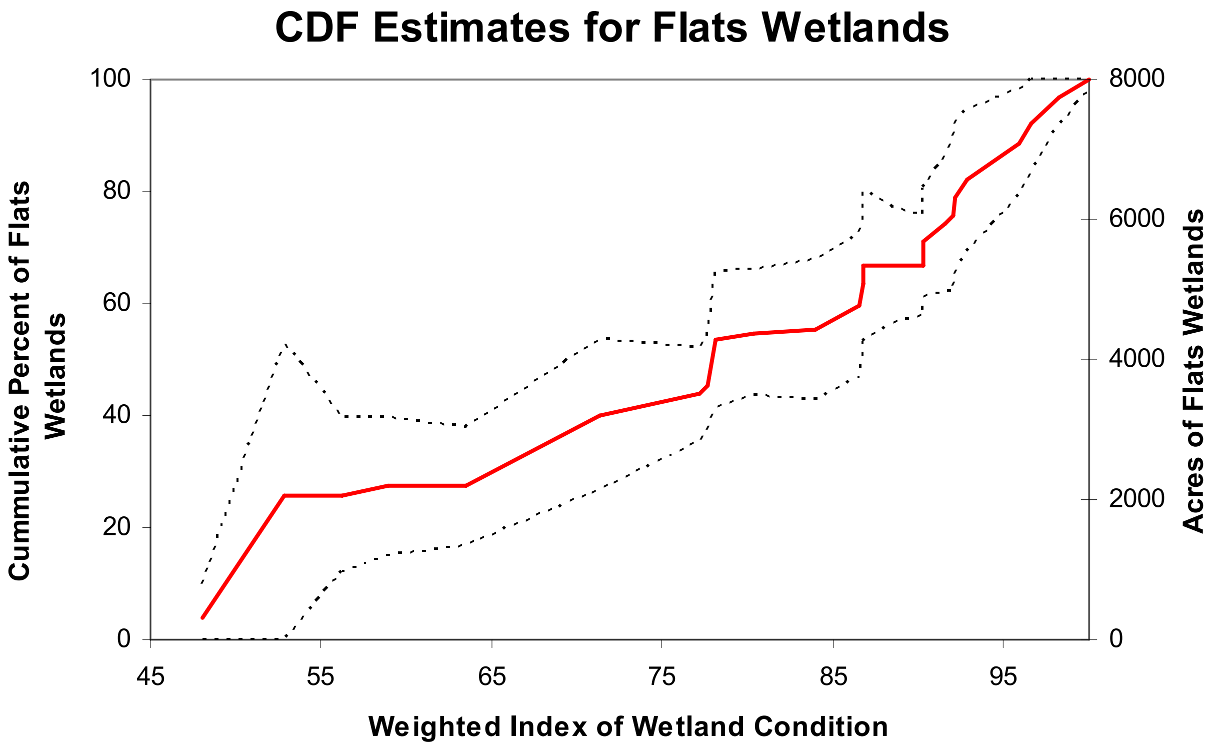


Figure 6. Cumulative distribution function (CDF) for the flats wetlands Index of Wetland Condition (IWC) in the Inland Bays watershed in 2005-2006.

The 5 function averages and scoring distribution for each are shown in Figure 7. Each bar represents the function average which is shown on the right side. Similar to traditional grading, the function scores are separated by colored 'grades' on a 20% scale. The proportion of wetlands falling into each grade for that function is noted as a percent above each colored block. The graded format highlights the function averages and the distribution of scores. For example, Wildlife Habitat and Hydrology have similar function averages, but the scoring distribution of each is quite different.

Plant Community stands out with the highest function average and the highest scoring composition. Plant Community Integrity assesses species composition of the vegetative community and was the highest performing function in the watershed for flats with an average score of 85.8%±13 and ranged from 50-100. Over 80% of flats scored ≥81% of reference standard condition for plant community and none scored <40%. We did not find grazing, burning, nutrient application or conversion to pine present and only 13% of flats had invasive plants present. The rarity of *Rubus*, richness of shrub species, and the high occurrence of wetland indicator tree species indicated the potential to maintain biological diversity, provide habitat for wildlife, and support biogeochemical cycling and storage processes.

Buffer Integrity, which evaluates the surrounding landuse of the assessment area, road density and tree cover, averaged 82%±18 and ranged from 46-100. Twenty percent of flats scored at reference standard buffer conditions (100%) and, again, no portion scored below 40%. A wetland buffer functioning at reference standard level has intact hydrologic patterns, mature forest cover and is interacting with surrounding habitats to protect water quality and prevent erosion and sedimentation. Buffer condition for flat wetlands was bolstered by a low coverage of roads and impervious surfaces surrounding the assessment area. The dominant stressor for flats buffers, as evaluated with DERAP were channelized streams and

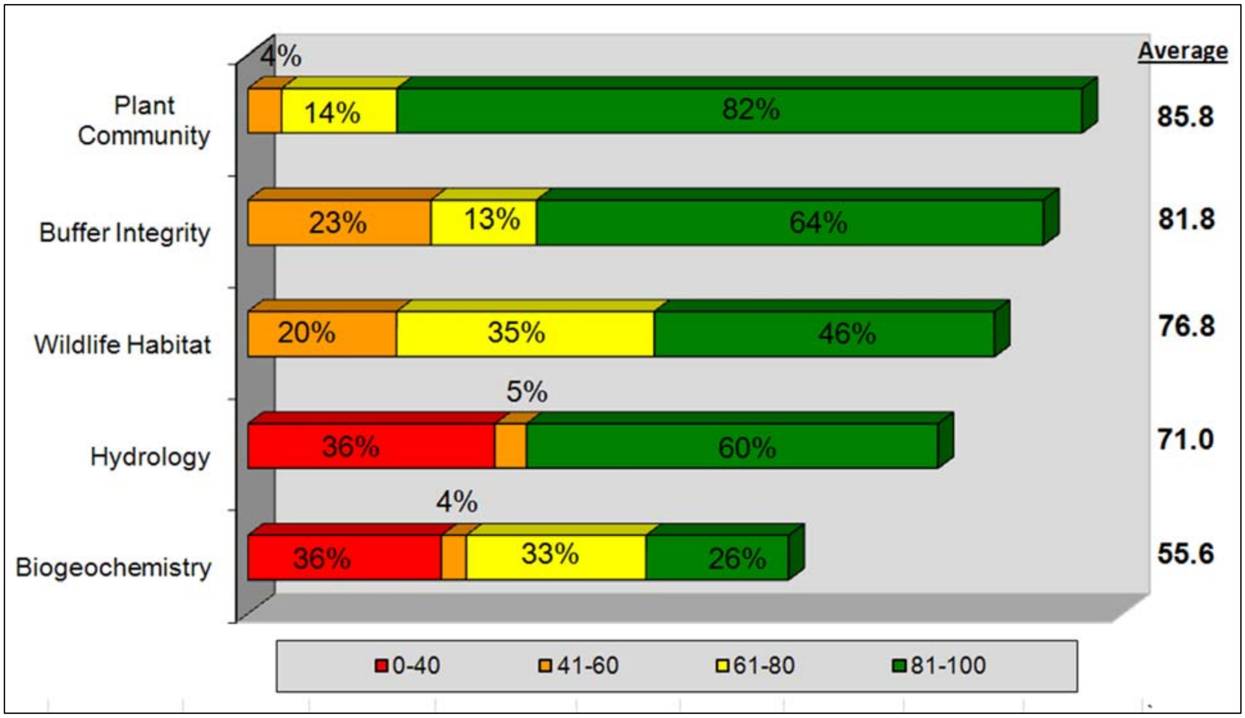
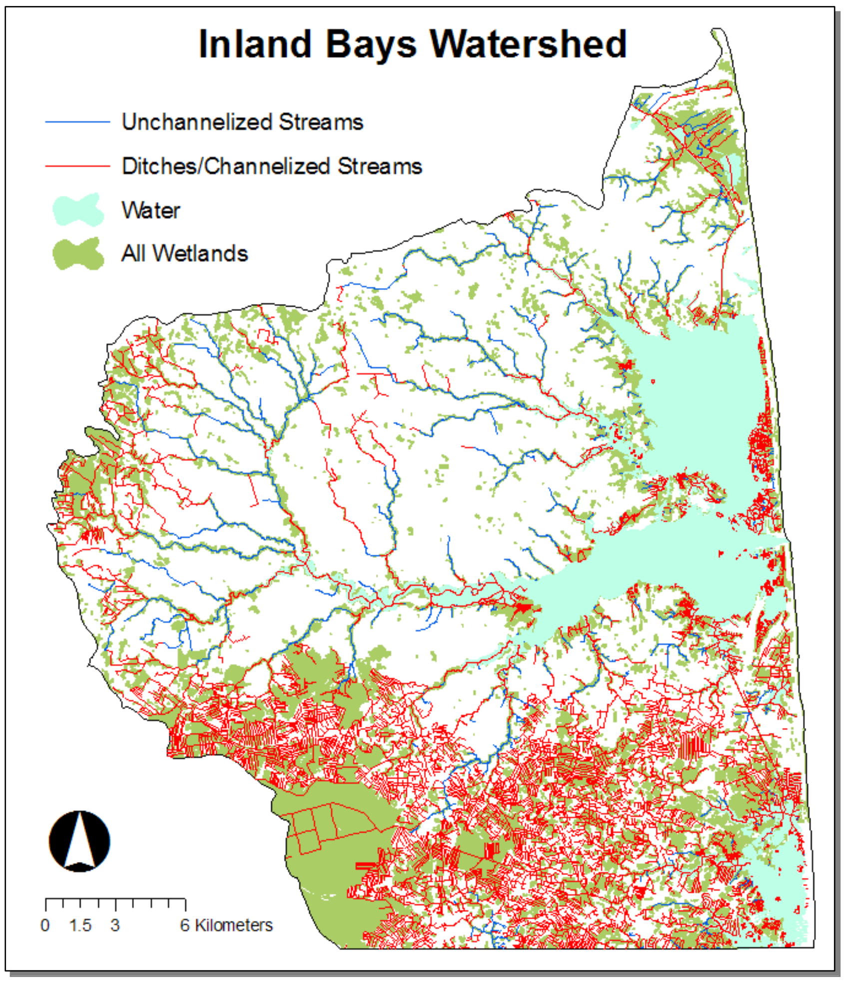


Figure 7. Average FCI scores and scoring distribution for flat wetlands in the Inland Bays Watershed. Function percentages above each bar represent the portion of flat wetlands scoring in that range. Average function scores at the end of each bar are the percent of reference standard.

ditches (30%) and trails (34%). The high scores for buffer integrity are due largely to the nature of probabilistic sampling, which evaluates buffer condition in a 200m area surrounding our assessment area as opposed to the area surrounding the actual wetland. Because flats are typically large wetlands, the assessment area buffer is often comprised of more wetlands. If the upland buffers of entire wetlands were evaluated, we suspect that the scores would be much lower.

The Wildlife Habitat function, which is derived from the size and density of trees, shrubs, dead wood, and the history of vegetative disturbance (e.g. forestry activities) averaged 77%±14 and ranged from 57 to 100. Forty-five percent of flats had a wildlife habitat function of >80% and no portion functioned less than 40%. A wetland with the components to provide habitat and resources for a broad spectrum of wildlife species through various seasons and stages of life and promote their community interactions would be indicative of reference standard conditions. Tree density consistently scored high for flats in the Inland Bays as well as shrub density and tree basal area. Habitat stressors that dominated flats included forestry activities within 50 years (34% of flats), and garbage and isolated dumping (26% of flats). Only 7% of flats had been managed or converted to a pine plantation compared to 27% in the Nanticoke watershed.

The Hydrology function is based on the extent of ditching and filling in a wetland, and averaged 71%±34 and ranged from 20 to 100. A large portion of flat wetlands were either functioning above 80% or below 40% with a very small portion in between. In fact, 50% of flats were functioning at reference standard level (100%) for hydrology, indicating that severe alterations to hydrology have been concentrated to a portion of flat wetlands leaving other portions largely intact. Of the flats that were functioning <100%, the dominant stressors based on DERAP were either moderate or severe ditching (28% of flats). Ditching to drain flats for agriculture and forestry practices is prominent especially in southern portion of the Inland Bays watershed (Map 7). In fact, based on 2008 flowline maps, 87% of non-shoreline or coastline waterways in the watershed (i.e. canals, ditches, streams, rivers or natural channels) are ditched, excavated or channelized.



Map 7. Distribution of natural and artificial waterways (i.e. canals, ditching and connectors) in the Inland Bays.

Biogeochemical Cycling and Storage function, which is based on the hydrology FCI, and deadwood and tree size, averaged 55%±29 and ranged from 11 to 100. This function exhibited the lowest portion of wetlands functioning >80% of reference standard conditions (26.4% of flats). A combination of intact hydrology and a mature forest would be indicative of reference standard conditions that promote optimum nutrient cycling, sediment retention and carbon storage in a wetland. Microtopographic features and forest cover were in place to contribute to nutrient cycling and storage. However, due to this function depending on the hydrology of wetlands, low hydrology FCIs in combination with low levels of deadwood largely contributed to lower biogeochemical functioning.

4.2.2 Cypress Swamp Flats

Eighteen of our 49 sampled flats were within the Cypress Swamp. Due to their location and ownership by a conservation partner we considered whether the condition of these wetlands would be different. If flats in the Cypress Swamp are afforded better protection from stressors and are in better condition, they should be considered separately from privately or publicly owned wetlands. By including Cypress Swamp flats with all other flats, we may be skewing overall scores and overlooking trends in wetlands stressors on other private and public lands which will affect how we prioritize management actions.

We separated data for the Cypress Swamp sites and compared the condition scores and stressors to privately and publicly owned sites. A simple t-test showed that flats in the Cypress Swamp differed in overall condition ($F_{23,1}$=9.34, P=0.044)and several functions. The Plant Community ($F_{18,1}$=6.42, P=0.002) and Buffer Integrity ($F_{16,1}$=9.34, P=0.001) function averages were greater in the Cypress Swamp. Table 6 highlights the differences between the average DECAP IWC and function scores.

Table 6. Average IWC and wetland function scores for Cypress Swamp and privately or publicly owned (other) flats sites in the Inland Bays watershed.

	DECAP IWC*	Plant Community*	Buffer Integrity*	Wildlife Habitat	Hydrology	Biogeo-chemistry
Cypress (n=11)	88.2	94.9	93.8	76.8	73.8	54.4
Other (n=14)	76.4	80.6	74.9	76.8	69.4	56.3

* denotes $P<0.05$

On average, sites in the Cypress Swamp had fewer stressors present (2.6) compared to the other flats sites (6.4). Several stressors were common at private or public sites but rare in the Cypress Swamp such as channelized streams and ditches, invasive plants, garbage, and microtopographic alterations. Invasive plant species is an important stressor to consider for wetland function. None of the flats sites in the Cypress Swamp had invasive plants present but almost a quarter (22%) of private or public sites did. Similarly, only 16% of all flats sites reported forestry activity present, but without the Cypress Swamp sites, that proportion increased to

26%. Also, garbage or isolated dumping was present at 27% of all flats sites, but when the Cypress Swamp sites were separated out, that figure jumped to 39%.

We also compared the 5 function averages and scoring distribution for Cypress Swamp sites to other flats sites. The function average and scoring composition for plant community and buffer integrity is very different (Figure 8).

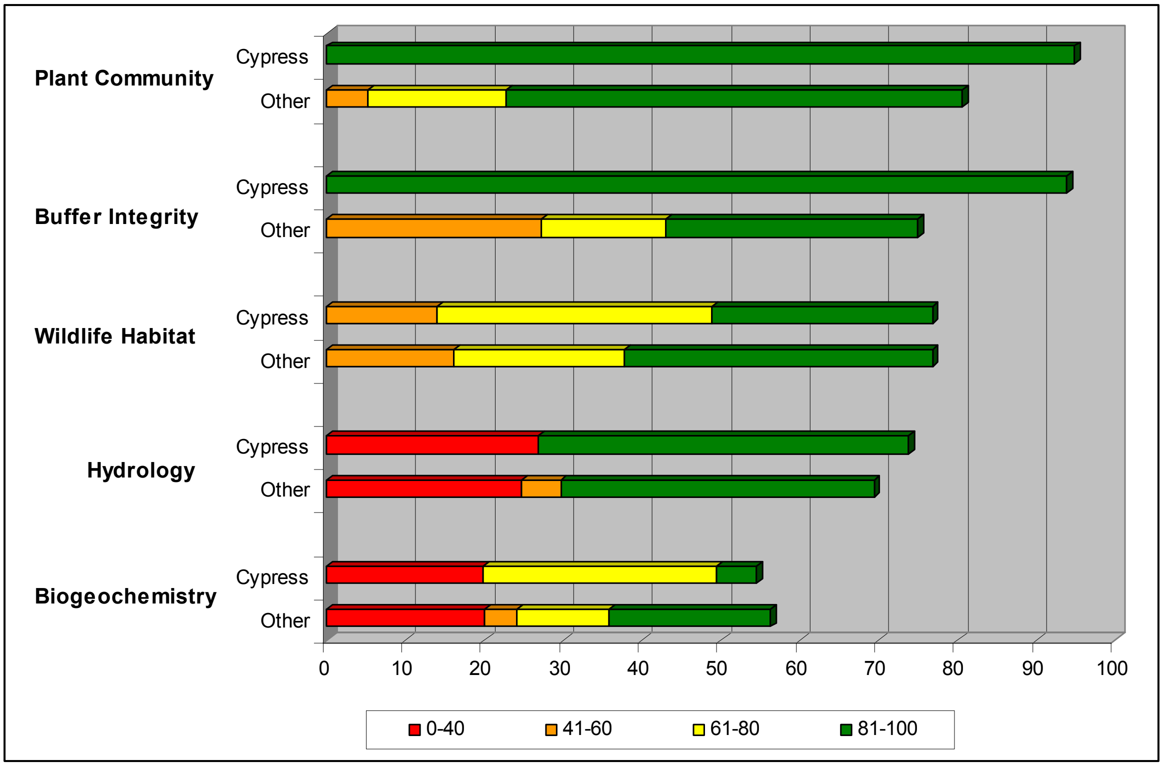


Figure 8. Average function scores and scoring composition for flats sites separated by sites in the Cypress Swamp and sites on private or public property ('other').

The colored scoring composition highlights how flats wetlands in the Cypress Swamp have intact or near reference standard level plant and buffer attributes. Stressors such as agriculture, forestry activity, and invasive plants were not issues affecting these wetlands. The remaining function averages and scoring distributions were similar. Similar Wildlife Habitat scores are the result of low scoring tree basal area and low occurrence of coarse woody debris or standing deadwood in the Cypress Swamp. Issues such as ditches in the AA (22%) and channelized streams in the buffer (22%) persist even in Cypress Swamp wetlands, which translate into lower hydrology and biogeochemistry functions.

4.2.3 Riverine Wetland Condition in the Inland Bays Watershed

Riverine wetlands are central for water quality maintenance through sediment retention and nutrient uptake, and provide storm water storage and important habitat for fish, wildlife and plants (DE DNREC 2001). These systems are critical links in the landscape because they connect processes occurring in uplands, flats and depression wetlands to surface waters that flow to larger water bodies. Nontidal riverine wetlands make up 16% of the nontidal wetlands in the Inland Bays watershed and are located adjacent to streams and rivers. Map 6 shows the present distribution of nontidal riverine wetlands in the Inland Bays watershed.

The index of wetland condition for riverine wetlands in the Inland Bays ranged from 21.2 to 98.5 with an average of 64.3 ± 24. This range illustrated a broad spectrum of condition in the watershed from undisturbed to highly altered. Based on the IWC, 32% of riverine wetlands were minimally or not stressed, 32% were moderately stressed and 36% were severely stressed (Figure 9). Minimally stressed wetlands, on average, were affected by 4 stressors. Sixty-seven percent had garbage or isolated dumping, 58% had invasive plants, and 29% had row crops or a nursery in the assessment area buffer. Ditching or stream channelization was not present in the assessment area at any of the minimally stressed sites and only 1 had channelized streams in the buffer. Moderately stressed riverine sites had an average of 8 stressors present including garbage or isolated dumping in the wetland (73%), invasive plants present (73%), and roads in the buffer (64%). Sixty-three percent of the moderately stressed sites had channelized streams in the assessment area, and over half (55%) had channelized streams or ditches in the buffer. Severely stressed riverine sites averaged 11 stressors each. All of them had channelized streams in the assessment area and in the buffer. Other common stressors for severely stressed sites included the presence of invasive plant species

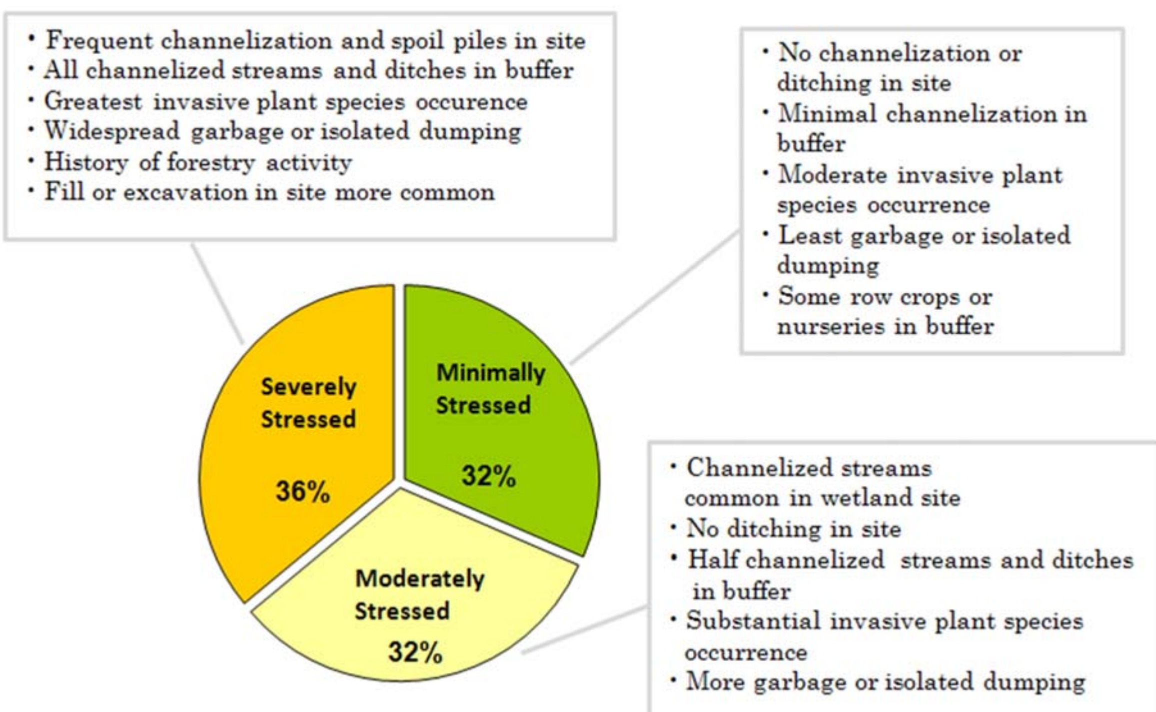


Figure 9. Proportion of Riverine wetlands by condition category with common stressors for each for the Inland Bays Watershed in 2005-6 based on the Index of Wetland Condition (IWC). Percentages represent percent of riverine wetland area in the watershed.

(87%), garbage and isolated dumping (80%), fill or excavation in the wetland (67%) and forestry activity in the buffer (53%). As wetland condition decreased, the proportion of sites that had not been forested in the past 50 years also decreased; 100% for minimally stressed sites, 72% for moderately stressed sites and 66% for severely stressed sites.

The adjusted IWC for the population is shown in Figure 10 as a cumulative portion of riverine wetland area and riverine wetland acreage. The estimate shows an evenly distributed population throughout the range of condition, indicating that every level of condition is represented in a portion of wetland area.

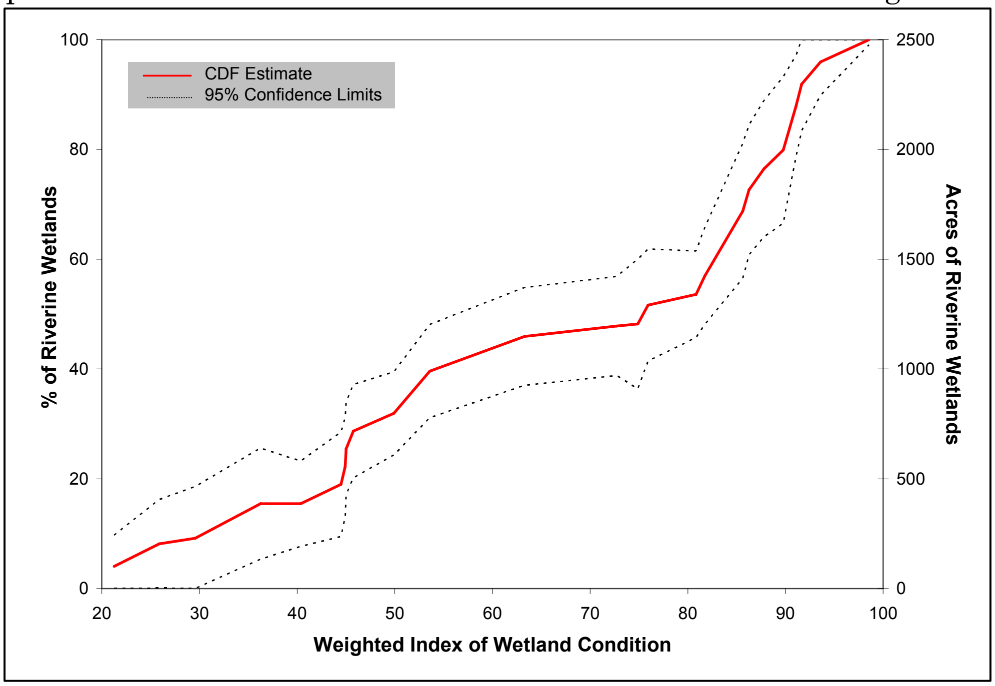


Figure 10. The CDF for the riverine wetland population based on the combined IWC for the Inland Bays watershed.

The 5 wetland functional categories, shown in Figure 11, reflected the major stressors and alterations that were impacting riverine wetlands in the Inland Bays watershed. The most pervasive was hydrologic alterations through ditching and channelization of natural stream channels which ultimately impacts every function. Consequently, Biogeochemistry and Hydrology scored the lowest. Buffer Integrity and Wildlife Habitat were functioning moderately although habitat quality was affected by garbage and isolating dumping being present at 72% of Riverine wetlands. The presence of invasive species at 64% of wetlands and the related shifts in the plant species composition was evidence of a disturbed plant community.

Plant Community Integrity function assesses species composition of the vegetative community and the potential to maintain biological diversity, provide habitat for wildlife, and support biogeochemical cycling and storage processes. The average Plant Community FCI for the riverine wetland population was 67.6±23 and was based on the plant species composition of riverine wetlands compared to reference sites. Scores ranged widely from 24 to 98, and 64% scored below 60%, indicating that a large portion has been altered. The presence and cover of invasive species and upland tree composition weakened this function score; invasive species are pervasive in riverine wetlands throughout the Inland Bays. Even the sites that we classified as reference standard sites or minimally disturbed had a very small percent of invasive species present because we were unable to find many sites where invasive plants were not present.

The Buffer Integrity function evaluates the surrounding landuse within 100m of the floodplain, road density and tree cover within 200m of the assessment area and the stream condition adjacent to the assessment area. A wetland buffer functioning at reference standard condition would be able to protect water quality, provide habitat and interact with surrounding habitats. This function averaged 70.8±25 and ranged from 32.2 to 100% of reference standard condition. Although only 4% of the riverine wetland population functioned at reference standard condition (100%) for buffer integrity, 55% functioned at >80% of reference standard condition and had largely intact buffer areas. The most common stressors within 100m of the site that were impacting buffer function were channelized streams and ditches (44%), septic systems (30%) and row crops or nurseries (36%).

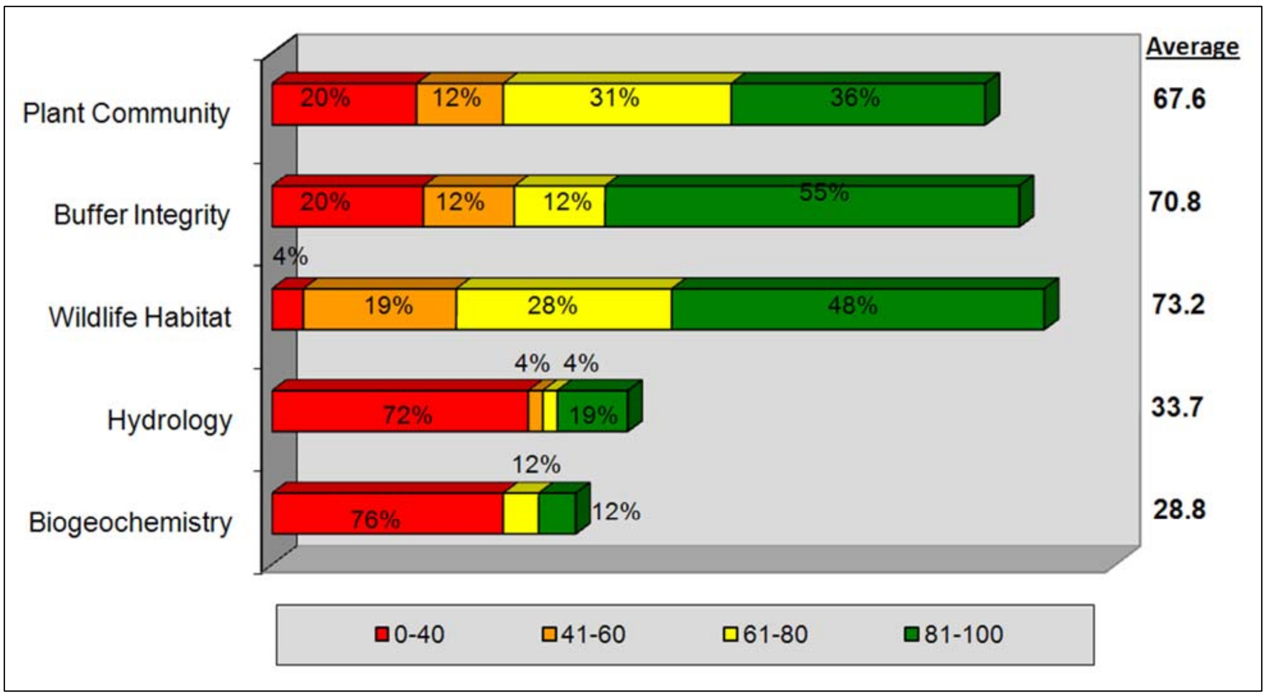


Figure 11. Average function scores and scoring distribution for riverine wetlands in the Inland Bays Watershed. Average function scores at the end of each bar are the percent of reference standard. Function percentages above each bar represent the portion of riverine wetlands scoring in that range.

The Wildlife Habitat Integrity function measures the vegetative structure, history of forestry disturbance and topographic richness of a wetland compared to reference standard condition. A wetland unaltered by forestry activity, with large trees, a healthy shrub understory and natural topographic variation would provide habitat and resources for wildlife species and promote their community interactions, would be indicative of reference standard conditions. The Wildlife Habitat FCI averaged 73.2±22 and ranged from 2.5 to 100. Wildlife Habitat Integrity had the highest average score of the functional categories with almost half of the population functioning greater than 80% of reference standard condition and only 4% functioning below 40%. Garbage and isolated dumping was the most common stressor affecting habitat for riverine wetlands.

The Hydrologic FCI is derived from the condition of the stream channel inside and outside the assessment area and from the presence of filling, ditching or excavating within the floodplain. Landscape level drainage for agriculture and development, and increased impervious surface areas has altered historic water flow paths to bypass wetlands and deliver runoff, surface waters and associated pollutants directly to the Bays. A reference standard site would be characterized by natural stream channels with no obstructions (e.g. dams and culverts) and a connected floodplain that allows bank overflow. Additionally, widespread stream channelization has disconnected many streams from their floodplain wetlands, eliminating nutrient processing from overbank flow and causing streams to shunt pollutants and sediments directly downstream. The mean Hydrology FCI was 33.7±35 and ranged from 1.3 to 100. Only 16% of the population had hydrology functioning at reference standard condition (100%) and most (72%) of the riverine wetland population was functioning at levels <40% of reference standard condition indicating severe alteration. Hydrologic alterations, such as channelization, were a main source of low function scores, as was the poor amount of overbank flooding. Within the assessment area, 44% of wetlands had channelized streams and ditches. The distribution of hydrology scores demonstrates that site hydrology is either intact (scoring >80%) or highly altered (scoring <40%); few areas (8%) are functioning at moderate levels.

The Biogeochemical Cycling and Storage was functioning the lowest for the riverine population, averaging only 28.7±31 and ranging from 0 to 97.6% to reference standard condition. The Biogeochemistry functional category is comprised of the Hydrology FCI, and microtopographic variation and tree basal area variables. A mature forest, rich in topographic features with natural hydrologic flowpaths would indicate a wetland functioning at reference standard condition. In this case, low Hydrology FCIs drove the Biogeochemistry function down. The scoring distribution shows that only 12% scored >80% of reference standard condition and 76% scored below 40%. Non-point source runoff from agriculture and urban areas, as well as municipal and industrial point source discharges have been the nutrient loading factors threatening and impairing water quality in the Inland Bays (DE DNREC 2001). High levels of nutrient runoff and water quality issues are related to channelized wetlands with disconnected floodplains and poor nutrient storage.

4.2.4 Comparison of Subclass Condition

We used average function and IWC scores for riverine and flats to compare the subclasses (Figure 12). Every function except habitat and overall IWC was greater for flats wetlands than riverine (P<0.05). Based on the condition categories for each subclass, 36% of the riverine wetlands were severely stressed compared to 18% of flats. Although riverine wetlands make up a much smaller portion of nontidal wetlands in the watershed, they are in poorer condition. The differences between subclasses varied by function and reflected how wetland subclasses are impacted by different stressors. For example, invasive plant species were present more frequently in riverine wetlands. Widespread ditching and channelization have altered hydrologic patterns and allowed invasives to colonize. The Wildlife Habitat function was similar between flats and riverine. Plant Community scores were lower in Riverine wetlands due to the greater prevalence of invasive species and Buffer Integrity differed by 10-20%. Hydrology and Biogeochemisty differed by 50% because of the extensive channelization of streams. The differences in functions and stressors are reflected in the average IWC; the condition of flats wetlands (81.4) was higher than riverine (64.4).

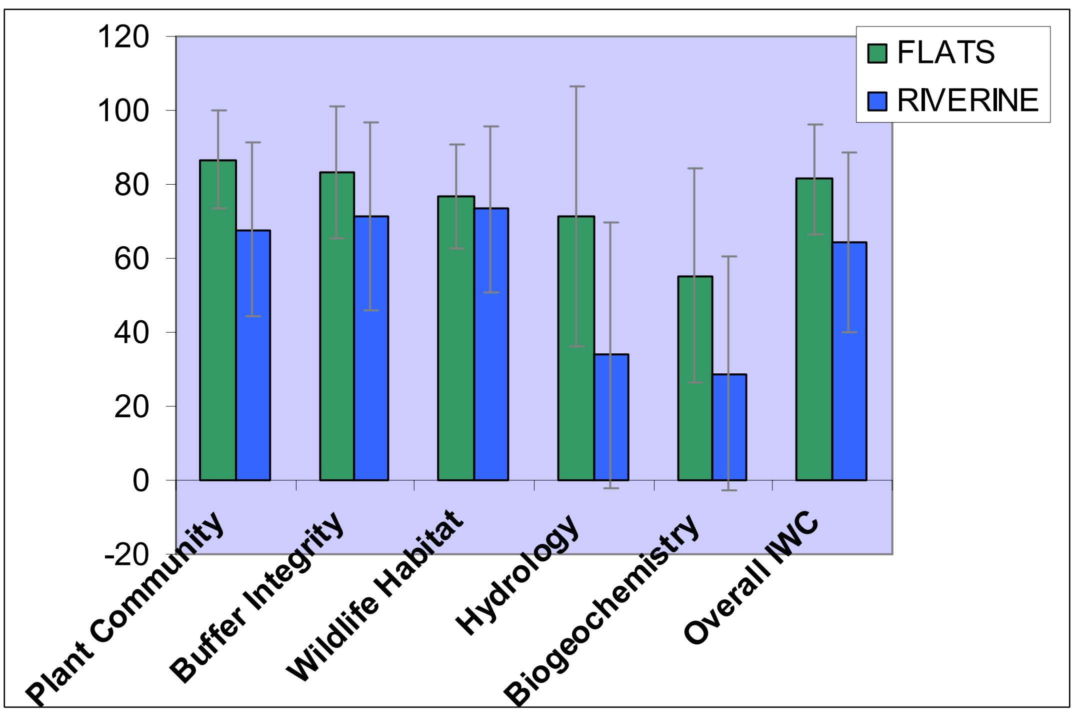


Figure 12. FCI and IWC scores for flat and riverine wetlands in the Inland Bays watershed. Scores on the y-axis are percent of reference standard condition.

4.2.5 Overall Condition of Nontidal Wetlands

Among the Inland Bays nontidal wetlands, there were 20,139 acres of flats (65%), 4,953 acres of riverine (16%), 5,094 acres of farmed wetlands (farmed and prior converted; 16%), and 723 acres of ponds (2.3%). Farmed wetland acreage was subtracted from the flats because all farmed wetlands were classified as flats. Based on the proportion of each wetland type and using the condition breakpoints for each respective subclass, 32% of the nontidal wetlands were minimally or not stressed, 31% were moderately stressed, and 36% were highly stressed (Figure 12). This perspective gives a simple view of nontidal wetland condition in the Inland Bays watershed; a third of the nontidal wetlands are minimally stressed and are functioning relatively well, but slightly more have been severely altered and, as a result, are not able to function well and provide the level of ecological benefits that they could.

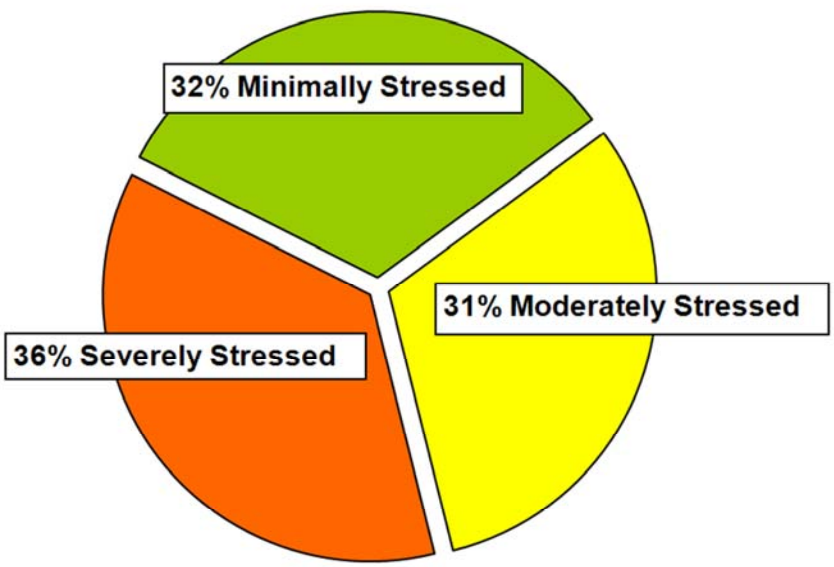
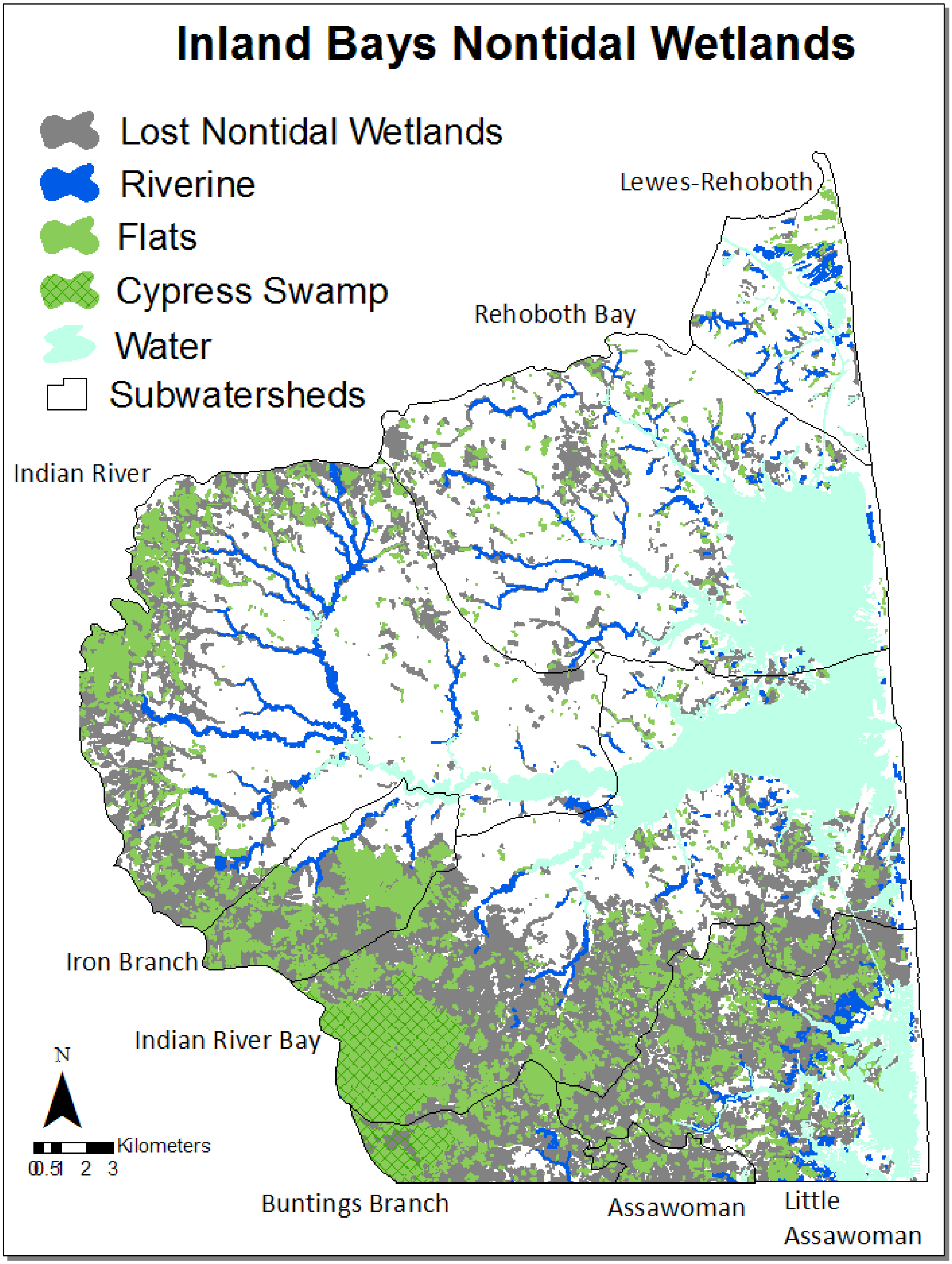


Figure 13. Condition of nontidal wetlands in the Inland Bays watershed 2005-2006 based on the Index of Wetland Condition (IWC). Wetlands included in this analysis are flats, nontidal riverine, excavated, and farmed.

4.2.6 Wetlands Loss by Subwatershed

Landuse patterns across the Inland Bays watershed vary greatly. Some areas are dominated by residential development, some by agriculture and some are more natural land types such as forests and wetlands. As a result, wetlands loss and wetland condition could vary between the subwatersheds of the Inland Bays. We examined the overall condition (IWC) of wetlands by subclass between the 8 subwatersheds across the Inland Bays to look for patterns. Subwatersheds where we sampled <5 sites were not compared because we did not have enough data to confidently estimate condition on such a small scale.



Map 8. Nontidal wetlands loss delineated by subwatershed. Existing nontidal wetlands are shown in green and blue, nontidal wetlands lost since settlement are in gray.

Map 8 shows the distribution of nontidal wetlands that have been lost since pre-settlement. The majority of nontidal wetlands lost have been in the southern portion of the watershed, in Iron Branch, Indian River Bay, Buntings Branch, Assawoman and Little Assawoman subwatersheds.

Table 7. Condition of Inland Bays nontidal wetlands by subwatershed. Reported wetlands lost represents the proportion of nontidal wetlands lost since pre-settlement.

Subwatershed	$flats_N$	mean IWC flats*	$riverine_N$	mean IWC riverine*	% wetlands lost
Little Assawoman	5	72.83	1	--	66
Rehoboth Bay	2	--	4	--	62
Indian River	7	71.06	30	70.32	61
Indian River Bay	23	78.62	6	63.09	60
Iron Branch	3	--	7	44.72	55
Buntings Branch	8	78.95	0	--	54
Lewes-Rehoboth	1	--	2	--	18

* Average IWC value was reported only if sample size for the subwatershed was ≥5.

For flats wetlands, we examined 4 subwatersheds and found some variation in overall condition (Table 7). Buntings Branch and Indian River Bay were in the highest condition with averages of 79, Little Asswoman and Indian River were lower with average conditions of 73 and 71, respectively (Table 7). The average condition within Indian River Bay is likely higher because the Cypress Swamp wetlands fall into this subwatershed. The rates of nontidal wetlands lost between these subwatersheds ranged from 18-76% of historic wetland acreage.

For riverine wetlands, we compared only 3 subwatersheds, Indian River, Indian River Bay and Iron Branch (Table 7). The average condition of riverine wetlands in Indian River (71) was about the same as for flats, but was the highest of the 3 compared here. Indian River Bay was lower (63) and Iron Branch was much lower with an average condition of 48. The amount of nontidal wetlands lost does not appear to be related to wetland condition, but a larger sample size in each subwatershed would make this comparison better. Although landuse patterns vary across the watershed, they tend to be less variable among watersheds because each watershed spans a landuse gradient from more agricultural in the headwaters to more developed near the Bays. This pattern may explain why we are not seeing large differences among the watersheds.

MANAGEMENT RECOMMENDATIONS

Wetland systems are vital to the health of the Inland Bays watershed, its biodiversity and water quality. We have shown that wetlands have been impacted in the Inland Bays watershed due to complete loss and conversion to other landuses, and from stressors that have reduced the level of functions and services that they provide. Given these impacts, it is critical to protect the wetlands that remain so that they may continue to provide services to the citizens of the watershed. Additionally, enhancing the condition of wetlands is necessary to improve the condition of the Inland Bays and the watershed as a whole.

To increase the function and services of wetlands in the watershed, natural wetlands that have been degraded should be enhanced. Working with existing wetlands is more cost-effective, returns greater function improvements, and often has a greater likelihood of success than reestablishing former wetlands. Reestablishing wetlands should be performed to increase our wetland acreage by selecting sites in the correct landscape position and using reference data to reestablish the appropriate hydrogeomorphic wetland type that will be sustained in that setting. Ultimately, the most cost-effective means of maintaining the services that wetlands provide is through protection of existing wetlands. Appendix G has been included to define relevant wetland management techniques.

We provide the following recommendations for focusing efforts to improve the condition of nontidal wetlands in the Inland Bays watershed:

1. Improve protection of nontidal wetlands. Protecting wetlands should be the highest priority strategy for maintaining wetland functions and services in the Inland Bays watershed. Increasing human population and associated landuse conversion threatens wetlands due to direct and indirect impacts from new developments, roads, and infrastructure. Given the substantial loss of over 60% of the wetland area that has already occurred, it is critical to protect all remaining wetlands. Every additional wetland lost contributes to a reduction of water quality, wildlife habitat, and flood abatement services, and increases societal costs for providing man-made alternatives to these services.

    a. Enact comprehensive State regulations that fill the gaps created by recent Supreme Court decisions. In recent years, several Supreme Court decisions have reduced the regulatory authority of the USACE to regulate the impact and destruction of some nontidal wetlands (see http://www.epa.gov/owow/wetlands/guidance/CWAwaters.html). This is especially significant in Delaware because we have no state regulatory program for nontidal wetlands with the exception of those wetlands that are >500 contiguous acres. Additionally, the court decisions have created uncertainty in how to determine which wetlands are regulated and thus have caused lengthy delays in the permitting process. A state regulatory program would eliminate the ambiguity surrounding which wetlands are regulated and provide a comprehensive and clear means to protect wetlands in the entire state.

b. Encourage wetland protection by local communities. Since wetlands provide valuable services to the citizens and visitors of the Inland Bays watershed, counties and municipalities should protect wetlands that provide valuable services such as water quality improvements. Local regulations can be incorporated into municipal and/or county code to protect wetland areas of special significance.
c. Use fee simple acquisitions and conservation easements to provide the strongest level of protection to high quality wetlands. Integrate protection for wetlands that are minimally or least stressed including their associated buffers into existing landscape conservation plans to ensure that these systems remain intact and continue to provide related functions.
d. Perform outreach activities to communities within the watershed and to decision makers on the importance of wetlands and options for better protection at the state and local level.

2. Ensure that wetland functions are replaced before permitting the destruction or degradation of wetlands. The Army Corps of Engineers (USACE) should adopt the use of the assessment methods applied in this study to evaluate the function and condition of all wetlands where a permit is submitted to impact the site. The USACE guidelines that require permitees to first avoid, then minimize and then compensate should be strictly enforced. If impacts are unavoidable, permitees should be required to document that the functions of the proposed impacted wetland have been replaced through mitigation using the DECAP and DERAP. When re-establishing wetlands, data from reference standard sites should be used as guidance during construction to ensure that projects will be sustainable in the current landscape (Bedford 1999).

3. Prioritize restoring hydrology to riverine wetlands by removing stream channelization and reconnecting surface water flow to wetlands. Hydrologic restoration will improve other wetland functions and services such as flood retention, water quality improvement, and wildlife habitat on site and also improve water quality downstream. Riverine wetlands, which comprise 16% of the nontidal wetlands in the watershed, were more severely stressed than flats, with lower overall condition, more stressors, and lower function. The average condition of riverine wetlands was 64 (on a scale of 0-100). The hydrology of riverine wetlands was particularly altered due to channelization of streams. The excavated spoil deposits on the stream edges prevent the water from reaching adjacent wetlands during storm events. Riverine wetlands that receive surface

water during high flow periods improve water quality via nutrient uptake and transformation, sediment retention, and reduction of flood damage by storing flood waters and precipitation (Bason 2008, Baker et al. 2007). Riverine wetlands are also valuable as wildlife and specialized plant habitat. Invasive plants were widespread, and sites that had altered hydrology generally had lower plant community function. Hydrology of these systems should be restored first, followed by evaluating the need for invasive species management to restore the native plant community.

4. Encourage the use of best management practices to protect flats wetlands from additional stressors. Flats wetlands make up nearly 80% of nontidal wetlands in the Inland Bays watershed. Flats were moderately stressed with fewer stressors on average and higher scoring habitat functions than riverine wetlands and had an average condition of 80. The two primary stressors that lowered the condition of flats in the Inland Bays watershed were hydrology alterations (primarily drainage ditches) and forestry activity (clear cutting and selective harvest).

    a. On sites with altered hydrology, extensive ditching has reduced water levels in wetlands and subsequently the opportunity for wetlands to improve water quality. Therefore, for these sites, hydrology should be the focus of restoration.
    b. For the portion of flats that have unaltered hydrology, management should focus on protecting them from additional stressors through the use of best management practices such as sustainable forestry activities, low impact methods for agriculture and residential drainage that eliminate disturbance to adjacent wetlands, and establishment of buffers around wetlands. Forestry activity in flats has affected the plant community, wildlife habitat and wetland buffer quality through reduced wildlife resources, landscape disturbance, removal of wildlife corridors, and the removal of trees as cover and for soil stability. However, given time, these forests will mature and improve these functions as long as additional stress is not placed on these systems.
    c. The flats data should be shared with landowner assistance programs to help inform and target their outreach to local farmers and timber companies supporting the use of best management practices.

5. Focus protection and re-establishment of flats with the goal of increasing large forested wetlands. Landuse activities in the watershed have converted flats that were once very large forest blocks to much smaller forested wetlands. Therefore, priority should be given to protecting and increasing large forested flats. These areas provide critical habitat for a variety of wildlife and because of their extent and primarily headwater position in the landscape improve water quality from adjacent surface runoff and precipitation that is a significant source of nutrients

to the Bays. The Cypress Swamp is an example of how protecting a large area of wetlands from common stressors can preserve important wetland functions. We found that Cypress Swamp flats were less often altered by invasive plants, forestry, agriculture, and roads. In return, plant and buffer functions scored higher. However, hydrologic alterations still occurred in the Cypress Swamp area which was reflected in the hydrology and biogeochemistry functions. Because the Cypress Swamp was protected and remains intact, it has allowed for ongoing and future restoration projects.

6. Develop a watershed restoration plan based on the best available science to prioritize areas for protection, enhancement, and re-establishment of wetlands. The plan should be comprehensive including all habitat types so that wetlands are not considered in isolation of other critical habitats. Existing conservation plans including Green Infrastructure and the Wildlife Action Plan should be used to create a plan that when implemented will maintain and improve a sustainable system of natural habitat and the continued delivery of the services that they provide. The plan should then be implemented through a network of conservation agencies to perform outreach to landowners encouraging their enrollment in voluntary restoration programs. The restoration plan could also be utilized to inform decision makers and to improve the protection of wetlands from direct and indirect impacts.

7. Outreach should be conducted to the general public within the watershed to better inform them about the status and value of their local wetland resources and ways in which they can better maintain their properties to reduce indirect wetland impacts. Active volunteers in the watershed should be targeted to encourage their participation in public decision making processes and to provide them with tools to train other members of the community to become more active in decision making processes that impact wetlands.

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APPENDIX A: DERAP STRESSOR CODES AND DEFINITIONS

Habitat Category (within 40m radius site/AA)	
Hmow	Mowing in AA
Hfarm	Farming activity in AA
Hgraz	Grazing in AA
Hfor50	No forestry activity within 50 years
Hfor30	Forestry activity 30-50 years ago
Hfor15	Forestry activity 15-30 years ago
Hfor2	Forestry within 15 years
Hforcc	Forestry Activity clear cut within 2 years
Hnorecov	Cleared land not recovering
Hfor10	Forest activity <10% of AA
Hherb	Excessive Herbivory/Pinebark Beetle/Gypsy Moth
Hinvdom	Invasive plants dominating AA
Hinvless	Invasives plants not dominating
Hchem	Chemical Defoliation
Hpine	Managed or Converted to Pine
Hburn	Burned (prescribed)
Htrail	Trails and Roads
Hgarb	Garbage/Isolated Dumping
Hnutapp	Nutrients direct application/runoff
Halgae	Nutrients dense algal mats
Hrdlog	Logging road in AA
Hrdgrav	Dirt or gravel road in AA
Hrdpav	Paved road in AA

Hydrology Category (within 40m radius site/AA)	
Wditchs	Slight Ditching; 1-3 shallow ditches (<.3m deep) in AA
Wditchm	Moderate Ditching; 3 shallow ditches (<.3m deep) in AA or 1 ditch >.3m deep within 25m of edge
Wditchx	Severe Ditching; >1 ditch .3-.6 m deep or 1 ditch > .6m deep within AA
Wditchfloodplain	Ditching in floodplain (not including main channel)
Wchannm	Channelized stream not maintained
Wchan1	Spoil bank only one side of stream
Wchan2	Spoil bank both sides of stream
Wincision	Stream channel incision
Wdamdec	WeirDamRoad decreasing site flooding
Wimp10	WeirDamRoad/Impounding water on <10% of AA
Wimp75	WeirDamRoad/Impounding water on 10-75% of AA
Wimp100	WeirDamRoad/Impounding water on >75% of AA
Wstorm	Stormwater Inputs
Wpoint	Point Source (non-stormwater)
Wfill10	Filling, excavation on <10% of AA
Wfill75	Filling, excavation on 10-75% of AA
Wfill100	Filling, excavation on >75% of AA
Wmic10	Microtopo alterations on <10% of AA
Wmic75	Microtopo alteations on 10-75% of AA

Wmic100	Microtopo alterations on >75% of AA
Wsedchan	Excessive Sedimentation in stream channel
Wsedwet	Excessive Sedimentation on wetland surface
Wsubsid	Soil Subsidence/Root Exposure
Wtidres	Tidal Restriction

Landscape/Buffer Category (within 100m radius outside site/AA)

Ldevcom	Development- commercial or industrial
Ldevres3	Residential >2 houses/acre
Ldevres2	Residential ≤2 houses/acre
Ldevres1	Residential <1 house/2 acres
Lsew	Served by sewer
Lsept	Served by septic
Ltrail	Trails (buffer)
Lrdgrav	Roads (buffer) mostly dirt
Lrd2pav	Roads (buffer) mostly 2- lane paved
Lrd4pav	Roads (buffer) mostly 4-lane paved
Llndfil	Landfill/Waste Disposal
Lchan	Channelized Streams or Ditches >0.6m deep
Lagrow	Row crops or nursery plants
Lagorch	Orchards
Lagpoul	Poultry or Livestock operation
Lfor	Forest Harvesting Within Last 15 Years
Ldock	Slips/Docks/Marina
Lmoor	Boat Moorings
Lgolf	Golf Course
Lmow	Mowed Area
Lmine	Sand/Gravel Operation

APPENDIX B: DERAP STRESSOR CHECKLIST FOR RIVERINE SITES

Habitat (H) category stressors are listed in peach; Hydrology (W) category stressors are listed in blue; Landscape/Buffer (L) category stressors are listed in mint green. ‘1’ indicates the presence of that stressor; ‘0’ indicates absence. Stressor definitions and codes are listed in Appendix A.

RIV Assess-ment Site #	QCR	Hmow	Hfarm	Hgraz	Hfor50	Hfor30	Hfor15	Hfor2	Hforcc	Hnorecov	Hfor10	Hpine	Hherb	Hburn	Htrail	Hgarb	Hchem	Hinvless	Hinvdom	Haglage	Hnutapp	Hrdlog	Hrdpav
0031	5	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0063	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0081	6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0
0102	4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0
0113	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0127	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0138	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0
0162	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0206	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0222	6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
0263	5	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0270	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0279	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0282	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0298	6	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1
0337	2	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
0349	4	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0
0359	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0382	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0391	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0400	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0409	5	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0423	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0426	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0431	5	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0442	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0446	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0466	3	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
0468	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0477	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0487	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0513	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0541	5	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
0551	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0554	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0562	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
0599	2	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0
1002	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1009	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1010	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1015	2	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
1018	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1021	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0

1069	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0
1073	6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
1098	5	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
1117	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1121	5	1	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
1138	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
1149	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0

Hydrology category stressors

RIV Assess-ment Site #	Wstorm	Wpoint	Wsubsid	Wtidres	Wsedchan	Wsedwet	Wimp10	Wimp75	Wimp100	Wdamdec	Wfill10	Wfill75	Wfill100	Wmic10	Wmic75	Wmic100	Wditchs	Wditchm	Wditchx	Wditchfloodplain	Wchan1	Wchan2	Wchanm	Wincision
0031	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0
0063	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0081	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
0102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0127	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0138	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
0162	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0206	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0222	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
0263	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
0270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0279	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0282	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
0298	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
0337	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
0349	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0
0359	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
0382	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
0391	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0400	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
0409	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0
0423	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
0426	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0431	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0
0442	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0446	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0466	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
0468	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
0477	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
0487	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
0513	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
0541	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
0551	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0554	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0562	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

0599	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1018	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
1021	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1069	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
1073	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
1098	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
1117	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
1121	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0
1138	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1149	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Landscape/Buffer category stressors

RIV Assess-ment Site #	Ldevres1	Ldevres2	Ldevres3	Ldevcom	Lsew	Lsept	Lrd2pav	Lrd4pav	Lrddirt	Lrdgrav	Llndfil	Lchan	Lagrow	Lagpoul	Lfor	Lpier/dock	Lgolf	Lmow	Lmine
0031	0	1	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
0063	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
0081	1	0	0	0	0	1	0	1	0	0	0	1	0	0	1	0	0	0	0
0102	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0113	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
0127	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
0138	0	0	1	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
0162	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
0206	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
0222	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0263	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0
0270	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
0279	0	2	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
0282	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
0298	1	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	1	0
0337	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0349	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	0	0
0359	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0
0382	1	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0	0	0
0391	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
0400	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
0409	1	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	1	0
0423	1	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0
0426	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0431	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
0442	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
0446	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0466	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0468	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
0477	0	0	0	1	0	1	0	0	1	0	1	1	0	0	0	0	0	1	0
0487	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0

0513	0	1	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
0541	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0
0551	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
0554	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0562	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0599	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1010	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
1015	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
1018	0	0	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0
1021	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1069	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
1073	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0
1098	0	1	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	1	0
1117	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
1121	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0
1138	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1149	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

APPENDIX C: DERAP STRESSOR CHECKLIST FOR FLATS SITES

Habitat (H) category stressors are listed in peach; Hydrology (W) category stressors are listed in blue; Landscape/Buffer (L) category stressors are listed in mint green. '1' indicates the presence of that stressor; '0' indicates absence. Stressor definitions and codes are listed in Appendix A.

Flat Assess-ment Site #	QCR	Hmow	Hfarm	Hgraz	Hfor50	Hfor30	Hfor15	Hfor2	HforCC	Hnorecov	Hfor10	Hherb	Hinvdom	Hinvless	Hchem	Hpine	Hburn	Htrail	Hgarb	Hnutapp	Halgae	Hrdlog	Hrdgrav	Hrdpav
0045	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0052	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0071	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0084	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0090	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0152	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0153	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0070	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0108	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0003	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0007	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0027	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0043	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0019	4	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0029	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0059	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0061	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0110	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0020	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0051	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0133	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
0172	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
0030	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
0044	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
0168	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
0008	5	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
0046	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
0169	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0132	4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0
0039	3	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0
0035	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0011	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
0130	4	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
0004	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
0075	5	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
0065	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
0176	3	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0139	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
0012	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0
0026	4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0
0192	5	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

0023	6	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
0033	5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0
0473	5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0177	4	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0
0151	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
0092	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
0068	6	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	1	0
0292	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Hydrology category stressors

Flat Assess -ment Site #	Wditchs	Wditchm	Wditchx	Wchannm	Wchan1	Wchan2	Wdamdec	Wimp10	Wimp75	Wimp100	Wstorm	Wpoint	Wfill10	Wfill75	Wfill100	Wmic10	Wmic75	Wmic100	Wsubsid	Wtidres
0045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0052	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0071	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0084	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0152	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0153	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
0070	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0027	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0043	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0059	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0061	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0020	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0051	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0044	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0168	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0008	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
0046	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
0169	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0132	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0035	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0011	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
0130	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
0004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
0075	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
0065	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
0176	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0

0139	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0012	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0
0026	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0
0192	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0023	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
0033	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
0473	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
0177	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
0151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
0092	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0068	0	1	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0	0	0
0292	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0

Landscape/Buffer category stressors

Flat Assess-ment Site #	Ldevcom	Ldevres3	Ldevres2	Ldevres1	Lsew	Lsept	Ltrail	Lrdgrav	Lrd2pav	Lrd4pav	Llndfil	Lchan	Lagrow	Lagorch	Lagpoul	Lfor	Ldock	Lmoor	Lgolf	Lmow	Lmine
0045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0052	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0071	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0084	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0152	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
0153	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0070	0	1	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0007	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0027	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0043	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0059	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0061	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0020	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
0051	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
0133	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0172	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0030	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0044	0	0	0	0	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0
0168	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
0008	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0
0046	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
0169	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0132	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
0039	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0035	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0011	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
0130	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0

0004	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0075	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0065	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0176	0	1	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
0139	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	1	0	0	0	0	0
0012	0	0	0	1	0	1	1	0	1	0	0	1	1	0	0	1	0	0	0	1	0
0026	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
0192	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0
0023	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0
0033	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0
0473	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
0177	0	0	0	1	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
0151	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
0092	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0
0068	0	0	0	1	0	1	1	1	0	0	1	1	0	0	1	0	0	0	0	1	0
0292	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0

APPENDIX D: RAPID IWC STRESSORS AND WEIGHTS

Category/Stressor Name*	Stressor Abbreviation	Stressor Weights**	
		Flats	Riverine
Habitat Category (within 40m radius site/AA)			
Mowing in AA	Hmow	-10.8	0
Forestry activity 15-30 years ago	Hfor15	-7.4	-8.4
Forest activity <10% of AA	Hfor10		
Forestry activity 3-15 years ago	Hfor2	-20.7	
Clear cut within 2 years	Hforcc		
Excessive Herbivory/Pinebark Beetle/Gypsy	Hherb	-6.8	0
Invasive plants dominating site (>50% of AA)	Hinvdom	0	-24.3
Invasive plants not dominating (<50% of AA)	Hinvless	0	-5.5
Chemical Defoliation	Hchem	0	-30.6
Managed or Converted to Pine	Hpine	-6.1	0
Trails and Roads	Htrail	-2.4	0
Nutrients direct application/runoff	Hnutapp	-15.1	0
Hydrology Category (within 40m radius site/AA)			
Ditching –slight	Wditchs	-9.5	0
Ditching –moderate	Wditchm	-10.2	0
Ditching –severe	Wditchx	-16.4	0
Channelized stream not maintained	Wchannm	0	-10.5
Spoil bank only one side of stream	Wchan1	0	-25.7
Spoil bank both sides of stream	Wchan2	0	-33.9
Stream channel incision	Wincision	0	-18.9
Impounding water on 10-75% of AA	Wimp75	0	-16.9
Impounding water on >75% of AA	Wimp100	0	
Filling, excavation on 10-75% of AA	Wfill75	0	-12.5
Filing, excavation on >75% of AA	Wfill100	0	
Microtopography altered on 10-75% of AA	Wmic75	-15	-11
Microtopography altered on >75% of AA	Wmic100		
Buffer Category (100m radius around site/AA)			
Roads mostly dirt	Lrdgrav	-2.7	0
Roads mostly 2- lane paved	Lrd2pav		0
Roads mostly 4-lane paved	Lrd4pav		0
Forest Harvesting Within Last 15 Years	Lfor	-3.3	0
Mowed Area	Lmow	-8.9	0
Intercept/Base Value		94.4	90.4
Flats IWCrapid= 94.4 +(∑weights(Habitat+Hydro+Buffer))			
Riverine IWCrapid= 90.4 +(∑weights(Habitat+Hydro))			

*DERAP stressors not listed in this table are not included in the rapid IWC calculation.
**Stressor weights that are boxed should only be counted once, even if more than one is present.

APPENDIX E: DECAP METRIC AND VARIABLE DATA FROM INLAND BAYS FLATS SITES*

Assess-ment Site #	QCR	% AA affected by ditching	Vdrain	Vdisturb	Tree Density trees / ha	Vtreeden	% FACU Trees >7.5cm dbh	Vtreespp	Tree Basal Area m²/ ha	Vtba	Vmicro	Vherb	Rubus frequency in veg plots	Vrubus
0003	2	0.0	1.00	1.00	200	0.94	0.0	1.00	7.9	0.27	1.00	1.00	2	0.50
0007	1	0.0	1.00	1.00	520	1.00	0.0	1.00	38.4	1.00	1.00	1.00	0	1.00
0012	3	44.5	0.56	1.00	373	1.00	7.1	0.50	32.8	1.00	0.75	1.00	0	1.00
0019	2	0.0	1.00	0.75	520	1.00	0.0	1.00	24.5	0.82	1.00	1.00	0	1.00
0023	6	100.0	0.10	0.50	427	1.00	3.1	0.50	38.3	1.00	0.10	0.25	1	0.75
0026	4	75.4	0.25	1.00	680	0.85	2.0	0.50	44.2	1.00	0.75	0.50	1	0.75
0029	2	0.0	1.00	0.75	467	1.00	0.0	1.00	16.9	0.57	1.00	0.75	0	1.00
0033	5	100.0	0.10	0.75	293	1.00	0.0	1.00	23.7	0.80	0.10	0.25	0	1.00
0035	2	100.0	0.10	1.00	227	1.00	0.0	1.00	12.5	0.42	1.00	0.75	0	1.00
0043	2	100.0	0.10	1.00	320	1.00	0.0	1.00	23.6	0.79	1.00	1.00	0	1.00
0045	2	0.0	1.00	1.00	507	1.00	0.0	0.75	19.4	0.65	1.00	0.75	0	1.00
0051	3	100.0	0.10	1.00	347	1.00	0.0	1.00	24.6	0.83	1.00	1.00	0	1.00
0059	2	0.0	1.00	0.75	613	0.92	0.0	1.00	23.6	0.79	1.00	0.75	0	1.00
0061	2	0.0	1.00	0.75	413	1.00	0.0	1.00	12.9	0.43	1.00	1.00	0	1.00
0070	2	0.0	1.00	1.00	387	1.00	0.0	1.00	27.8	0.93	1.00	1.00	0	1.00
0090	1	20.7	0.79	1.00	427	1.00	9.4	0.50	23.3	0.78	1.00	0.75	0	1.00
0108	2	0.0	1.00	0.75	613	0.92	0.0	1.00	29.3	0.98	0.75	1.00	1	0.75
0132	4	0.0	1.00	0.50	280	1.00	4.8	0.50	28.1	0.94	0.75	0.75	1	0.75
0139	5	100.0	0.10	0.25	67	0.31	0.0	0.75	5.8	0.19	0.50	1.00	2	0.50
0153	1	0.0	1.00	1.00	333	1.00	0.0	1.00	33.6	1.00	1.00	0.75	0	1.00
0168	3	0.0	1.00	0.50	427	1.00	0.0	1.00	34.7	1.00	0.75	1.00	2	0.50
0169	2	0.0	1.00	0.75	187	0.88	0.0	1.00	14.8	0.50	0.75	0.75	0	1.00
0172	3	0.0	1.00	0.75	413	1.00	0.0	1.00	17.3	0.58	0.75	1.00	1	0.75
0176	3	100.0	0.10	0.75	360	1.00	2.1	0.50	36.8	1.00	0.75	1.00	0	1.00
0011	4	100.0	0.10	0.10	213	1.00	12.5	0.25	12.5	0.83	0.50	1.00	0	1.00

APPENDIX E continued

Assess-ment Site #	Shrub Density shrubs / ha	Vshrub den	% Fill in AA	Vfill	LDW Volume / ha	Snag Density / ha	Vdead -wood	Buffer Tree Basal Area m²/ha	VbuffBA	% High Impact Landuse in Buffer	Vbuffuse 200	Vshrub spp	Vbuffimp 200	Vbuffrd 200
0003	15733	0.96	0	1.00	97.4	66.8	0.50	7.3	0.29	0.00	1.00	1.00	1.00	1.00
0007	5147	1.00	0	1.00	75.3	0.0	0.50	32.8	1.00	0.00	1.00	1.00	1.00	1.00
0012	4013	0.84	≤10	0.75	1.6	13.3	0.50	33.3	1.00	55.16	0.45	1.00	1.00	0.69
0019	16773	0.95	0	1.00	1.0	13.3	0.50	23.7	0.92	0.06	1.00	1.00	1.00	1.00
0023	3547	0.75	>10 ≤50	0.50	0.8	53.3	0.50	33.5	1.00	52.80	0.47	0.50	0.92	0.79
0026	120	0.10	>10 ≤50	0.50	1.8	0.0	0.50	14.1	0.55	47.38	0.54	0.75	1.00	0.75
0029	4440	0.93	0	1.00	0.8	0.0	0.50	20.4	0.79	0.00	1.00	1.00	1.00	1.00
0033	3867	0.81	>10 ≤50	0.50	35.2	13.3	1.00	31.1	1.00	63.93	0.35	0.25	0.89	0.83
0035	4040	0.85	≤10	0.75	53.6	26.7	1.00	9.0	0.35	0.00	1.00	1.00	1.00	1.00
0043	6907	1.00	0	1.00	40.2	13.3	1.00	29.1	1.00	0.00	1.00	1.00	1.00	0.92
0045	3213	0.68	0	1.00	0.0	0.0	0.10	31.1	1.00	0.00	1.00	1.00	1.00	0.87
0051	11520	1.00	0	1.00	156.9	26.7	1.00	21.2	0.82	0.00	1.00	1.00	1.00	0.87
0059	3293	0.69	0	1.00	0.0	0.0	0.10	23.8	0.93	0.00	1.00	1.00	1.00	1.00
0061	37227	0.71	0	1.00	0.0	0.0	0.10	12.9	0.50	0.00	1.00	1.00	1.00	1.00
0070	7333	1.00	0	1.00	2.5	13.3	0.50	31.0	1.00	38.59	0.64	1.00	0.67	0.50
0090	5867	1.00	0	1.00	0.0	13.3	0.50	27.7	1.00	5.65	1.00	1.00	1.00	1.00
0108	1067	0.22	0	1.00	10.0	0.0	1.00	32.6	1.00	0.00	1.00	0.50	1.00	1.00
0132	2227	0.47	0	1.00	9.6	0.0	1.00	36.7	1.00	38.85	0.63	1.00	0.83	0.65
0139	3920	0.82	0	1.00	15.8	0.0	1.00	7.4	0.29	28.13	0.76	1.00	1.00	1.00
0153	7960	1.00	0	1.00	8.9	40.0	1.00	34.6	1.00	0.00	1.00	1.00	1.00	1.00
0168	1293	0.27	≤10	0.75	0.1	0.0	0.50	35.6	1.00	12.02	0.94	1.00	1.00	0.88
0169	14240	0.97	0	1.00	12.7	40.0	1.00	14.3	0.56	6.54	1.00	1.00	1.00	1.00
0172	1400	0.29	0	1.00	0.6	0.0	0.50	23.5	0.91	15.85	0.90	0.75	1.00	1.00
0176	6947	1.00	≤10	0.75	29.6	0.0	1.00	49.5	1.00	47.74	0.53	0.75	0.85	0.48
0011	6920	1.00	>75	0.50	1.3	0.0	0.50	28.1	1.00	0.00	1.00	1.00	1.00	1.00

*Gray columns denote raw data; Green column denote scored metric data; All sites were assessed in 2004-2005 and scored with Flats protocol version 2.0

APPENDIX F: DECAP METRIC AND VARIABLE DATA FROM INLAND BAYS RIVERINE SITES*

Assess-ment Site #	Stream Order	QCR	Vveg disturb	FACU Tree IV	Vtree comp	Tree Basal Area m²/ha	Vtba	Vmicro-topo	% Rubus in veg plots	Vrubus	Shrub Density shrubs /ha	Vshrub den	Buffer BA m²/ha	Vbufferba
0031	3	4	0.10	0.22	0.25	40.0	0.95	0.94	50	0.50	1150.0	0.55	26.8	0.75
0063	4	1	1.00	0.47	0.10	41.7	1.00	0.50	33	1.00	1306.7	0.62	54.4	1.00
0081	2	6	0.10	none	0.10	0.0	0.00	0.00	66	0.10	0.0	0.10	10.4	0.29
0102	1	4	1.00	none	1.00	26.6	0.64	1.00	66	0.50	4466.9	1.00	30.7	0.86
0113	1	2	1.00	none	1.00	32.6	0.79	1.00	0	1.00	3840.2	1.00	22.6	0.63
0127	3	2	1.00	0.02	0.50	42.8	1.00	0.50	0	1.00	10853.8	0.72	30.4	0.85
0138	1	5	0.50	0.44	0.10	62.6	1.00	0.31	100	0.10	3294.0	1.00	20.7	0.58
0162	2	2	1.00	0.02	0.75	52.3	1.00	1.00	0	1.00	9868.0	0.88	45.6	1.00
0206	1	2	1.00	none	1.00	23.6	0.56	1.00	0	1.00	4840.2	1.00	30.4	0.85
0222	1	6	0.10	none	1.00	41.6	0.99	1.00	0	1.00	973.4	0.46	24.5	0.69
0263	1	4	0.10	0.11	0.50	29.1	0.69	0.38	100	0.10	1420.0	0.68	27.8	0.78
0270	1	3	1.00	none	1.00	17.4	0.42	1.00	33	1.00	5800.3	1.00	27.6	0.77
0279	1	2	1.00	0.45	0.10	45.4	1.00	1.00	33	1.00	2440.1	1.00	33.5	0.93
0282	2	3	1.00	none	1.00	21.6	0.51	1.00	0	1.00	2520.4	1.00	51.7	1.00
0298	2	5	0.10	none	1.00	25.4	0.60	0.75	0	1.00	3110.0	1.00	32.4	0.91
0337	2	2	1.00	0.07	0.50	27.6	0.66	0.92	33	1.00	400.1	0.10	21.5	0.60
0349	2	5	0.50	none	1.00	21.2	0.50	0.75	100	0.10	2560.0	1.00	35.6	1.00
0359	3	5	0.75	0.25	0.25	34.3	0.81	1.00	33	1.00	1413.4	0.67	30.5	0.85
0382	1	3	1.00	none	1.00	36.3	0.86	1.00	0	1.00	946.7	0.45	47.6	1.00
0391	2	2	1.00	none	1.00	34.8	0.83	1.00	0	1.00	5973.6	1.00	20.4	0.57
0400	4	5	0.25	0.02	0.75	42.5	1.00	0.13	0	1.00	2110.0	1.00	36.0	1.00
0409	1	5	0.50	0.28	0.10	17.8	0.43	1.00	66	0.50	453.4	0.10	23.3	0.65
0423	2	3	0.50	none	1.00	40.8	0.98	1.00	100	0.10	3107.1	1.00	19.4	0.54
0426	4	1	1.00	0.19	0.25	39.9	0.95	1.00	33	1.00	1360.2	0.65	35.1	0.99
0431	1	5	0.50	0.18	0.25	15.8	0.38	0.00	100	0.10	1560.1	0.74	26.6	0.75

APPENDIX F continued

Assess-ment Site #	% High Impact Landuse Buffer	Vbuffuse 200	% of Floodplain Alterations in AA	Vflood-plain	% invasive herbs	Vinvasive	% Channel-ization 500m from AA	Vchannel out	Vinstream	Avg. CoC	FQAI'	VFQAI'	Vdist to_roads	Vhydro _alt_out
0031	35.0	0.70	>10 ≤75	0.25	5.84	0.10	50	0.50	0.30	4.48	36.26	0.45	0.50	0.25
0063	0.7	1.00	none	1.00	0.25	0.75	0	1.00	1.00	4.35	42.90	0.83	1.00	1.00
0081	9.8	1.00	>75	0.10	0.13	0.75	100	0.10	0.10	3.68	33.48	0.30	0.24	0.75
0102	63.1	0.37	none	1.00	0.50	0.75	10	0.75	0.10	5.00	47.98	1.00	0.09	0.50
0113	36.5	0.69	none	1.00	0.16	0.75	0	1.00	1.00	4.75	46.35	1.00	1.00	1.00
0127	11.2	0.99	none	1.00	0.00	1.00	0	1.00	1.00	5.13	50.49	1.00	1.00	1.00
0138	40.9	0.63	>10 ≤75	0.25	6.38	0.10	70	0.10	0.30	4.3	39.25	0.62	0.10	0.25
0162	15.1	0.94	none	1.00	0.00	1.00	0	1.00	1.00	4.40	44.12	0.90	1.00	0.25
0206	22.3	0.85	none	1.00	0.00	1.00	0	1.00	0.60	4.58	44.76	0.94	1.00	0.25
0222	82.5	0.14	>10 ≤75	0.25	7.63	0.10	10	0.75	0.60	4.07	37.50	0.52	0.23	0.25
0263	0.5	1.00	>10 ≤75	0.25	2.59	0.25	100	0.10	0.10	4.25	39.32	0.63	1.00	1.00
0270	56.3	0.45	none	1.00	0.83	0.75	10	0.75	0.60	4.57	44.64	0.93	0.67	0.50
0279	31.0	0.75	none	1.00	0.00	1.00	0	1.00	0.60	4.54	44.13	0.90	1.00	0.75
0282	52.3	0.50	none	1.00	0.21	0.75	40	0.50	1.00	4.33	41.10	0.73	0.03	0.25
0298	57.5	0.44	>75	0.10	0.19	0.75	60	0.75	0.10	4.6	43.25	0.85	0.00	1.00
0337	0.0	1.00	≤10	0.75	0.21	0.75	0	1.00	0.60	4.34	42.50	0.81	1.00	1.00
0349	77.1	0.21	≤10	0.75	7.81	0.10	100	0.10	0.10	4.1	40.02	0.67	0.70	1.00
0359	44.8	0.59	>75	0.10	0.33	0.75	100	0.10	0.10	4.67	43.66	0.87	1.00	0.50
0382	30.0	0.76	≤10	0.75	0.00	1.00	40	0.50	0.10	4.40	42.52	0.81	1.00	0.50
0391	62.9	0.38	none	1.00	0.00	1.00	0	1.00	0.30	4.51	42.64	0.82	0.39	0.50
0400	23.4	0.84	>75	0.10	2.75	0.25	100	0.10	0.10	4.35	42.51	0.81	1.00	1.00
0409	35.9	0.69	≤10	0.75	1.50	0.50	80	0.10	0.60	5.04	49.34	1.00	1.00	1.00
0423	40.7	0.64	>10 ≤75	0.25	0.00	1.00	100	0.50	0.60	4.86	47.67	1.00	0.24	1.00
0426	12.1	0.97	none	1.00	0.00	1.00	0	1.00	1.00	4.95	49.01	1.00	0.70	1.00
0431	34.0	0.72	>75	0.10	3.83	0.25	100	0.10	0.10	4.06	38.92	0.61	1.00	1.00

*Gray columns denote raw data; Green columns denote scored metric data; All sites were assessed in 2006 and scored with Riverine variable scoring protocol version 2.0.

APPENDIX G: WETLAND MANAGEMENT DEFINITIONS

Definitions for Wetland Management
(www.epa.gov/owow/wetlands/restore/defs.html)

Protection/Maintenance: removing a threat to wetlands or preventing decline of wetland conditions. Includes purchase of land or easement, repairing water control structures or fences, or structural protection such as repairing a barrier island. Also includes activities commonly associated with the term 'preservation'. Protection/Maintenance does not result in a gain of wetland acres or function.

Restoration: the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to former or degraded wetland. For the purpose of tracking net gains in wetland acres, restoration is divided into:

Re-establishment: the manipulation of the physical, chemical, or biological characteristics of a site with the goal of *returning* natural/historic functions to a former wetland. Results in rebuilding a former wetland and results in a gain in wetland acres.

Rehabilitation: the manipulation of the physical, chemical, or biological characteristics of a site with the goal of *repairing* natural/historic functions of degraded wetland. Rehabilitation results in a gain in wetland function, but does not result in a gain in wetland acres.

Establishment: the manipulation of the physical, chemical, or biological characteristics present with the goal of *developing* a wetland that did not previously exist on an upland or deepwater site. Establishment results in a gain in wetland acres.

Enhancement: the manipulation of the physical, chemical, or biological characteristics of a wetland (undisturbed or degraded) site to heighten, intensify, or improve specific function(s) or for a purpose such as water quality improvement, flood water retention or wildlife habitat. Enhancement results in a change in wetland function(s) and can lead to a decline in other wetland function, but does not result in a gain in wetland acres. This term includes activities commonly associated with the terms enhancement, management, manipulation, directed alteration.