Condition of Wetlands in the St. Jones River Watershed

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EXECUTIVE SUMMARY

The Delaware Department of Natural Resources and Environmental Control (DE DNREC) assessed the condition of wetlands in the St. Jones River watershed in 2007-2008. The goal of this project was to determine the condition of both tidal and nontidal wetlands in the St. Jones River watershed and changes in wetland acreage, and to identify the presence of wetland stressors that are degrading wetlands. We will use wetland condition, stressor information and watershed wide trends to guide and improve future protection and restoration activities, education and effective planning to ensure the conservation Delaware's wetland resources.

Located in Kent County Delaware, the St. Jones River watershed covers 23,327ha (57,643ac) of the Delaware Bay and Estuary Basin. The St. Jones River is dammed at Silver Lake in Dover and then winds 16km (10mi) through residential and commercially developed areas, the Delaware National Estuarine Research Reserve, and the Ted Harvey Wildlife Area before emptying into Delaware Bay. Flat wetlands, usually forested, exist mostly in the upper portion of the watershed and eventually drain into tributary creeks and streams. Nontidal riverine wetlands and tidal emergent wetlands line the banks of the river, sometimes up to 1km wide toward the mouth of the river. Wetlands comprise 3,913ha (9,669ac) of the watershed and provide critical services such as nutrient removal, erosion control, habitat for plants and wildlife, flood abatement, and storm water detention to the citizens of Delaware. The extent to which wetlands can perform these functions and thrive in the future depends on their condition.

We evaluated changes in acreage for major wetland subclasses by comparing the 1994 state wetland inventory to historic wetland acreage based on hydric soils. Our comparison indicated that 47% of the wetland acreage has been lost from the St. Jones River watershed since the time of settlement. The loss of 57% of nontidal wetlands was largely accounted for by conversion to cropland or residential development. Tidal wetland loss occurred mostly at tributary headwaters where the high tide line has risen and in coastal towns where development has increased.

To assess the condition of wetlands and identify the prominent stressors affecting wetland health, we applied a rapid assessment method to random sites across the watershed on nontidal flat, riverine, and depressions, as well as tidal wetlands on both private and public land. We used a probabilistic sampling design that allowed us to correct for site access and extrapolate sample results to represent the entire wetland population in the watershed.

We completed rapid assessments on 32 flats, 29 riverine, 5 depressions and 50 tidal sites. Each assessment method evaluated indicators of condition and stressors related to plant community, hydrology and wetland buffers. We also collected more intensive data from a subsample of sites, including detailed

vegetation measurements, soil characterizations, surveys of the bird community and quantification of vegetative biomass.

Tidal wetlands were in fair condition with an average condition score of 76 out of 100. The highest condition sites scored over 90 and were characterized as having undisturbed hydrology, little to no development or barriers to marsh migration, extensive buffers and very little invasive plant cover. The most degraded wetlands scored as low as 39 and were characterized by severe wetland diking and tidal restrictions, disturbed buffer condition, and low density of below ground plant fragments. Overall, hydrology features appeared to be less impacted compared to habitat and buffer features. Compared to the nearby Murderkill and Inland Bays watersheds, the St. Jones River had the highest average tidal condition and the largest portion of tidal wetlands considered to be minimally or not stressed by disturbance.

Intensive surveys of the avian community and vegetative biomass indicated that tidal sites with higher wetland condition scores had lower avian species richness composed of primarily wetland specific species. Lower condition sites had greater species, but also included more upland species. We did not see a relationship between site condition scores and the marsh bird community index. Wetlands with greater condition scores had greater amounts of total below ground biomass and had a greater ratio of total above to total below ground biomass.

Historically, large areas of headwater flats have been lost, mostly to agricultural production and development. Thirty-five percent of wetlands across the watershed were flats and had an average condition of 81, ranging from 57 to 94. Using condition categories, 37% of flat wetlands were minimally stressed, 47% were moderately stressed, and 16% were severely stressed. Among the 1,385ha of flats, over half (53%) had not been forested (e.g. clear-cut, selective cut) in at least 50 years. Flats in higher condition had minimal garbage or dumping, low coverage by invasive plants, minimally altered microtopography, and had a low occurrence of wetland ditching. Forestry activity, such as cutting and harvesting, within wetlands as well as development and agriculture in buffers appeared to be the major source of stressors.

Riverine wetlands, found adjacent to streams and rivers, accounted for 24% of the watershed's wetland acreage and had an average condition score of 72. Over half (55%) were considered minimally stressed, with low occurrences of invasive species, fill, and ditching, but frequently had dumping in addition to development and roads in the buffer. The severely stressed portion (10%) had condition scores as low as 27, related to the high prevalence of forestry activity, dumping, fill, storm water inputs and development within the buffer. The presence and intensity of development (residential, commercial and/or transportation) in the 100m

assessment site buffer were related to the prevalence of wetland stressors such as storm water inputs, invasive plants and garbage or dumping.

Based on our findings, we offer specific recommendations to improve wetland management, to maximize the natural benefits of tidal and nontidal wetlands, and encourage informed decisions concerning the future of wetlands.

1. Improve protection of nontidal wetlands through improved regulations on the state and municipal level, conservation easements and education of citizens and decision makers.
2. Protect tidal wetlands from further degradation and prepare for future changes by utilizing existing regulations and land use planning to their fullest extent. Track permitted impacts thoroughly.
3. Focus on restoring and re-establishing degraded and fragmented flat wetlands to improve wetland services such as improving water quality, providing wildlife habitat and maintaining native biodiversity.
4. Improve tidal wetland buffer regulations by consistently enforcing codes, promoting natural shorelines in lieu of shoreline stabilization and requiring natural plant communities and the removal of invasive plants.
5. Improve nontidal wetland buffer regulations by updating regulations to begin at the wetland-upland boundary, by protecting buffers from disturbances and by requiring forested buffers.
6. Collaborate with the Delaware National Estuarine Research Reserve and their Coastal Training Program to enhance education and outreach efforts and share our coastal wetland information with professionals and decision makers.
7. Design a restoration plan for the St. Jones River watershed that identifies restoration and protection priority areas pertinent to the county, state, federal and non-profit organizations.
8. Ensure that wetland functions are replaced before permitting the destruction or degradation of wetlands by adopting assessment methods into the Army Corps of Engineers review process and by strictly enforcing current guidelines.
9. Control the extent and spread of invasive plants to improve wetland condition, promote native communities and improve biodiversity.

INTRODUCTION

Wetlands in the St. Jones watershed provide many benefits to citizens and the natural world and are valued as an integral part of watershed ecology. Wetlands transition between terrestrial and aquatic habitats and are one of the most productive ecosystems in the world. Wetlands minimize flooding from storms, control erosion, and improve water quality by removing nutrient runoff and pollutants from non-point sources. Wetlands can help prevent large amounts of soil, sand, and gravel that result from agricultural tilling, land clearing and development from entering tidal and nontidal waterways. They also have substantial cultural and economic value as a source of recreation (e.g. hunting, fishing, birding) and livelihood (e.g. fishing, crabbing, fur-bearer trapping).

Tidal wetlands are biologically rich and provide habitat and resources for wildlife and wetland adapted plants. Delaware's tidal wetlands have been prized as a resource for migrating shorebirds and wintering waterfowl. Tidal wetlands in particular provide nurseries for commercial fish and shellfish species. Freshwater wetlands process and funnel water (both ground and surface water) into our waterways, providing wildlife habitat along the way. Wetlands have a rich history across the region and their aesthetics have become the symbol of the Mid-Atlantic Coast. The State of Delaware is dedicated to improving wetlands through restoration, protection, education, and effective planning (DE DNREC 2008) to ensure that they will continue to provide these services to the citizens of Delaware.

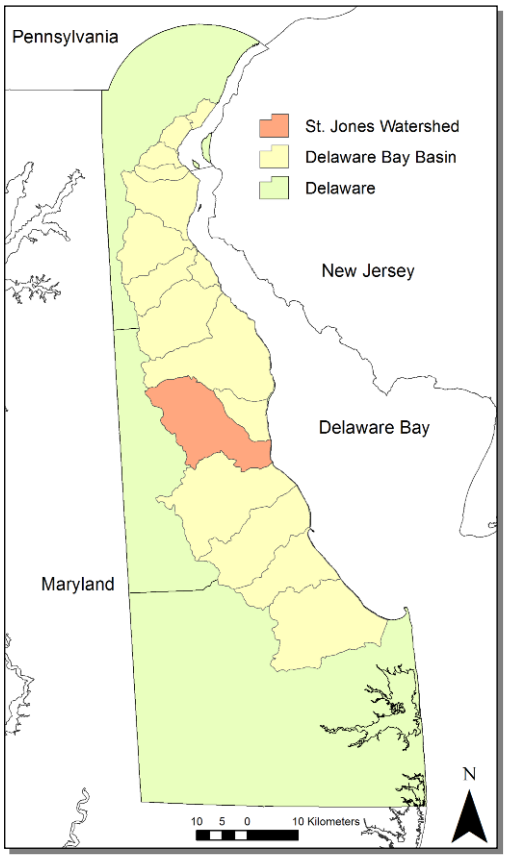
Assessing the status of wetlands and monitoring changes over time is needed to guide management and protection efforts. In the past, the status of wetlands in terms of losses and gains in wetland acreage (Tiner 2001) was used as the primary tool to monitor wetlands. More recently, the Delaware Department of Natural Resources and Environmental Control (DE DNREC) has developed and implemented a wetland assessment and monitoring program to evaluate the health of wetlands. Evaluating wetland health or condition including the stressors that are degrading wetlands on a watershed scale compiles useful information that watershed organizations, state planning and regulatory agencies, and other stakeholders can use to improve wetland restoration and protection efforts. Protection efforts can be directed toward wetlands in good condition and allow restoration efforts to 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 different types of wetlands, which can be used to set priorities on the type of restoration projects that are needed.

DE DNREC has developed scientifically robust methods to assess the condition of wetlands on a watershed scale. These methods can be used to generate an overall evaluation of the condition of wetlands in a watershed as well as to identify common stressors by wetland type. In this report, we summarize the condition of tidal and

freshwater wetlands in the St. Jones watershed, identify the common stressors degrading wetlands, and provide recommendations for improving the resource.

WATERSHED OVERVIEW

The St. Jones River watershed in central Kent County, Delaware is one of 16 watersheds that comprise the Delaware Bay and Estuary Basin (Map 1). The watershed is 23,327ha (57,643ac) with land use ranging from natural areas of wetlands and forest, to highly managed land uses of agriculture and development. Dover, the state capital of Delaware, falls mostly within the St. Jones River watershed as does part of the Dover Air Force Base (Map 2). The St. Jones River runs from Dover to the Delaware Bay and transitions from upland freshwater habitat to brackish marshes to the saline bay. The river is dammed 16km (10mi) upstream from the Delaware Bay to form Silver Lake in Dover. The St. Jones Reserve component of the Delaware National Estuarine Research Reserve covers 1517ha (3750ac) of the lower watershed and runs along 8.8km (5.5mi) of the river (NERRS 2009).



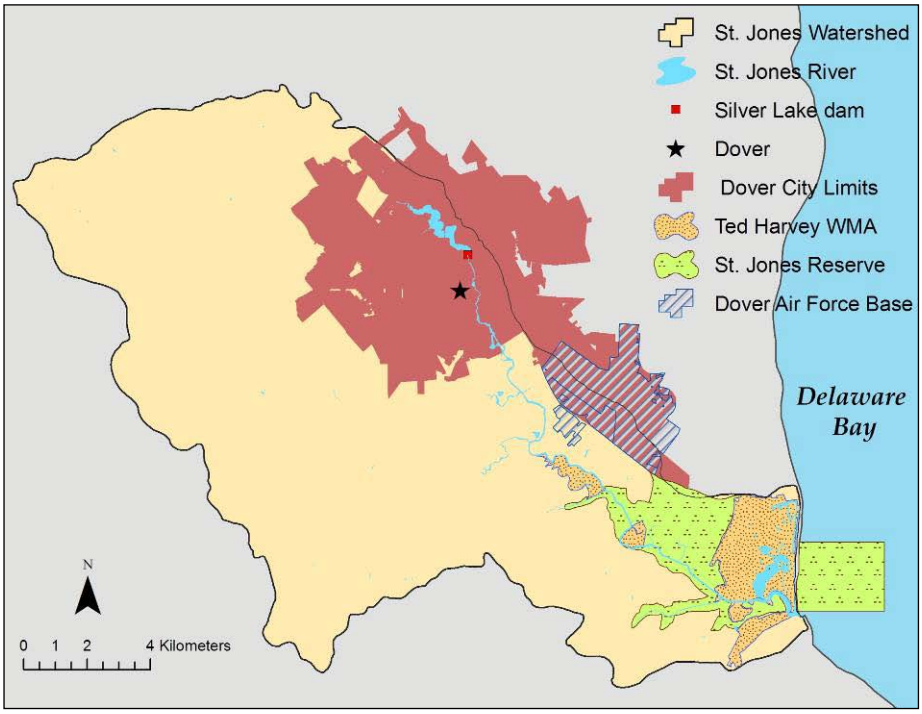
Map 1. Location of the St. Jones River watershed in central Delaware. The St. Jones is a subwatershed of the Delaware Bay Basin.

2.1 Geologic History

The St. Jones River watershed falls within the Atlantic Outer Coastal Plain Physiographic Province about 72km (45mi) south of the Appalachian Piedmont Fall Zone. Sediments from the ancient Appalachians were carried down the Delaware River, Susquehanna River and others and settled onto the coastal plain of Delmarva (DE DNREC 2005). Most of Delaware was submerged by sea water which deposited silts that reach 400 feet deep in the St. Jones River region (NERRS 2009). Repeated continental glacier advances and retreats helped to shape the relative sea level of the area as well as dictate stream formations (NERRS 2009).

2.2 Watershed Hydrogeomorphology

The St. Jones River watershed contains 3 of the 4 hydrogeomorphic regions, as defined by topography, geology, hydrogeology and soils that are found in the Delaware Bay and Estuary Basin: poorly-drained uplands, well-drained uplands, and beaches/tidal marshes/ lagoons/barrier islands (DE DNREC 2005). The northwestern portion is poorly-drained and home to most of the flat wetlands in the watershed whereas most of the central watershed is well-drained uplands. Riverine wetlands formed on floodplains



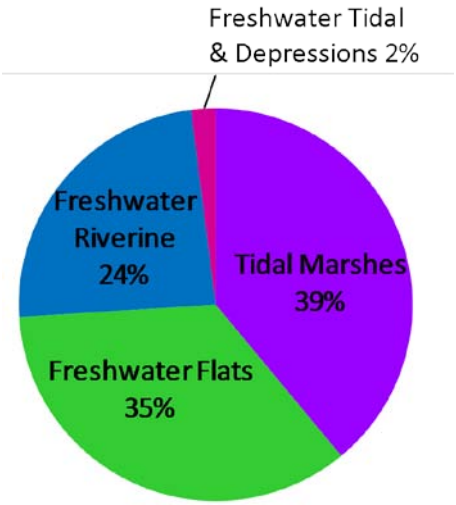
Map 2. Features of the St. Jones River watershed in Delaware.

adjacent to natural streams and rivers. Each of the major tributaries to the St. Jones River, except Trunk Ditch, has been diked or dammed. Tidal wetlands are found in the lower portion of the watershed that lies on coastal lowland along with beaches, lagoons and barrier islands which run from mean sea level to 5 feet above mean sea level.

Based on the Delaware Bay and Estuary Whole Basin Report (DE DNREC 2005) the unconfined aquifer (water table) and several deeper confined aquifers, throughout the Delaware Bay and Estuary area, support the ground water for the basin and are the source of potable water in the St. Jones River watershed. The unconfined aquifer in the northern and mid-watershed flows through gravelly sands and is recharged through precipitation in areas where permeable sediments allow water to infiltrate down to the aquifer. The water table aquifer is heavily drawn from for agricultural, industrial and municipal (City of Dover) uses.

2.3 Wetlands

Excluding unconsolidated bottom and shoreline acreage, 39% of the watershed's wetlands are tidal salt or brackish marshes, 35% are freshwater flats and 24% are riverine wetlands (State of Delaware 1994; Figure 1). Less than 2% are freshwater tidal or depressions.

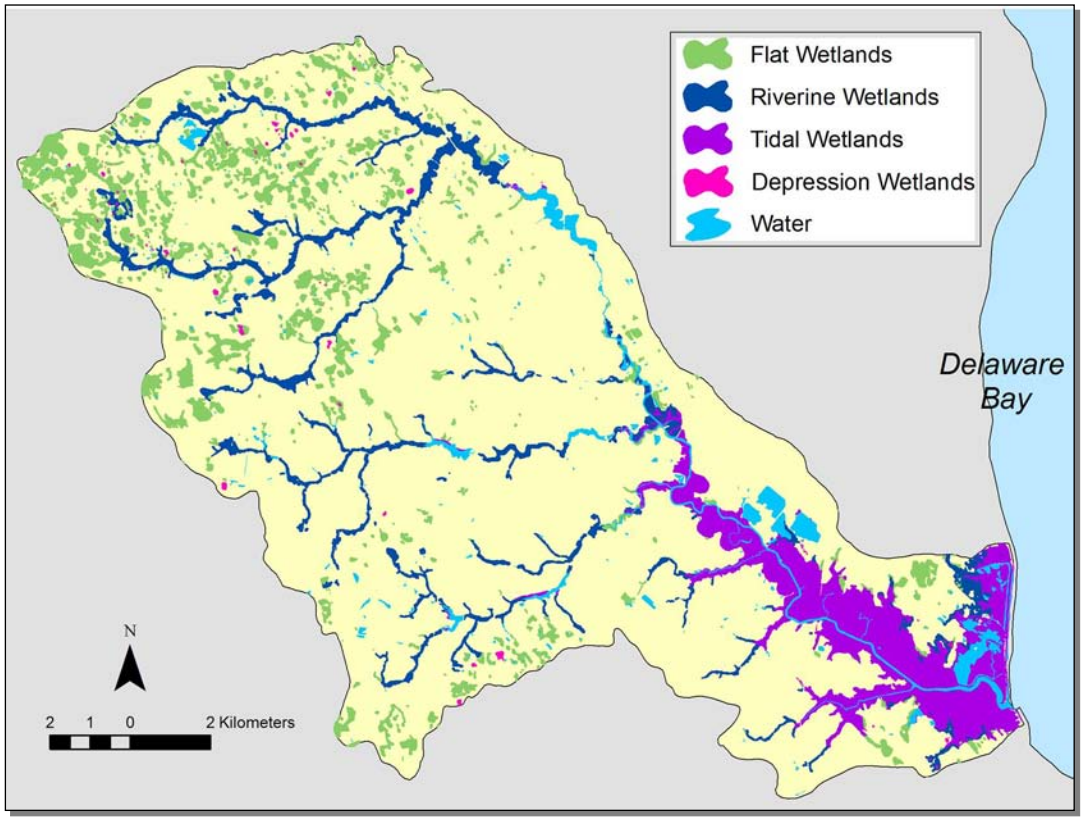


Wetland Type	Hectares	Acres
Tidal Salt or Brackish	1,513	3,739
Freshwater Flats	1,385	3,423
Riverine	951	2,350
Freshwater Tidal & Depression	62	150

Figure 1. Wetland proportion and acreage by wetland types in the St. Jones River watershed, Delaware.

Wetlands of the Delaware Bay and Estuary were recognized by the Ramsar Convention on Wetlands (www.ramsar.org) as international wetlands of importance related to their role in shorebird migration and waterfowl wintering habitat. In 1986, The Delaware Bay and Estuary was recognized as the first Western Hemisphere Shorebird Reserve site of Hemispheric Importance (WHSRN 2009). This is the highest rank recognized by the global organization and indicates that at least 500,000 shorebirds visit annually, or that at least 30% of the biogeographic population for a species is supported by the site.

There are 3,913ha (9,669ac) of wetlands in the St. Jones River watershed (State of Delaware 1994). Wetlands in this estuary are characterized as mesohaline (5-18 ppt) with a mean tidal range of 1.5m and are dominated by brackish to salt tidal wetlands (Wilson 2004; DNERR 1999). Nontidal freshwater wetlands such as riverine and flats dominate the upper watershed, whereas tidal salt marshes dominate the lower portion of the watershed (Map 3). Small pockets of tidal freshwater wetlands found at creek headwaters and depression wetlands make up a small portion of the wetland resource (Map 3).



Map 3. Distribution of tidal and nontidal wetlands across the St. Jones River watershed, Delaware.

Within the watershed the State of Delaware's Division of Fish and Wildlife manages 1,077ha (2,661ac) of habitat on the Ted Harvey Conservation Area including coastal wetland impoundments for waterfowl and shorebirds. Large tracts of land are managed using dikes, levees and water control structures to allow water levels and vegetation to be

controlled seasonally. Impoundments generally restrict tidal activity, which floods the area, reduces water salinity, and allows brackish and freshwater vegetation favored by migrating and wintering shorebirds and waterfowl to grow.

The St. Jones watershed has several unique and threatened wetland types including bald cypress, Atlantic white cedar, and coastal plain ponds (State of Delaware 1994). There are 46ha (113ac) of bald cypress wetlands across the western half of the watershed, 49ha (121ac) of Atlantic white cedar wetlands in the southern portion of the watershed and 24ha (59ac) of coastal plain ponds in the northwestern corner. Although these wetland habitats make up a small portion in the watershed, they are historically unique and valuable to plant, animal and insect communities, as detailed in the Delaware Wildlife Action Plan (DE DNREC 2006).

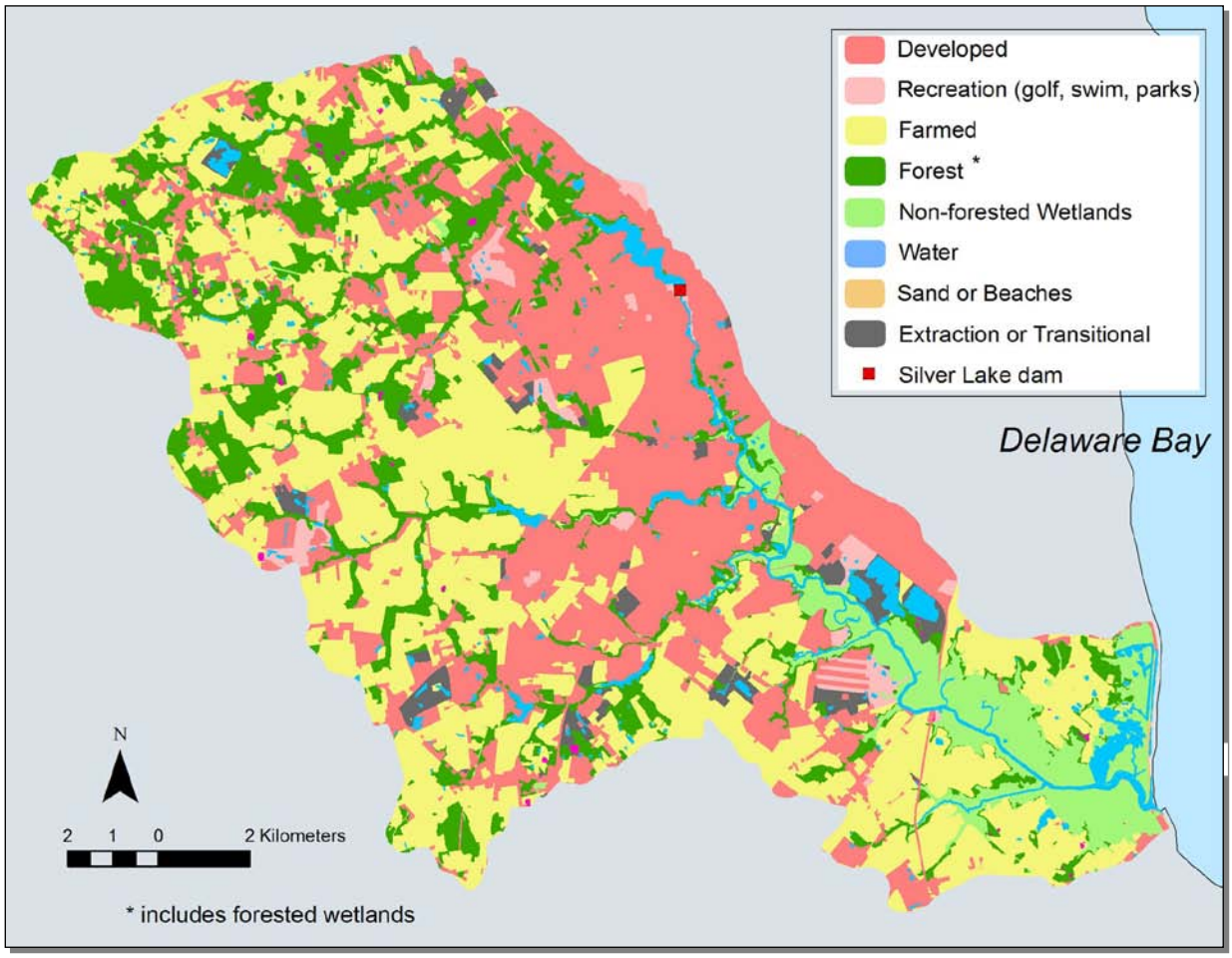
2.4 Land Use Changes and Wetland Issues

Based on 2007 National Land Cover Dataset (NLCD), development and agricultural land comprise almost 70% of the entire watershed's acreage (Table 1). Agricultural land is spread throughout the watershed, forested patches are noticeable in the northern portion, and most of the developed acreage is associated with the city of Dover and adjacent towns of Camden and Wyoming. Large areas of tidal wetlands occur in the southeastern portion of the watershed, bordering the river as it flows to the Delaware Bay. Patches of nontidal wetlands are spread throughout the upper watershed and along streams and creeks. Map 4 shows the distribution of land use across the watershed based on 2007 National Land Cover Dataset (NLCD).

Table 1. Land use changes for the St. Jones River watershed between 1997 and 2007.

Land Use Category	1997 (%)	2007 (%)	10-year % Change
Developed	25.5	31.5	+6.0
Recreational	1.4	1.8	+0.4
Farmed	44.5	38.0	-6.5
Forest	9.8	8.4	-1.4
Wetlands	14.9	15.1	+0.2
Water	2.1	2.7	+0.6
Beaches/Sand	<1.0	<1.0	0
Extraction or Transitional	1.8	2.4	+0.6

Using similar land use information from 1997 as comparison, the St. Jones River watershed has experienced a 6% increase in developed landcover in the past decade (Table 1). Agricultural land decreased by almost an identical figure (6.5%) suggesting a direct conversion of farmed land into residential housing. Additionally, lands categorized as transitional are often in the process of converting to development and this category also increased during this period. Although wetland acreage appears to have remained stable during this 10-year period, historically over half of the wetlands in the Delaware Estuary have been lost. In recent decades, losses in freshwater wetlands in the Delaware Bay



Map 4. Land cover for the St. Jones River watershed in 2007 based on NLCD land use categories.

Basin were led by conversion to agriculture and residential development, particularly in nontidal forested and scrub-shrub wetland habitats (Tiner 2001). The excavation and filling of hydric sediments and the creation of impoundments have resulted in emergent tidal wetland losses (Tiner 2001). Changes in land cover and land use patterns, especially adjacent to wetlands, are important to consider when evaluating wetland condition.

Existing and historic land use practices can affect wetland condition. Common stressors to wetlands from agricultural and developed lands are alterations to the hydrology from drainage ditches, water quality issues related to sediment, nutrient and chemical runoff, and the disruption and compaction of soil layers. The conversion to a

development will result in a large increase in impervious surfaces causing more storm water flashes and down basin soil erosion, and reducing the groundwater recharge potential. Runoff from roads (potentially containing oil, antifreeze, salt, and/or gas) as well as lawn fertilizers and pesticides will affect water quality. Depending on if septic systems or central sewer are used, wastewater may also be a source of nutrients into groundwater. Channelization and ditching for drainage for agriculture and mosquito control has been extensive and has changed wetland hydrology, created a source of fill and altered natural wetland functions (DE DNREC 2005).

The spread of invasive species such as *Phragmites australis* throughout fresh to brackish wetlands is also pervasive across the watershed. As natural hydrology patterns are altered by impoundments, dams, tidal restrictions and fill, *Phragmites* is able to aggressively out-compete native species and create large monotypic stands that provide poor habitat and food resources (DE DNREC 2005).

Sea-level rise and the effects of climate change continue to be a concern for all coastal watersheds. Coastal development and the hardening of shorelines reduce the ability of wetlands to migrate upland with increasing sea level, impinging wetlands until they convert to open water. Further south in the state, biologists discovered sudden wetland dieback in the Inland Bays watershed in 2006. Dieback is defined as the rapid, partial or complete death of emergent saltmarsh vegetation or the failure of that vegetation to grow during one or several growing seasons. Similar occurrences have not been reported in the St. Jones area, but DNREC continues to research this phenomenon and monitor for its presence.

METHODS

We assessed the condition of tidal and nontidal wetlands in the St. Jones River Watershed. We used a probabilistic survey approach to assess wetlands on private and public lands within the watershed. For tidal wetlands, we used the Mid-Atlantic Tidal Rapid Assessment Method (MidTRAM) and for nontidal wetlands we used the Delaware Rapid Assessment Protocol (DERAP, Jacobs 2007) to evaluate wetland condition and identify wetland stressors. We used comprehensive wetland data to validate our rapid methods.

3.1 Site Selection

EPA's Ecological Monitoring and Assessment Program (EMAP) in Corvallis, Oregon assisted with selecting 500 potential sample sites in estuarine intertidal emergent wetlands and 500 potential sample sites in nontidal wetlands using a generalized random tessellation stratified (GRTS) design (Stevens and Olsen 1999, 2000). The target population was mapped wetlands from the state wetland maps (State of Delaware 1994), which are based on 1992 aerial photography. Sampling sites were randomly chosen points within mapped wetlands, which gives each point an equal probability of being selected and to allow more than one point to fall in a wetland polygon. Sites were selected and sampled in numeric order as dictated by the EMAP design, lowest to highest. Sites were only excluded from sampling if permission for access was denied, if the site was of the wrong wetland classification, or if the site was upland. Our goal was to sample 50 tidal sites and 30 nontidal sites in each subclass (riverine, flats, and depression). For the nontidal sites, once we sampled 30 sites of one subclass we did not sample additional sites of that subclass but rather would continue to sites of the remaining subclasses in order of the EMAP selection.

3.2 Changes in Wetland Acreage

We determined historic wetland acreage using U.S. Department of Agriculture Natural Resource Conservation Service soil maps. We identified hydric soil map units from soil survey data (which are based on soil indicators such as drainage class, landform, and water flow) as 'historic wetlands'. We added the historic wetland units to existing wetland units to create an estimated pre-settlement wetland layer. We identified existing wetlands using the most recent wetland inventory based on 1992 aerial photography (SWMP; State of Delaware 1994). We determined changes in wetland acreage across the watershed from pre-settlement to 1992 by comparing the acreage of historic to existing wetlands as classified by Cowardin et al. (1979).

3.3 Data Collection

3.3.1. Assessing Tidal Wetlands

3.3.1.a Rapid Sampling in Tidal Wetlands

We evaluated the condition of tidal wetlands using the MidTRAM. The MidTRAM was developed in 2007-2008 by adapting the New England Rapid Assessment Method (NERAM; Carullo et al. 2007) and the California Rapid Assessment Method (CRAM; Collins et al. 2008) to tidal wetlands in the MidAtlantic Region. MidTRAM consists of 15 scored metrics that represent the condition of the wetland buffer, hydrology, and habitat characteristics (Table 2). MidTRAM uses a combination of qualitative evaluation and quantitative sampling to record the presence and severity of stressors in the field or in the office using maps and digital orthophotos.

We completed the MidTRAM at the first 50 random points that we could access and that met our criteria of being of an estuarine intertidal emergent wetland. We established a site assessment area (AA) as a 50m radius circle centered on each random point (Figure 2). We defined the AA buffer area as a 250m radius area around the AA. If a 50m radius circle would go beyond the wetland into upland or open water, we moved the circle <50m or changed to a rectangle of equal area to have the entire AA within the wetland. The AA buffer could extend into upland or open water.

For metrics measured within the AA (Table 2) we evaluated indicators throughout the entire AA with the exception of the soil profile, plant fragments, and soil bearing capacity. For these 3 metrics, we established 4 1m² subplots within the AA along 2 100m transects that bisected the AA. We oriented one transect perpendicular to the nearest source of open water (>30m wide) and the other was perpendicular to the first. We placed each of the 4 subplots 25m from

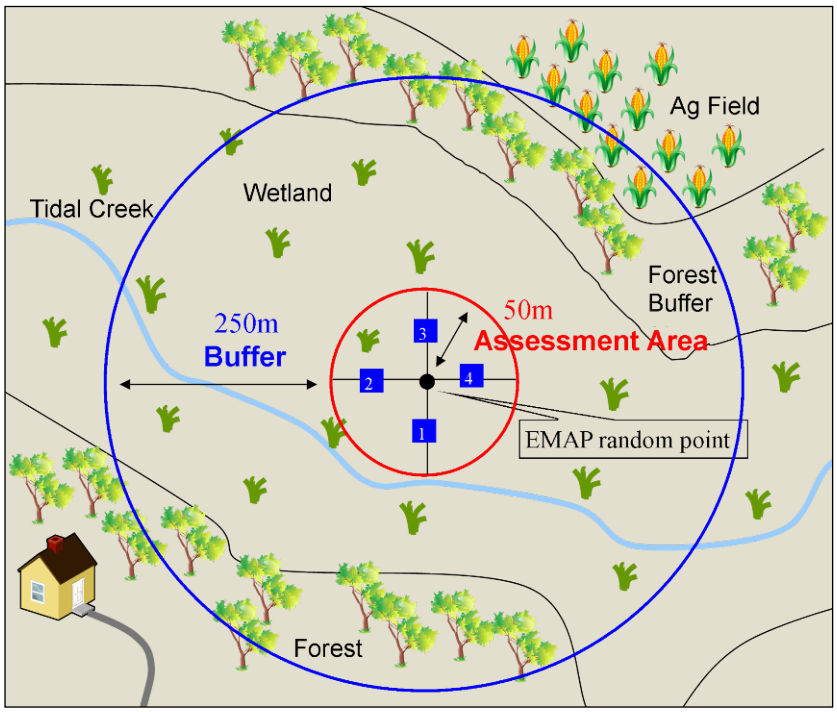


Figure 2. Assessment area and subplots used to collect data for the MidAtlantic Tidal Rapid Assessment Method.

the center of the AA and numbered them clockwise starting with one towards the open water (Figure 2). If a subplot fell in a habitat type or patch that was not characteristic of the site (e.g. in a ditch) we moved it 1m along the transect.

We completed all metrics within the AA via visual inspection during the field visit, with the exception of soil bearing capacity and plant fragments. We measured soil bearing capacity using a slide hammer technique on a random spot in each subplot (Figure 2). To take the measurement, we raised the slide hammer and released 4 times to exert a consistent force on the soil surface. We subtracted the final depth below the marsh surface of the bottom of the slide hammer from the initial depth to get the change in depth due to the total force. We also measured plant fragments in each subplot by removing a 2cmx2cm piece of the soil from 2-4cm below the ground surface. We rinsed the sample to remove soil and measured the volume of the roots compressed in a plastic syringe to the nearest $0.1cm^3$. Each metric was scored a 3, 6, 9, or 12, except Plant Fragments which was on a 4, 8, 12 scale, based on the narrative or numeric criteria in the protocol.

Table 2. Metrics comprising the MidAtlantic Tidal Rapid Assessment Method.

Attribute Group	***Metric Name***	***Description***	***Measured in AA or Buffer***	***Qualitative or Quantitative***
Buffer/Landscape	Percent of AA Perimeter with 5m-Buffer	Percent of AA perimeter that has at least 5m of natural or semi-natural condition land cover	Buffer	Quantitative Office
Buffer/Landscape	Average Buffer Width	The average buffer width surrounding the AA that is in natural or semi-natural condition	Buffer	Quantitative Office
Buffer/Landscape	Surrounding Development	Percent of developed land within 250m from the edge of the AA	Buffer	Quantitative Office/Field
Buffer/Landscape	250m Landscape Condition	Landscape condition within 250m surrounding the AA based on the vegetative community, substrate condition and extent of human visitation	Buffer	Qualitative Field

Attribute Group	***Metric Name***	***Description***	***Measured in AA or Buffer***	***Qualitative or Quantitative***
Buffer/Landscape	Barriers to Landward Migration	Percent of landward perimeter of marsh within 250m that has physical barriers preventing marsh migration inland	Buffer	Quantitative Office/Field
Hydrology	Ditching & Draining	The presence and functionality of ditches in the AA	AA	Qualitative Field
Hydrology	Fill & Fragmentation	The presence of fill or marsh fragmentation from anthropogenic sources in the AA	AA	Qualitative Field
Hydrology	Diking/Restriction	The presence of dikes or other restrictions altering the natural hydrology of the wetland	AA and Buffer	Qualitative Field
Hydrology	Point Sources	The presence of localized sources of pollution	AA and Buffer	Qualitative Field
Habitat	Bearing Capacity	Soil resistance using a slide hammer	AA subplots	Quantitative Field
Habitat	Plant Fragments	Volume of plant fragments in the upper soil horizon	AA- subplots	Quantitative Field
Habitat	Vertical Biotic Structure	The interspersion and complexity of the vegetation community.	AA	Qualitative Field
Habitat	Number of Plant Layers	Number of plant layers in AA based on plant height	AA	Quantitative Field
Habitat	Percent Co-dominant Invasive Species	Percent of co-dominant species that are invasive in the AA	AA	Quantitative Field
Habitat	Percent Invasive	Percent cover of invasive species in the entire AA	AA	Qualitative Field

We assessed buffer metrics (i.e. buffer width, surrounding development, percent of assessment area with a 5m buffer, and barriers to landward migration) in the office using ArcMap GIS software (ESRI, Redlands, CA, USA) and then verified visually in the field.

At the completion of the site visit and assessment, crew members gave each site a Qualitative Disturbance Rating (QDR) to rank the level of anthropogenic disturbance to the site's natural structure and biotic community. Descriptions of the disturbance ratings are provided in Appendix A. The average field time to sample each site was 2h. Metrics completed in the office took up to ½ hour to complete. Detailed instructions for using MidTRAM are provided in the protocol (Jacobs et al. 2009).

We calculated attribute group scores by summing the metric scores and dividing by the total possible value. That value was adjusted to be on a 0-100 scale since each metric can only score a minimum of 3 or 4:

Attribute Group score = $((((\sum(\text{metric}_{1...n})/\text{MAX}_a)*100)-\text{floor}_x)/\text{ceiling}_x$

where $\text{metric}_{1...n}$=metric scores for the buffer, hydrology or habitat group, MAX_a=the maximum possible attribute group score if all metrics in that group scored the highest value (e.g. 60, 48, 72), floor_x = used to adjust to a 0-100 scale; the minmum calculated score for each group multiplied by 100 (e.g. 25, 25, 26.4), and ceiling_x= used to adjust to a 0-100 scale; 100-floor_x (e.g. 75, 75, 73.6). Final MidTRAM condition scores were calculated by averaging the 3 attribute group scores and ranged from 0-100:

MidTRAM condition score =
(Buffer Attribute Score + Hydrology Attribute Score + Habitat Attribute Score)/ 3

Example: Site B

Buffer group score= ((((9+9+6+12+3)/60)*100)-25)/(100-25)= 0.53*100=53

Hydrology group score= ((((12+9+6+12)/48)*100)-25)/(100-25)= 0.75*100=75

Habitat group score=((((3+3+6+12+9+12)/72)*100)-26.4)/(100-26.4)= 0.48*100=48

MidTRAM condition score = (53+75+48)/3 = 59

We used SAS (Version 9.1, Cary, NC. USA) and Excel for all of our statistical analyses with an alpha level of 0.10.

3.3.1.b Intensive Sampling in Tidal Wetlands

i. Marsh Birds

We performed point count surveys for marsh birds at 25 sites that were also sampled with the MidTRAM; 7 in the Inland Bays, 10 in the Murderkill and 8 in the St. Jones watershed. We analyzed the combined dataset with all three watersheds to increase sample size and statistical power. We surveyed the first 7-10 random sites in each watershed. We sampled sites once during each of two periods: May 5-15 and June 2-10 2008. We completed our surveys between 30 min before and 2h after sunrise (modified from Gibbs and Melvin 1993). We did not conduct surveys during precipitation, heavy fog, or wind speeds >12mph (Gibbs and Melvin 1993).

At each site, we recorded all species that were visually or audibly detected within 75m of our assessment point during a 5-minute passive survey when no calls were played, followed by a 6-minute callback survey. During the callback survey a portable CD player with a speaker was used to broadcast the calls of black rail (*Laterallus jamaicensis*), least bittern (*Ixobrychus exilis*), Virginia rail (*Rallus limicola*), king rail (*R. elegans*), clapper rail (*R. longirostris*), and American bittern (*Botaurus lentiginosus*). We played each species' call for one minute with a 30-second listening period in between.

We calculated an Index of Marsh Bird Community Integrity (IMBCI) based on DeLuca et al. (2004) and Pepper (2008). Following this technique, for every species detected during the point count surveys, we assigned a score based on their wetland specializations and compiled them to calculate a site score for each wetland. Wetlands with a richer diversity of wetland marsh birds scored a higher index value and indicated a healthy wetland ecosystem. For example, a wetland with an IMBCI score of 0 indicated that only generalist species were present whereas an IMBCI score of 12 indicated that several species detected had wetland specialist attributes.

The species scores were determined from 4 attribute values (L_s) listed below (values are listed in parentheses):

1. *Foraging habitat*. Primary foraging habitat. Scored as habitat generalist (1), marsh facultative (2.5) or marsh specialist (4).
2. *Nesting substrate*. Primary nesting location. Scored as non-marsh nesters (1), nesting in marsh vegetation (2.5) or marsh ground-nesters (4).
3. *Breeding range*. Restrictions for breeding habitat in North America. Scored as North America (1), North America only east of the Rocky Mountains (2), coastal North America (3), or North America east coast only (4).
4. *Conservation status*. Scored as low concern (1) moderate (2.5) or high (4) based on species' status according to state and federal wildlife agencies and scientific partnerships such as Partners in Flight.

Attribute values for each species were provided by DeLuca et al. (2004), Pepper (2008) or were determined using guides (National Geographic Society 1987) and species literature (Burger 1996, McCrimmon et al. 2001, McGowan 2001, McNicholl et al. 2001, Nisbet 2002, Pierroti and Good 1994, Thompson et al. 1997). Calculations for the species' scores and wetland site scores (W_{IMBCI}) were calculated using the following formulas:

$$\mathbf{S_{IMBCI}} = \sum L_s \qquad W_{IMBCI} = [(\sum S_{IMBCI} / S_N) + MO_N] - 4$$

Where S_{IMBCI} was the score for each species, L_s represented each attribute score, S_N was the total number of species detected at the site and MO_N was the total number of obligate marsh species detected at the site as determined by the nesting and foraging requirements of the species. We subtracted 4 to ensure a scoring scale that begins with a zero and remains constant (DeLuca et al. 2004). The example below demonstrates the calculation of a wetland site score.

Example: Site A

Species	Foraging Habitat	Nesting Substrate	Breeding Range	Conservation Rank	Sum (S_{IMBCI})
Boat-tailed grackle	1	2.5	4	1.5	9
Clapper rail *	4	4	3	1	12
Glossy ibis	1	2	4	1	8
Red-winged blackbird	1	2.5	1	1	5.5
Seaside sparrow *	4	2.5	4	3	13.5
Willet *	4	4	4	2	14

* indicates a marsh obligate species

$$\begin{aligned} \mathbf{W_{IMBCI}} &= [((\sum S_{IMBCI})/ S_N) + MO_N] - 4 \\ &= [((9+12+8+5.5+13.5+14)/6) + 3] -4 \\ &= 10.3 + 3 - 4 \\ &= 9.3 \end{aligned}$$

We used linear regressions between IMBCI values and species richness, MidTRAM condition scores, and attribute group scores to determine if a relationship existed between MidTRAM and the bird survey data.

ii. Vegetative Biomass

We collected vegetative above and below ground biomass samples from 22 sites across the Inland Bays (N=10), Murderkill (N=2) and St. Jones (N=10) watersheds. We sampled the first 2 to 10 random sites in each watershed that we had also sampled with the MidTRAM. We had also sampled most of the 22 sites for marsh birds. We collected biomass from subplots 1, 2 and 3 August 21-26, 2008. We sampled above ground biomass by clipping all vegetation within a 15.24cm

radius circle randomly placed at the outside edge of the subplot. We sorted the vegetation to separate live stems from dead. We collected below ground biomass by extracting sediment cores to 30cm below the marsh surface. We thoroughly rinsed the cores clean of any sediment, separated live from dead roots, and chilled the samples until we could dry them. We dried the samples (80-85ºF) for approximately 72h until there was no additional weight loss detected with additional drying time. We weighed each sample to the nearest 0.01g (Turner et al. 2004).

We used averages of the 3 subplots at each site for all biomass comparisons and analyses. We used a Spearman's ranking correlation because the data was not normally distributed to look for and measure the relationship between MidTRAM condition scores and total above ground (biomass), total below ground, above ground live, above ground dead, below ground live, below ground dead, above ground live:below ground live ratio, above ground dead:below ground dead ratio, and total above ground:total below ground ratio. We used regression to display the relationships between MidTRAM condition scores and total above ground (biomass), total below ground and total above:total below ground ratio.

3.3.2 Assessing Nontidal Wetlands

3.3.2.a Rapid Sampling in Nontidal Wetlands

We assessed the condition of nontidal wetlands in the St. Jones River watershed using the DERAP. DERAP collects data on the presence and intensity of stressors related to habitat, hydrology, and buffer features to assess the condition of wetlands by watershed. DERAP scores are calibrated to comprehensive wetland condition data collected using the Delaware Comprehensive Assessment Procedure.

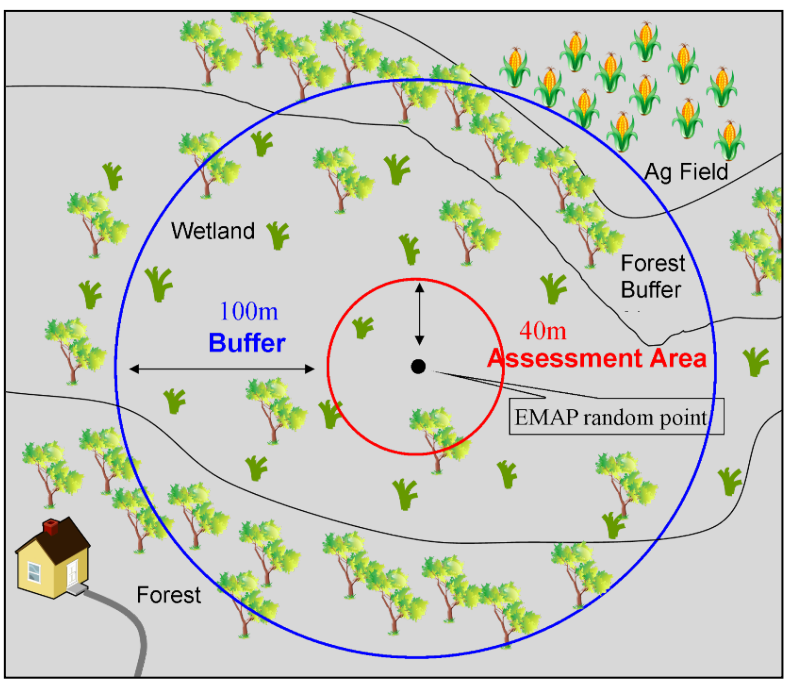


Figure 3. Assessment area and buffer used to collect data for nontidal rapid and comprehensive assessments.

We sampled 66 nontidal wetland sites in the St. Jones River watershed using DERAP (N_{FLAT}=32, N_{RIV}=29, N_{DEP}=5) in 2006. We established a 40m radius AA and 140m radius buffer around a random EMAP point (Figure 3). If the 40m radius circle extended beyond the wetland edge into upland or open water, we moved the AA <40m or changed to a rectangle of equal area in order to stay within the wetland. The stressors evaluated using the DERAP are provided in Table 3. A complete list of stressor

names and abbreviations is in Appendix B. The DERAP takes a field crew of 2 people 30 minutes to 2h to complete, depending on field conditions. In 2009, we also sampled 12 restoration sites (11 Depression, 1 Flat) with DERAP to gain descriptive information on the condition of restored wetlands compared to natural sites.

Scoring for the DERAP to produce one overall score of condition was developed through a process to calibrate the presence of stressors at a site to comprehensive wetland condition data using the DECAP Index of Wetland Condition (IWC). We developed the DECAP IWC using a process to screen hydrogeomorphic (HGM) variables specific to wetland subclass to select the strongest variables that would represent the condition of the primary wetland attributes of plant community, hydrology, and buffer (Jacobs et al. 2009). The DERAP was then calibrated to the DECAP IWC using a data set of over 250 sites from the Nanticoke, Inland Bays, and Delaware Bay watersheds in Delaware (Sifneos et al. In Press).

Table 3. Stressors evaluated using the Delaware Rapid Assessment Procedure.

Habitat Stressors	Hydrology Stressors	Buffer Stressors
Mowing	Presence and depth of ditches	Development-commercial/industrial /residential
Farming activity	Ditching in floodplain	Waste water disposal method
Grazing	Channelized stream	Landfill
Forestry activity (time since last activity)	Channel incision	Channelized Streams or Ditches
Cleared land	WeirDamRoad	Roads
Excessive Herbivory/ Pinebark Beetle /Gypsy Moth	Stormwater Inputs	Trails
Invasive species	Point Source	Row crops/Nursery
Chemical defoliation	Filling, Excavation	Orchard
Managed or converted to pine	Microtopography alterations	Poultry/Livestock Operation
Burned	Excessive sedimentation	Forest Harvesting within 15 Yrs
Trails	Soil Subsidence/Root Exposure	Slips/Docks
Roads		Boat moorings
Garbage/Isolated dumping		Golf course
Excessive nutrients		Mowing
		Sand/Gravel Operation

We selected stressors using step-wise multiple regression and Akaike's information criteria (AIC) to develop the best model that correlated with comprehensive assessment data without over-fitting the model to this specific dataset. Coefficients or weights associated with each stressor were assigned using

multiple linear regression (Appendix C). We calculated the DERAP IWC score by summing the stressor coefficients for each of the selected stressors that were present and subtracting the sum from the linear regression intercept. For flats wetlands, 15 stressors were selected to be included in the DERAP IWC calculation; 7 habitat stressors, 5 hydrology and 3 landscape or buffer stressors (Appendix C). We selected 17 stressors for riverine wetlands including 7 habitat stressors, 10 hydrology stressors and 0 buffer stressors (Appendix C). In depressions, we selected 6 stressors; 4 for habitat, 1 in hydrology and 1 buffer stressor.

$$\text{DERAP IWC}_{\text{FLATS}} = 94.4 + (\sum \text{stressor weights})$$
$$\text{DERAP IWC}_{\text{RIVERINE}} = 90.4 + (\sum \text{stressor weights})$$

The stressor dataset from 32 flats, 29 riverine and 5 depression sites in the St. Jones watershed are provided in Appendix G, H, and K, respectively.

3.3.2.b Intense Sampling in Nontidal Wetlands

We collected DECAP data from 5 flats, 6 riverine sites, and 2 depressions. Each site that was sampled with DECAP was also sampled with DERAP. We followed the Delaware Comprehensive Assessment Procedure as outlined in the protocol (Jacobs et al. 2008). These data will be combined with other DECAP data from sites throughout Delaware to continue to validate and calibrate the DERAP. Flats, riverine and depression DECAP data are provided in Appendix I, J and K, respectively. Due to our small sample size for depression wetlands, we were not able to report on the condition of the depression subclass.

3.4 Presenting Wetland Condition

We present our results at the site and population level. We discuss site level results by summarizing the range of scores that we found in sampled sites (e.g. Habitat attribute scores ranged from 68 to 98). Population level results are presented using weighted means and standard deviations (e.g. Habitat for tidal wetlands averaged 87±13) or weighted percentages (e.g. 20% of riverine wetlands had channelization present). Population level results have incorporated weights that corrected for any bias due to sample sites that could not be sampled and

Condition Breakpoint Criteria –*calculated for each subclass (tidal, flats, riverine)*

Minimally or not stressed – High scoring sites. Sites with condition scores ≥25th percentile of the range for sites with a low disturbance QDR rating of 1 or 2.

Moderately stressed – Sites in between minimally and highly stressed.

Highly stressed – Low scoring sites. Sites with condition scores ≤75th percentile of the range for sites with a high disturbance QDR rating of 5 or 6.

different rates of access on private and public lands. The cumulative results represented the total area of the respective wetland subclass for the entire watershed.

Sites in each HGM subclass were placed into 3 condition categories (Minimally or Not Stressed, Moderately Stressed or Severely Stressed; Table 4). We determined breakpoints by applying a percentile calculation to the QDR's and condition scores from sites in several watersheds. For the tidal portion we used sites from the St. Jones, Murderkill, and Inland Bays watershed (N=136) combined for a larger, regional sample. We used the 25th percentile of MidTRAM scores for sites with a QDR of 1 or 2 to separate Minimally or Not Stressed from Moderately Stressed. We used the 75th percentile of MidTRAM scores from sites with a QDR of 5 or 6 to separate Moderately Stressed from Severely Stressed. Based on the 3 watersheds combined, the condition breakpoints for tidal sites are provided in Table 4.

For the nontidal portion, we used assessment sites from the Nanticoke and Inland Bays watersheds (N=115) to determine condition breakpoints separately for flat and riverine wetlands. We used the 25th percentile of DERAP scores for sites with a QDR of 1 or 2 to separate Minimally or Not Stressed from Moderately Stressed. We used the 75th percentile of DERAP scores from sites with a QDR of 5 or 6 to separate Moderately Stressed from Severely Stressed. Based on the 2 watersheds combined, the condition breakpoints for nontidal sites that we applied in the St. Jones watershed are provided in Table 4.

Table 4. Condition categories and breakpoint values for tidal, and nontidal flats and riverine wetlands in the St. Jones River watershed as determined by wetland condition scores.

Wetland Type	Method	Minimally or Not Stressed	Moderately Stressed	Severely stressed
Tidal	MIDTRAM	≥81	<81 and ≥ 63	<63
Nontidal Riverine	DERAP	≥85	<85 and ≥44	<44
Nontidal Flats	DERAP	≥87	<87 and ≥64	<64

We used a cumulative distribution function (CDF) to display wetland condition on the population level. A CDF extrapolates assessment results to the entire population and can be interpreted by drawing a horizontal line anywhere on the graph and reading that as: 'z' proportion of the area of tidal wetlands in the watershed falls above (or below) the score of 'w' for wetland condition. 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. For example, in Figure 4, roughly 40% of the wetland area scored above an 80 for wetland condition. A CDF also highlights clumps or platueas where either a large or small portion of wetlands are in similar condition. In the example, there is a condition plateau from 50 to approximately 75, illustrating that only a small portion of the population had condition scores in this range.

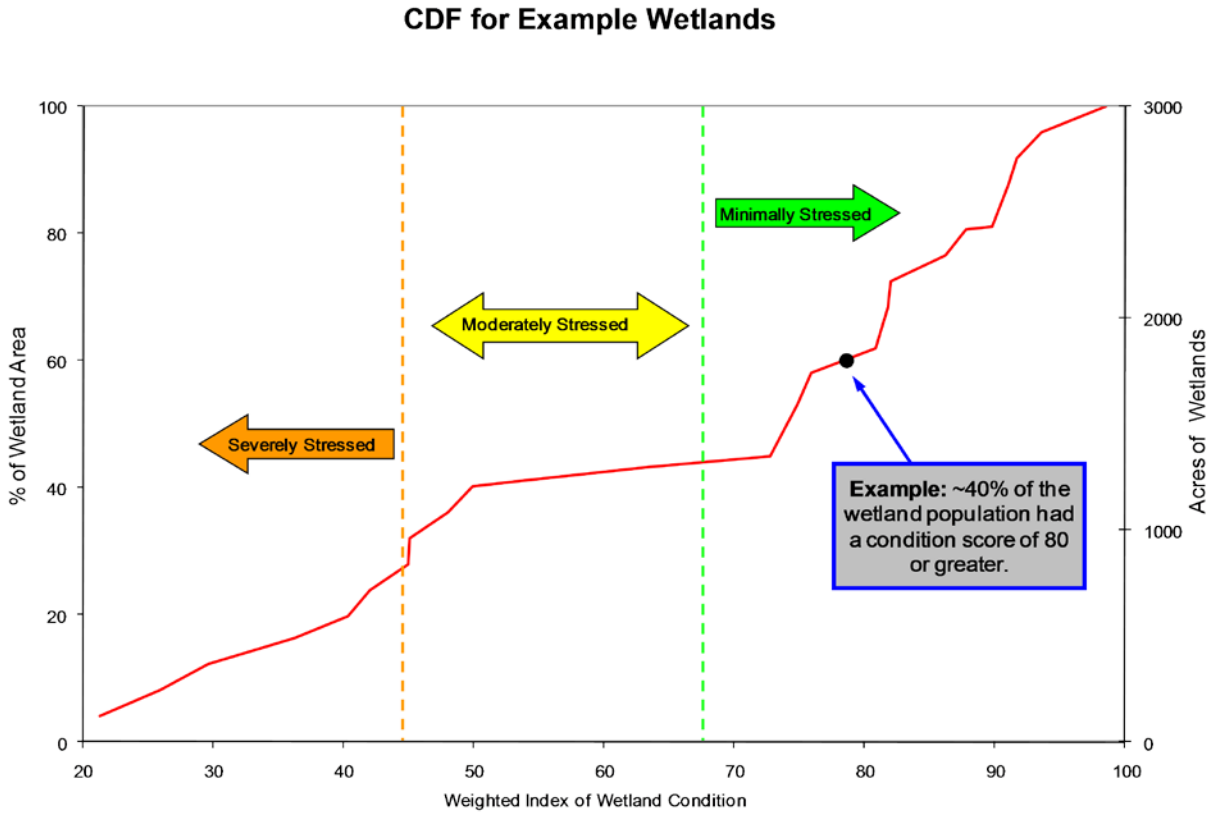
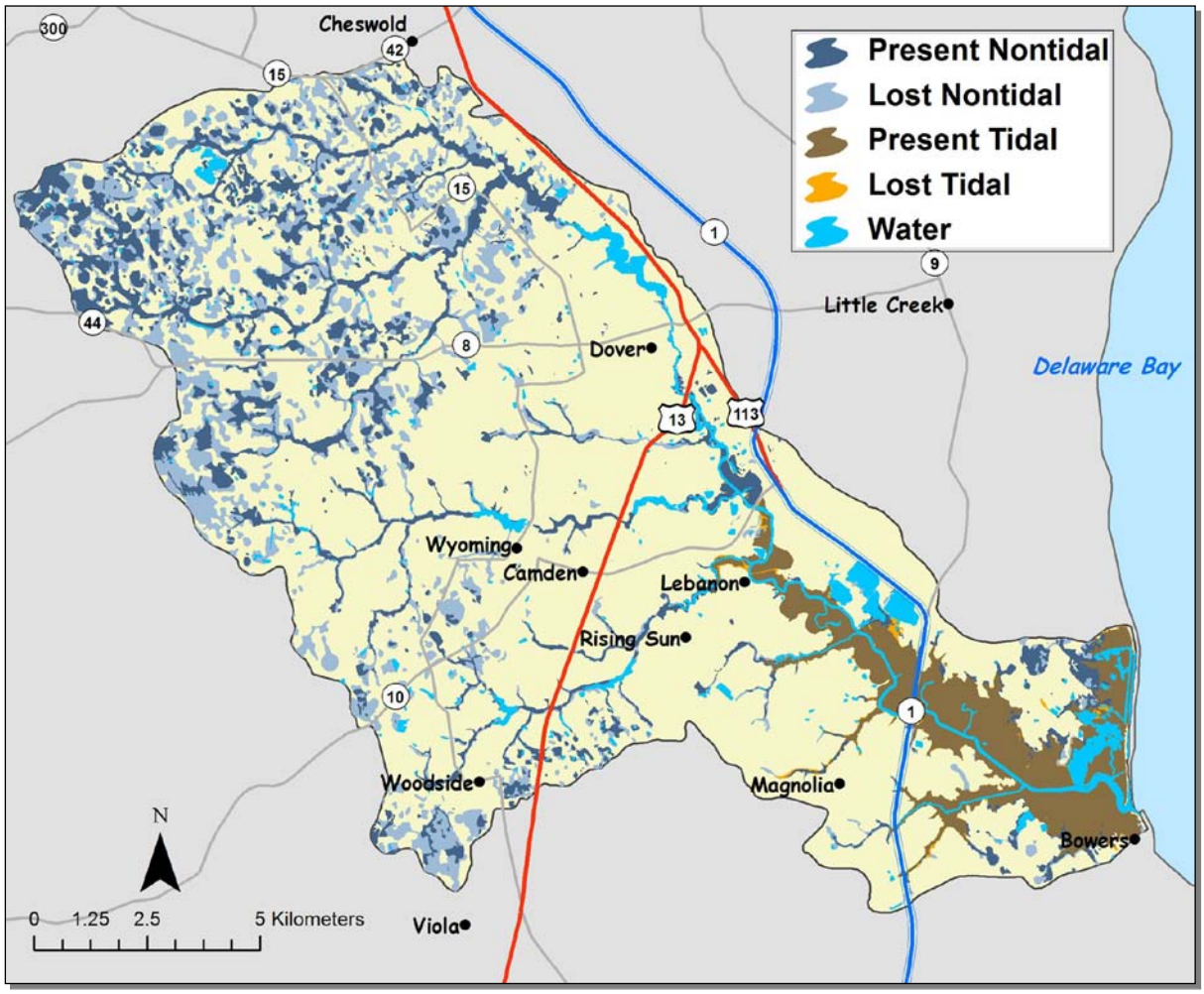


Figure 4. An example CDF showing wetland condition. The red line is the population estimate. The orange and green dashed lines show the breakpoints between condition categories.

RESULTS

4.1 Changes in Wetland Acreage

Our comparison of estimated historic to current wetlands (1992) indicated that 47% of the wetland acreage has been lost from the St. Jones River watershed since the time of settlement. Wetlands that historically covered over 7,285ha (18,000ac) across the watershed have been reduced to 3,914ha (9,670ac). Nontidal wetlands incurred the majority of loss, being reduced by 57% of their historic acreage. Nontidal wetland loss has been concentrated in the northwestern portion of the watershed (Map 5). Conversion of flat wetlands for development, cropland or pasture accounted for most of the loss. Tidal wetlands have been reduced by 9% of



Map 5. Present wetland coverage based on 1992 inventory and wetlands lost since settlement in the St. Jones River watershed, Delaware.

their historic coverage, mostly at tributary headwaters and in coastal towns along the bay. Bowers Beach and Kitts Hummock have both lost tidal wetlands to coastal development by filling and stabilization. A few areas of tidal wetlands at the upper

tidal reach of the river appear to have been affected by highway construction and the diversion of tidal flow, resulting in a conversion to nontidal wetlands.

4.2 Landowner Contact and Site Access

We obtained landowner permission prior to accessing and sampling all sites. We identified landowners using county tax records and mailed a post card providing a brief description of our study goals, sampling techniques, and contact information. If a contact number was available, we followed the mailings with a phone call to discuss the site visit and secure permission.

Overall, across all wetland types we had a 58% success rate for gaining access to our sites. We had a 98% success rate for gaining access to tidal wetlands, and a 47% for nontidal wetlands. We attempted to gain access to 53 tidal sites of which only one denied permission, and two were dropped because of being a different wetland type (Figure 5 *left*). The high success rate was due, in part, to the high percentage of tidal wetlands in public ownership (Figure 5 *right*).

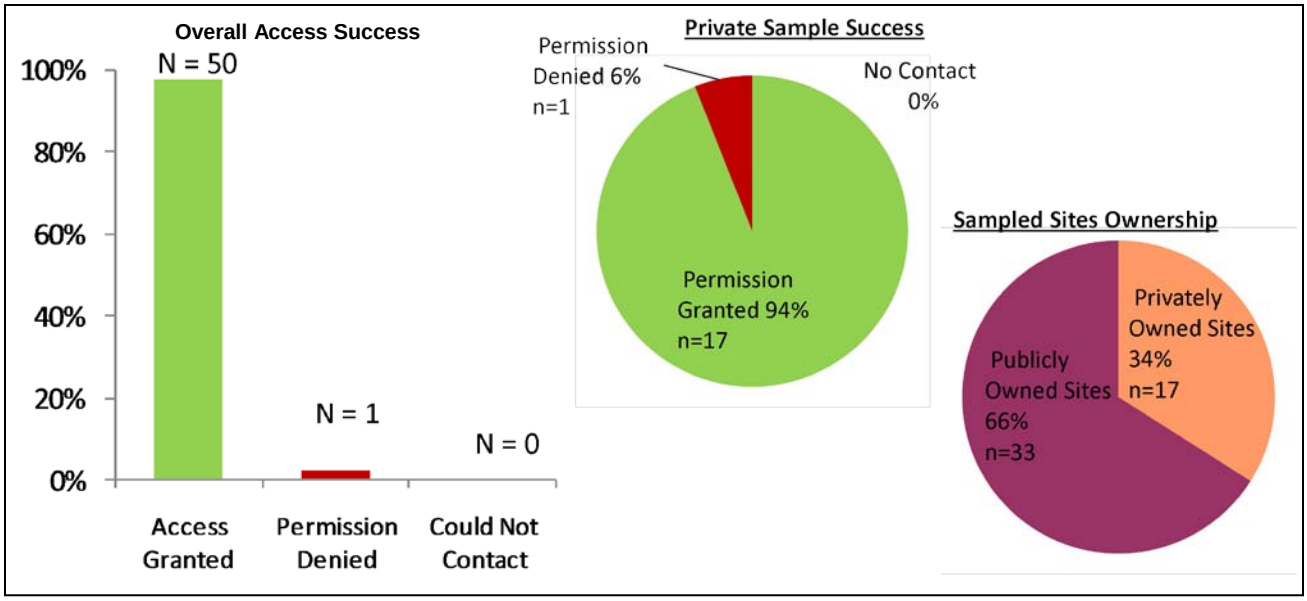


Figure 5. Overall access success rates for tidal wetlands (*left*), access success rates for privately owned sites (*middle*), and ownership proportions for sampled tidal site (*right*) in the St. Jones River watershed, Delaware in 2008.

For nontidal wetlands, our success at securing access varied between flat, riverine and depression wetlands (Figure 6). For flats, 88% of the sites were privately owned and we were successful in gaining access to 52% of the 77 sites that we attempted to access. We were unable to contact the owners of 44% of the sites. Of the privately owned sites where we made contact with the landowner (38), we had a 92% success rate of gaining access. We validated 40 flat sites of which 7 were dropped because they were a different wetland subclass and one was too difficult to access due to unusually high water. .

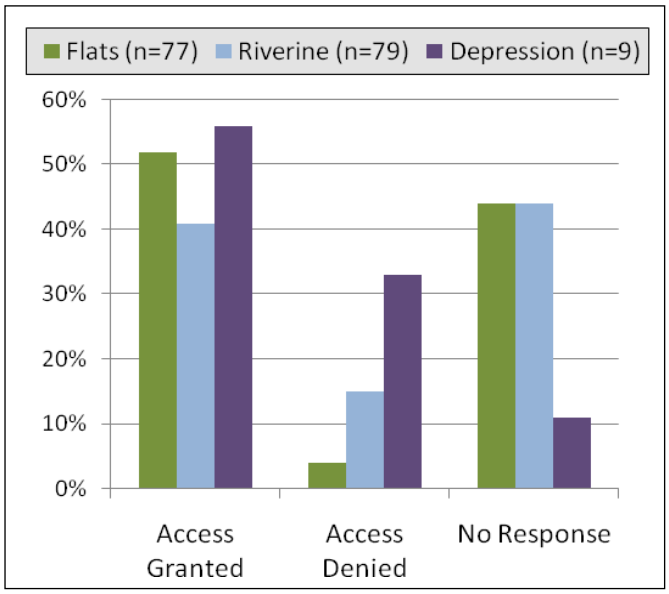


Figure 6. Success rates for accessing all wetland sites in the St. Jones River watershed Delaware in 2008 by wetland subclass.

For riverine wetlands, we attempted to access 79 sites, of which 71 (90%) were privately owned. Overall, we were successful in gaining access to 41% of the 79 attempted. The high percentage of landowners that we were unable to contact (44%) lowered our overall success rate but once we made contact with private landowners, 73% of the requests were granted. We field validated 32 riverine sites, of which we dropped one because it was a different wetland subclass and one was unsafe to access due to unusually high water.

Depression wetlands made up a very low proportion of sites and we identified only 9 sites in the first 200 random EMAP points. We were denied permission to access one site (11%), 3 (33%) could not be contacted, and 5 (56%) allowed access. Access rates for depressions were sensitive due to the small sample size.

4.3 Wetland Condition

4.3.1 Tidal Wetland Condition

Tidal wetlands provide coastal populations with more ecosystem services than any other habitat. They are highly fertile and productive, and are able to minimize flooding from storms, control erosion, and improve and maintain water quality by sequestering and storing excess nutrients, sediments and toxic chemicals.

Tidal wetlands in the St. Jones River watershed were in fair condition with an average condition score of 76±15 and ranged from 39-95. The top 12% of the tidal population scored >90 and were characterized as having undisturbed hydrology metrics, no development or barriers to landward migration, wide buffers and no invasive plants. Conversely, wetlands scoring in the bottom 8% of the population had condition scores ≤50 and were impacted by invasive plants and soil compaction, low density of below ground plant fragments, and had a tidal regime affected by water flow restrictions such as diking, berms or fill for roads. Appendix D provides the raw values and scored metric data for tidal wetland sites.

The cumulative distribution function for the tidal wetland population in the watershed showed a relatively steady slope of wetland condition scores illustrating that wetlands spanned the range of condition from 94 down to a score of 39 (Figure 7). A flattened segment in the severely stressed category suggested that a very small portion of the tidal population (4%) had condition scores between 52 and 62. A steep incline between 85 and 92 showed a larger percent of the population (30%) in this condition. Overall, our calculated condition breakpoints fell closely to the natural breakpoints in the curve, indicating that, based on MidTRAM results, our break points are reflective of natural break points in the wetlands population.

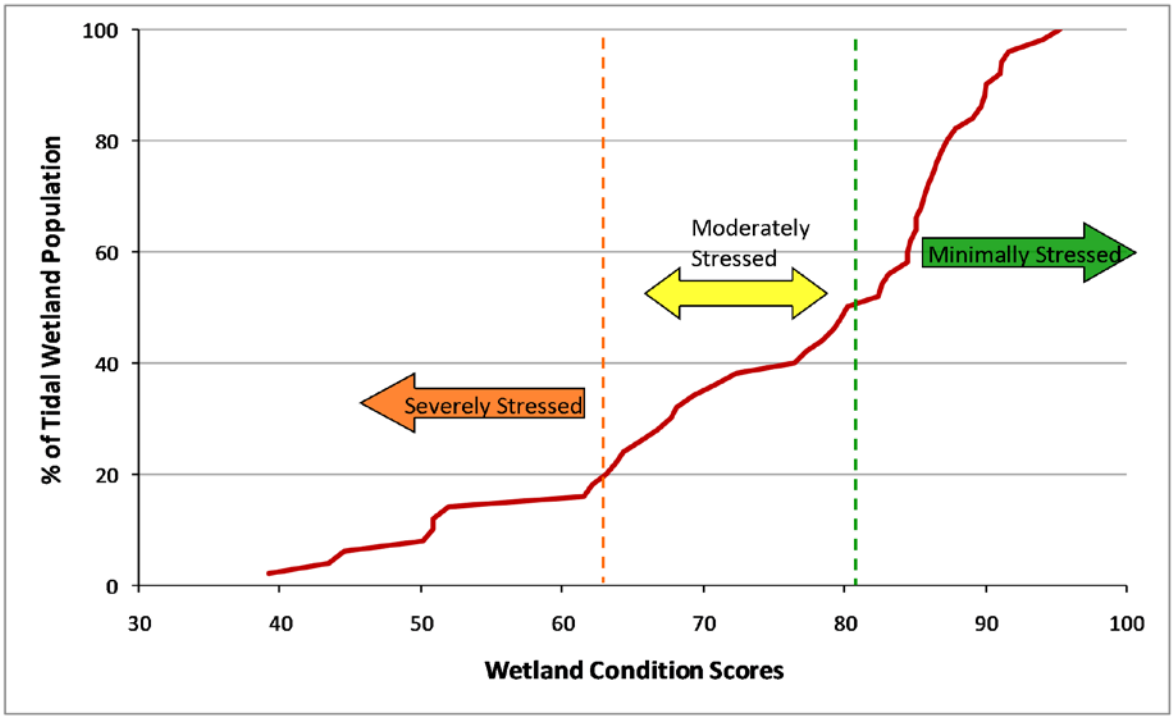
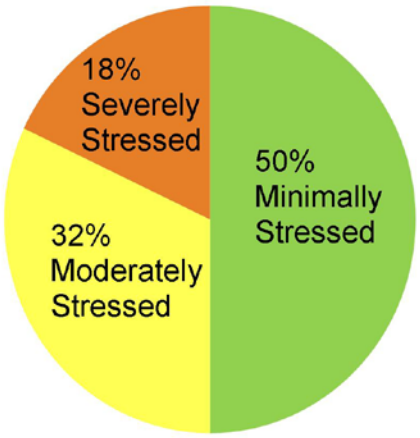


Figure 7. The Cumulative Distribution Function for tidal wetland condition based on the MidTRAM in the St. Jones River watershed, Delaware in 2008. The orange and green dashed lines designate the condition category breakpoints.

Overall, 50% of the tidal wetlands in the St. Jones River watershed were minimally or not stressed (Figure 8 *left*). Thirty-two percent were moderately stressed and 18% were severely stressed (Figure 8 *left*). Minimally stressed wetlands averaged 4 stressors compared to 7 for moderately stressed and 10 for severely stressed wetlands. In addition to the number of stressors, the intensity of several stressors increased with decreasing condition category (Figure 8 *right*). Impacts to landscape condition, such as invasive plants, soil disturbance and human visitation, were pervasive, and ditching and draining affected wetlands in all conditions. The amount of fill in the AA, the cover of invasive species, the amount of development in the buffer, and the proportion of obstructed shoreline increased with decreasing condition (Figure 8 *right*).



Metric Averages	Minimally Stressed N=9	Moderately Stressed N=16	Severely Stressed N=25
% fill in AA	<0.1%	1%	23%
% cover by invasive plants in AA	3%	18%	20%
Proportion with ditch-ing or draining in the AA	28%	44%	44%
% development in 250m buffer	0.1%	3%	6%
% of buffer shoreline obstructed from marsh migration	<1%	12%	47%
Buffer width (250m max)	228m	198m	132m

Figure 8. Tidal wetland condition proportions (*left*) and stressor prevalence (*right*) for the St. Jones River watershed, Delaware.

Comparatively, the wetland attribute group scores for the watershed were similar (Figure 9). The Habitat attribute group averaged 65±16 due to invasive plants as well as lower bearing capacity and plant fragments. Hydrology had an average of 85±20, supported by the low occurrence of fill and wetland fragmentation as well as no point source pollution. The Buffer group average of 76±18 was boosted by a high proportion of wetlands with a natural buffer, wide buffers, and low proportion of development in the buffer.

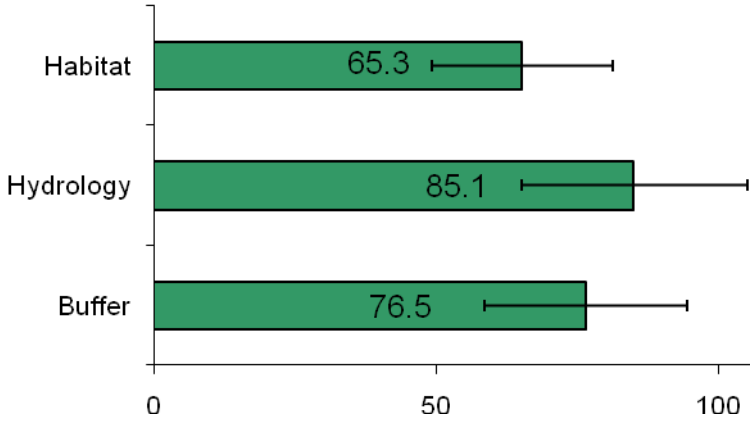


Figure 9. Attribute group averages and standard deviations for tidal wetlands in the St. Jones River watershed, Delaware.

4.3.1.a Impounded Wetland Condition

Wetland impoundments are a significant portion of the tidal marshes in the St. Jones River watershed, covering an area over 1,000ha. Ten of our 50 sampled tidal sites were impounded wetlands. The characteristics and condition of impounded wetlands may deviate from natural wetlands because they are managed specifically for waterfowl and shorebird habitat. We separated data for impounded sites and compared the condition scores and stressors to natural wetland sites. A 2-sample t-test showed that impounded wetlands had lower buffer, hydrology and habitat attribute scores, as well as a lower overall condition score (Table 5).

Table 5. Average attribute and MidTRAM condition scores for impounded wetland sites and natural sites in the St. Jones River watershed, Delaware in 2008.

	Natural n=40		Impoundment n=10				
	x	SD	x	SD	df	t	P
Buffer	80	18	63	15	1,16	2.97	0.009
Hydrology	90	16	62	16	1,14	5.11	<0.001
Habitat	70	13	49	15	1,13	4.08	0.001
Condition Score	80	12	58	9	1,18	6.34	<0.001

Specifically, impounded sites had lower hydrology scores due to diking and tidal restrictions. All of the impounded sites had a high level of tidal restrictions (26-100% reduction of normal tidal range) whereas only 4 of the 40 natural sites were affected by minor restrictions (<10% reduction of normal tidal range). In the 250m site buffer, impacts to the landscape condition such as invasive plants and soil disturbance were present equally but the percent cover of invasives and severity of disturbance were greater at the impounded sites. For the vertical biotic structure metric, which is a measure of habitat and vegetative complexity, fewer impounded sites (20%) scored the highest (12) whereas most natural sites (73%) scored 12. This may be partly due to the time of year that the sites were sampled and the impoundments being either flooded or recently drained.

Impoundments are an important habitat in Delaware for migrating shorebirds and waterfowl. Impounded wetlands are managed for desired water levels, access and vegetation, which are each dictated by the time of year. As a result of managing specifically for these functions, the wetland characteristics are much different than in a natural wetland. The MidTRAM was not developed to assess the condition of these habitats and would not be an appropriate tool to assess differences in conditions among impoundments, rather it is a tool that was developed to assess changes relative to undisturbed, natural tidal marshes.

4.3.1.b Tidal Watershed Comparison

To give us a regional aspect of how tidal wetlands in the St. Jones River compared to nearby watersheds, we compared their condition to those in the Murderkill and Inland Bays watersheds. We used the same condition category breakpoints in all three watersheds. Tidal wetlands in the St. Jones River watershed were in better condition, especially compared to the Inland Bays. We found lower stressor occurrence and severity, higher attribute scores and a higher overall condition score. The St. Jones River had the largest portion of minimally stressed wetlands, the smallest portion of moderately and nearly the smallest portion of severely stressed tidal wetlands compared to the other watersheds (Figure 10).

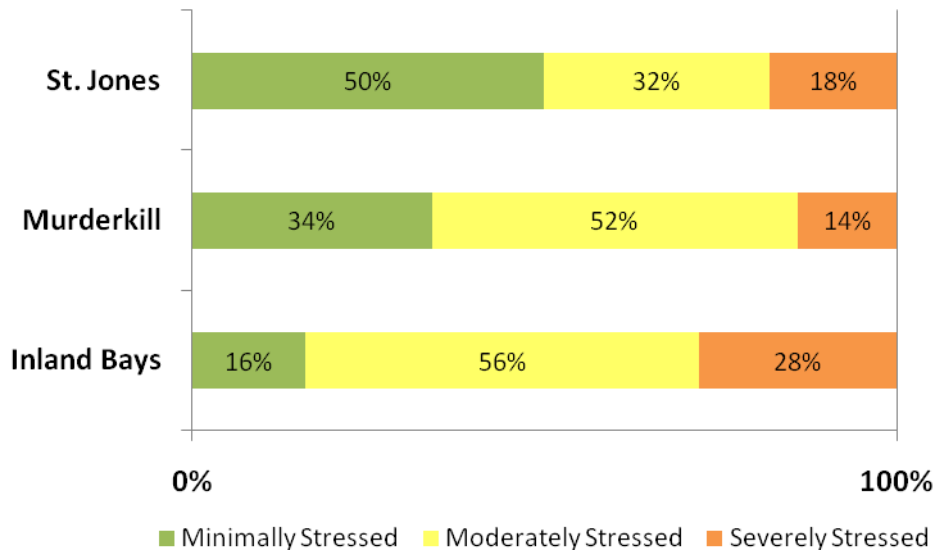


Figure 10. Comparison of the proportion of tidal wetland area in different condition categories in the St. Jones River, Murderkill and Inland Bays watersheds, Delaware.

4.3.1.c Intensive Data

We compared MidTRAM condition scores to more intensive measures of the biotic community using marsh birds and vegetative biomass. MidTRAM was designed to give a basic wetland condition rating based on variables and metrics that are responsive to disturbance. Correlating MidTRAM data to more intensive measures of wetlands validates the assessment method and increases confidence that it is able to distinguish and differentiate tidal wetlands based on changes in biological communities. Marsh birds are relatively easy to sample, represent a higher trophic level, and have previously been noted as indicators of marsh integrity (DeLuca et al. 2004, Banning et al. 2009, Conway 2008). Biomass is a comprehensive attribute of marsh systems that has been related to marsh condition (Turner et al. 2004) in regards to plant production, marsh stability and accretion.

i. Marsh Bird Community

We documented 37 bird species at 25 sites assessed for marsh bird community integrity in the three watersheds combined. Seaside sparrows, clapper rails and red-winged blackbirds were the most frequently detected. The W_{IMBCI} values ranged from 3.3 to 13.2. The calculated IMBCI values were not related to the attribute group scores nor to the MidTRAM condition scores (P=0.13). A regression of MidTRAM condition scores and IMBCI values colored by condition category showed weak separation. Interestingly, species richness decreased with increasing MidTRAM condition scores (r^2=0.2461, P=0.0117; Figure 11). We found that with increasing condition scores, the number of obligate marsh birds did not differ, but the number of other species (e.g. upland species) decreased, explaining the negative trend. A more thorough investigation of the relationship between rapid condition information and bird community integrity requires a larger sample size. Bird survey data for the eight St. Jones River sites are provided in APPENDIX E.

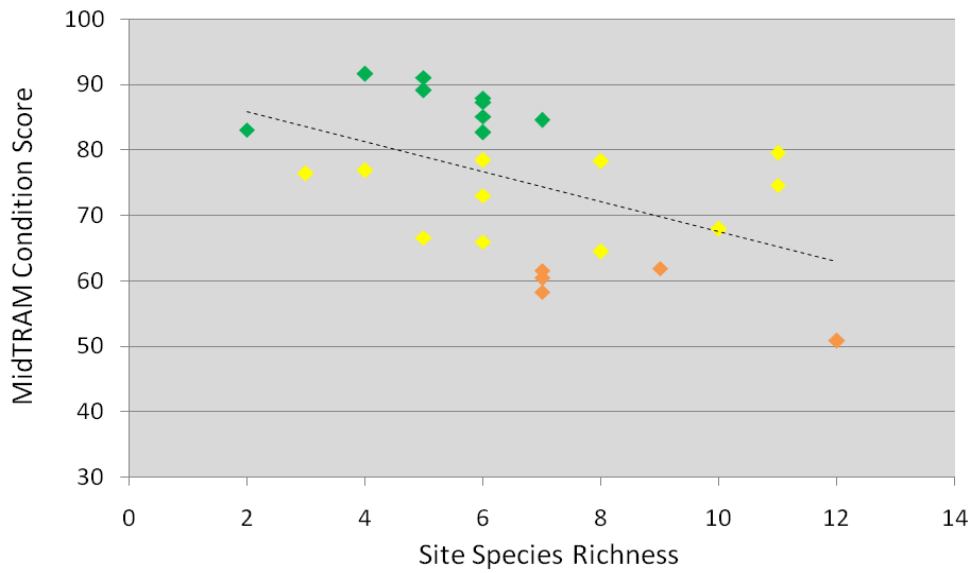


Figure 11. MidTRAM condition scores and overall bird species richness for tidal wetlands in the St. Jones River, Murderkill and Inland Bays watersheds, Delaware. Each site marker is colored by site condition category; green (minimally stressed), yellow (moderately stressed), and orange (severely stressed).

ii. Vegetative Biomass

We found a positive relationship between MidTRAM condition scores and below ground live (P=0.069), below ground dead (P=0.007), and total below ground biomass (P=0.005) indicating that sites with higher below ground biomass also had higher condition scores (Table 6 and Figure 12 *left*). We found a negative relationship between MidTRAM condition scores and above ground dead biomass (P=0.089) indicating

Biomass	r^2	P	trend
Below Live	0.15	0.069	+
Below Dead	0.32	0.007	+
Below Total	0.31	0.005	+
Above Dead	0.13	0.089	-
Above:Below	0.25	0.016	-
Above Dead:Below Dead	0.38	0.002	-

Table 6. Correlation values for 22 tidal sites in the St. Jones, Murderkill and Inland Bays watersheds.

*only significant variables (α<0.10) are listed.

that as condition scores increased, above ground dead biomass decreased. Also, total above:below ground biomass ratio (P=0.016), and above ground dead:below ground dead ratio (P=0.002) decreased with increasing condition scores which suggested that at sites with higher condition scores there is a greater proportion of below ground biomass compared to above ground biomass (Table 6 and Figure 12 *right*). This is consistent with the idea that stressed wetland plants place more energy in above ground biomass production rather than below ground (Turner et al. 2004). In a healthy system, plants should be able to produce ample root mass which accumulates as biomass.

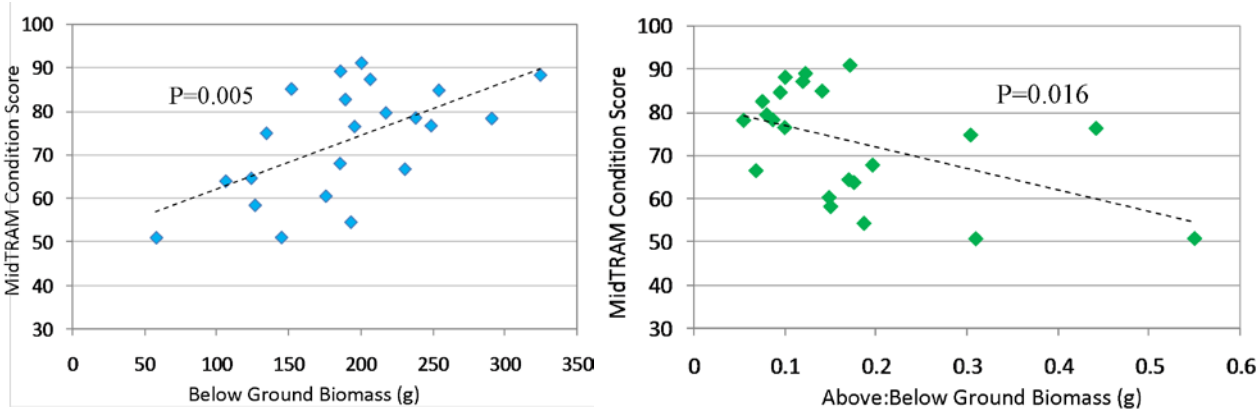


Figure 12. MidTRAM condition scores and total below ground biomass (*left*) and total above ground to total below ground biomass ratio (*right*) for 22 tidal sites in the St. Jones River, Murderkill and Inland Bays watersheds, Delaware from 2008.

We did not see a relationship between MidTRAM condition scores and above ground live biomass (P=0.380), above ground total (P=0.895), or above ground live:below ground live ratio (P=0.935). We recommend that the relationship between wetland condition and biomass be evaluated further with a larger dataset. The vegetative biomass data for the 10 St. Jones River sites are provided in APPENDIX F.

4.3.2 Nontidal Wetland Condition

4.3.2.a Flats

Flat wetlands comprise about one third of the wetlands in the St. Jones River watershed. Occurring in areas with very low, gradual slope, flats are typically found on the periphery of the watershed and are especially prevalent in the poorly drained northwestern portion of the watershed (Map 6). Flats are able to prevent flooding downstream by storing and slowly releasing water, improve water quality by filtering precipitation and runoff from surrounding land uses, and provide valuable wildlife habitat in large forested areas.

The average condition score for flats was 81±12 and ranged from 57 to 94. Thirty-seven percent of flats in the watershed were minimally stressed, 47% were moderately stressed, and 16% were severely stressed (Figure 13 *right*). One feature

of the flats population was that over half (53%) have not been forested in at least 50 years and no sites had clear cutting within the last 2 years. However, even the highest condition sites had garbage or isolated dumping present. Microtopographic alterations were common for sites with a history of forestry activity; both forestry activity and microtopographic alterations were found in 37% of flats. Invasive plants were common for flats where ditching, fill or microtopographic alterations within the wetland were also present (43% of flats had both invasives and surface alterations), suggesting that invasive plants commonly follow a surface or hydrologic disturbance.

Buffer stressors were also common throughout the flats population, with 62% having row crops within the 100m buffer, and 31% having high-density residential development (≥2 houses/ac) as well as the presence of septic systems (34%). The common presence of agriculture and development adjacent to flat wetlands points out how highly fragmented flats are from one another. We noted that 34% of flats had both agriculture in the buffer as well as ditching and invasive plants within the wetland. Only 34% of flats had a 100m buffer free of other land uses such as development or agriculture.

	Proportion with Stressor Present		
Stressor Name	Minimally Stressed N=12	Moderately Stressed N=15	Severely Stressed N=5
Forestry activity within 50 years	25%	47%	100%
Garbage or isolated dumping in AA	58%	67%	60%
Invasive plants present <50% in AA	25%	53%	60%
Fill in AA	17%	53%	60%
Ditching in AA	0%	80%	60%
Microtopographic Alterations	25%	40%	80%
Farming within Buffer	50%	73%	40%
Development within Buffer	25%	47%	20%

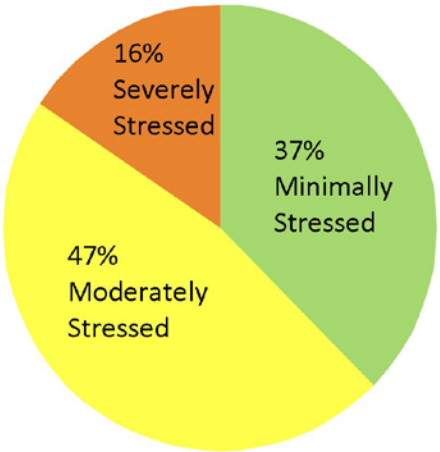


Figure 13. Stressor occurrence by condition group for common stressors (*left*) and condition of *flat* wetlands in the St. Jones River watershed, Delaware in 2007 (*right*).

Minimally stressed wetlands averaged fewer stressors (4) compared to moderately stressed (7) and severely stressed flats (8). The occurrence of individual stressors also differed by condition group, such as forestry activity, fill, ditching, and microtopographic alterations (Figure 13 *left*). Other stressors had similar occurrence across condition groups, such as garbage and isolated dumping, and homes and roads in the buffer (Figure 13 *left*).

The cumulative distribution function of the flats population shows a skewed distribution toward the higher condition rating because the lowest score of any site was a 57. Within the range of scores, there was an even distribution of condition in the population. There is a sharp rise at the high end of the curve indicating that the minimally stressed sites are in similar condition around a score of 92-95 (Figure 14). The maximum score that a wetland would score if no stressors were present is 94.4, which is a based on the average DECAP IWC score for sites without any stressors present.

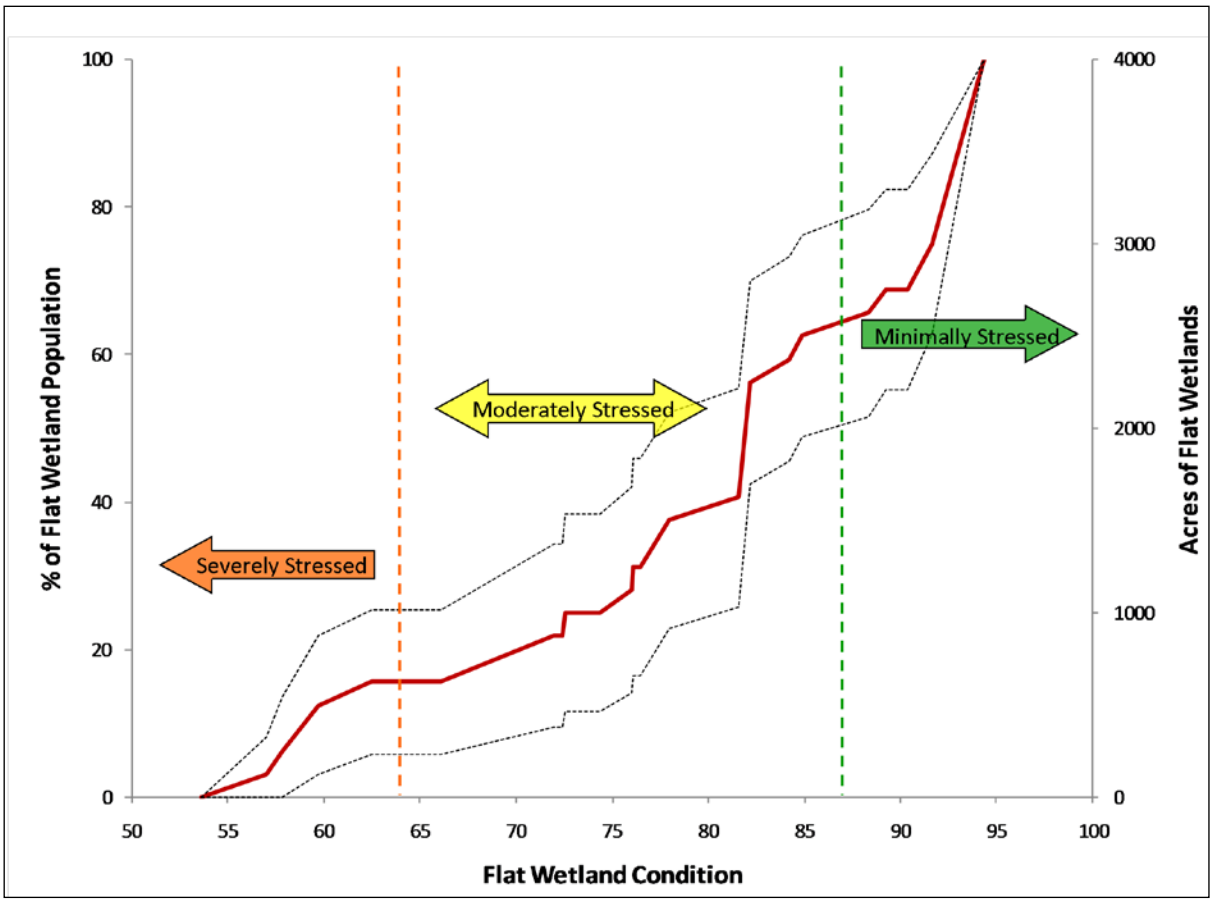


Figure 14. Cumulative Distribution Function for nontidal flat wetlands in the St. Jones River watershed, Delaware in 2007. The orange and green dashed lines signify condition category breakpoints dividing severely, moderately and minimally stressed portions of the flat wetland population.

4.3.2.b Riverine

Riverine wetlands are central for water quality maintenance through sediment retention and nutrient uptake, provide storm water storage, which reduces flooding downstream, and are 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 24% of the wetlands in the St. Jones River watershed and are located adjacent to streams and rivers.

The average condition of riverine wetlands was 72±18 and ranged widely from 27 to 90. The top portion of the population that scored near 90 had only gravel roads and garbage present, whereas the lowest segment that scored under 30 were characterized by severe fill, intense development, paved roads and forestry activity in the buffer. Overall, riverine wetlands often had habitat and plant community, and buffer stressors present, whereas the hydrology seemed less affected. For instance, although 69% of riverine wetlands had not been forested in at least 50 years, 93% had invasive plants, and 79% had isolated dumping or garbage present.

In the 100m buffer, 72% of riverine wetlands had residential or commercial development, 52% had paved roads, and 45% had agricultural fields. The presence of agriculture did not appear to be linked to the presence of channelized streams, unlike the Inland Bays and Nanticoke where this was a major stressor. For 80% of riverine wetlands with commercial or high-density development in the buffer we also found storm water inputs in the assessment area. We also noted that 93% of wetlands with paved road in the buffer had garbage or dumping in the assessment area. Every wetland where the assessment area was dominated (≥50%) by invasive plants also had row crops and/or development in the buffer.

	Proportion with Stressor Present		
Stressor Name	Minimally Stressed N=16	Moderately Stressed N=10	Severely Stressed N=3
Forestry activity within 50 years	31%	20%	67%
Garbage or isolated dumping in AA	69%	90%	100%
Invasive plants dominating AA	0%	40%	33%
Fill in AA	6%	40%	66%
Ditching in AA	0%	0%	33%
Stormwater Inputs	0%	30%	66%
Trails or roads within buffer	44%	70%	100%
Development within buffer	81%	50%	100%

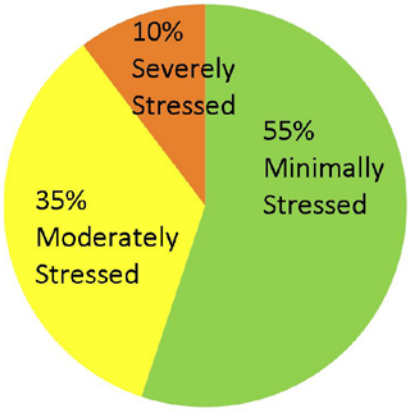


Figure 15. Stressor prevalence by condition group (*left*) and condition proportions (*right*) for *riverine* wetlands in the St. Jones River watershed, Delaware in 2007.

Based on the condition categories, over half (55%) the riverine wetlands in the St. Jones River watershed were minimally stressed, about a third (35%) were moderately stressed, and a very small portion (10%) were severely stressed (Figure 15 *right*). Minimally stressed wetlands were affected by fewer stressors (6) than moderately and severely stressed wetlands (8 and 12 stressors, respectively).

For several stressors, condition groups separated their prevalence. For example, the proportion of riverine wetlands affected by garbage, fill in the assessment area, stormwater inputs and roads went up incrementally with decreasing condition (Figure 15 *left*). Although a high proportion of minimally stressed riverine wetlands had development present in the buffer, half of that figure was low density residential housing (<1house/2acr) whereas development in severely stressed buffers was either commercial/industrial or high density residential (>2houses/ac). Half of moderately stressed riverine wetlands had development in the buffer, which was an even mix of commercial or high density, and medium (≤2houses/ac) or low density residential housing.

The CDF of the riverine wetland population illustrates two points. First, the lower range of wetland condition extends below 30, much lower than tidal or flats. Secondly, a very large portion of wetlands fall around the same condition at 85 (Figure 16). Wetlands that scored 85 (52% of the population) all had the same stressor present: invasive plants covering 1-50% of the site. Although other stressors were likely present at these sites, because the scoring of DERAP is calibrated to DECAP results, DERAP lumped all of the sites scoring 85 into the same condition score. For example, 76% of the sites with invasive plants also had residential development in the buffer area, and many had roads as well. Lastly, the segment in highest condition, around 90, was very small.

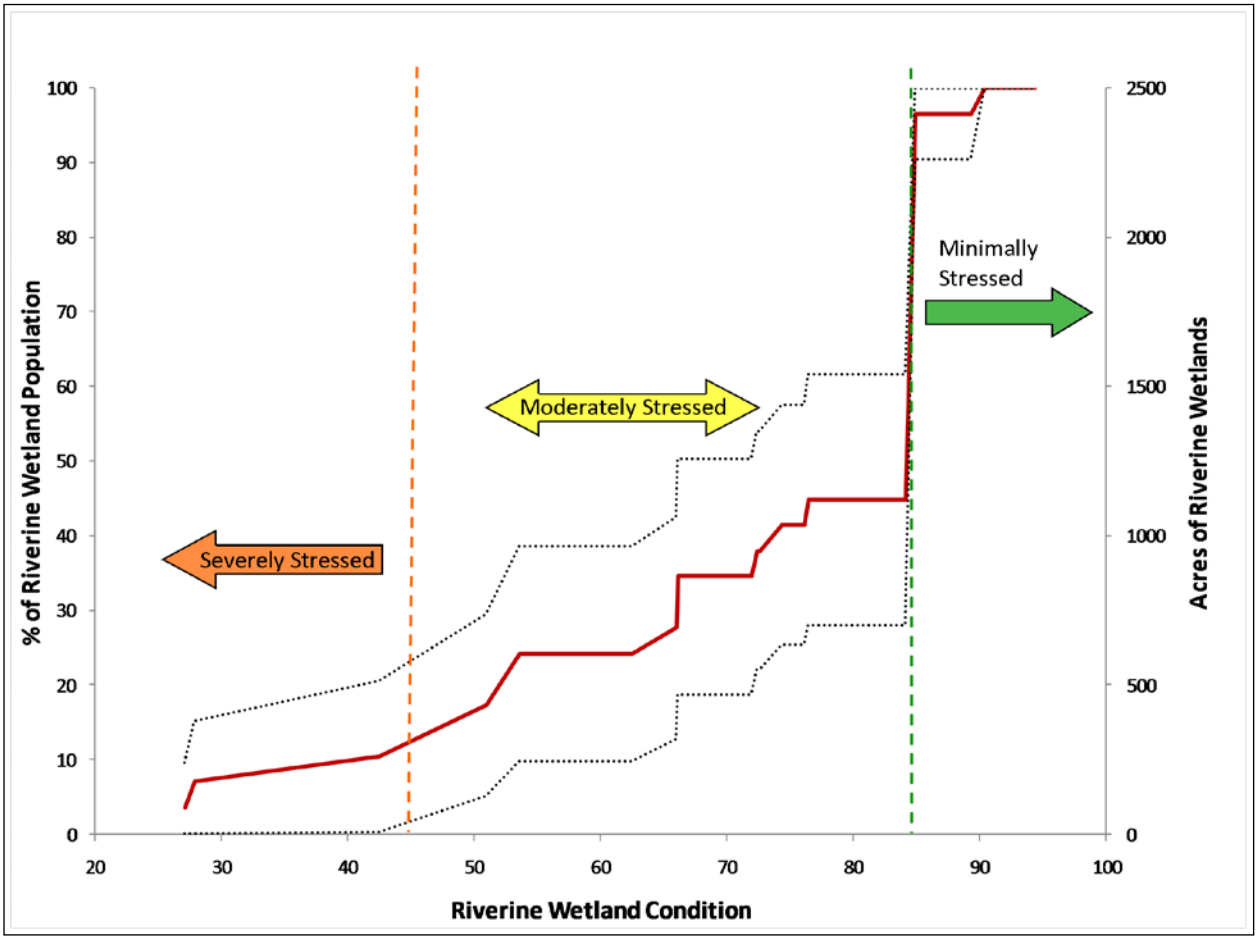


Figure 16. Cumulative Distribution Function for nontidal riverine wetlands in the St. Jones River watershed. Orange and green dashed lines signify the condition category breakpoints dividing severely, moderately and minimally stressed portions of the riverine wetland population.

Stressor dataset from 29 riverine DERAP sites are provided in Appendix H. Raw metric and scored variable data from 6 riverine DECAP sites are provided in Appendix J.

4.3.2.c Depressions

Depressions occur throughout the watershed in low-lying areas and topographical depressions. They accumulate direct precipitation, surface water as well as ground water during winter and spring. Although depressions comprise a very small portion of wetlands in the watershed, they include rare habitats such as coastal plain ponds. As a result of their seasonality, depressions are especially important habitat for juvenile amphibians. Depressions collect and moderate storm water, cycle nutrients and improve water quality through sediment retention and nutrient uptake.

Although we were not able to score or rate the condition of depressions based on our small data set, we could discern some characteristics. Four of our five sampled sites had a history of forestry activity, from recent clear-cut to selective cut 30-50 years ago. Small amounts of fill and microtopographic activity (<10% of the AA) were also present. Roads, trails and row crops were common in the buffer.

4.3.2.d Restored Wetlands

Lastly, we assessed the condition of 7 restored wetland sites in the St. Jones River watershed using the DERAP with slight modifications. Only 1 site was public, 6 were privately owned. We assessed 1 site that had been restored 6 years ago, 2 were 7 years old, 1 was 8 years old, 1 was 9 years old and 1 was 13 years old. The HGM classification for the restored wetlands was 6 depressions and 1 flat.

We found that these young, restored sites had similar characteristics. Compared to natural wetlands, restored wetlands were highly disturbed, had young to no forest cover, had invasive plants present, had nutrient indicator plant species present and generally had roads and agricultural fields in the buffer. At the oldest site, we found similar conditions except with greater tree cover, 30-45%. The condition of these sites may improve if they are allowed to continue to develop further and naturally succeed to a forested system. Repeat assessments over time will help to understand the timeline for restoring wetland condition.

4.3.2.e Nontidal Watershed Comparison

We used the nontidal wetland condition results in combination with nontidal

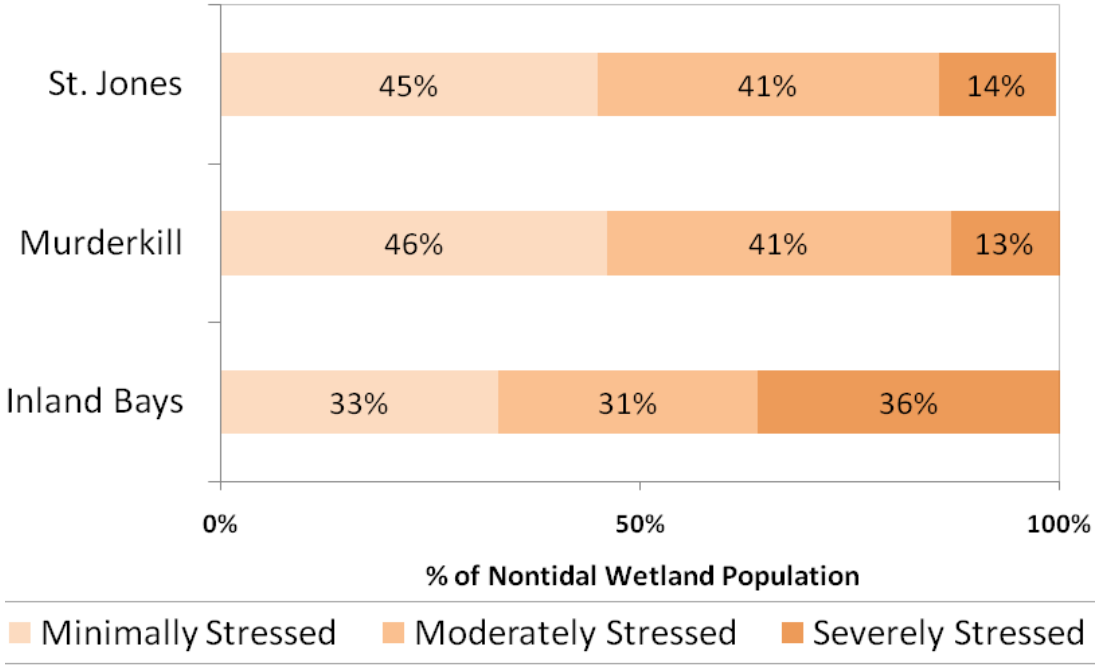


Figure 17. Comparison of condition proportions for nontidal wetlands in the St. Jones, Murderkill and Inland Bays watersheds, Delaware.

wetland proportions for the 3 watersheds to determine overall condition proportions for nontidal wetlands only (Figure 17). Nontidal wetlands in the St. Jones watershed nearly match the condition proportions of the Murderkill watershed. Both the St. Jones and Murderkill watersheds had higher proportions of minimally and moderately stressed nontidal wetlands. Similar to the tidal condition proportions (Figure 10) the Inland Bays watershed had the highest proportion of severely stressed wetlands.

4.4 Overall Condition

For an overall view of the wetland condition in the St. Jones River watershed, we combined the condition score for flats, riverine and tidal wetlands based on the acreage of each in the watershed. Of the 3,913ha (9,669ac) of wetlands in the watershed, 1,513ha (39%) were tidal, 1,385ha (35%) were freshwater flats, 951ha (24%) were riverine, and about 247ha were other wetland types including depressions and freshwater tidal wetlands. About half (49%) of the wetlands in the watershed were minimally or not stressed, 35% were moderately stressed and 16% were severely stressed (Figure 17).

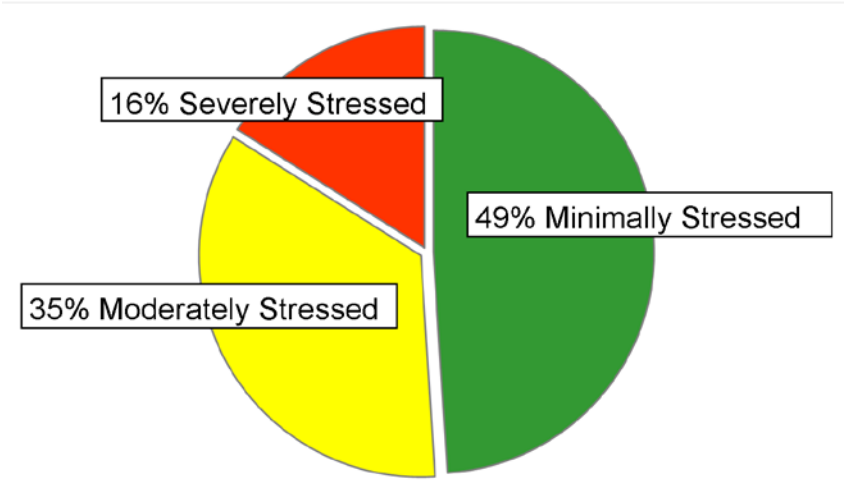


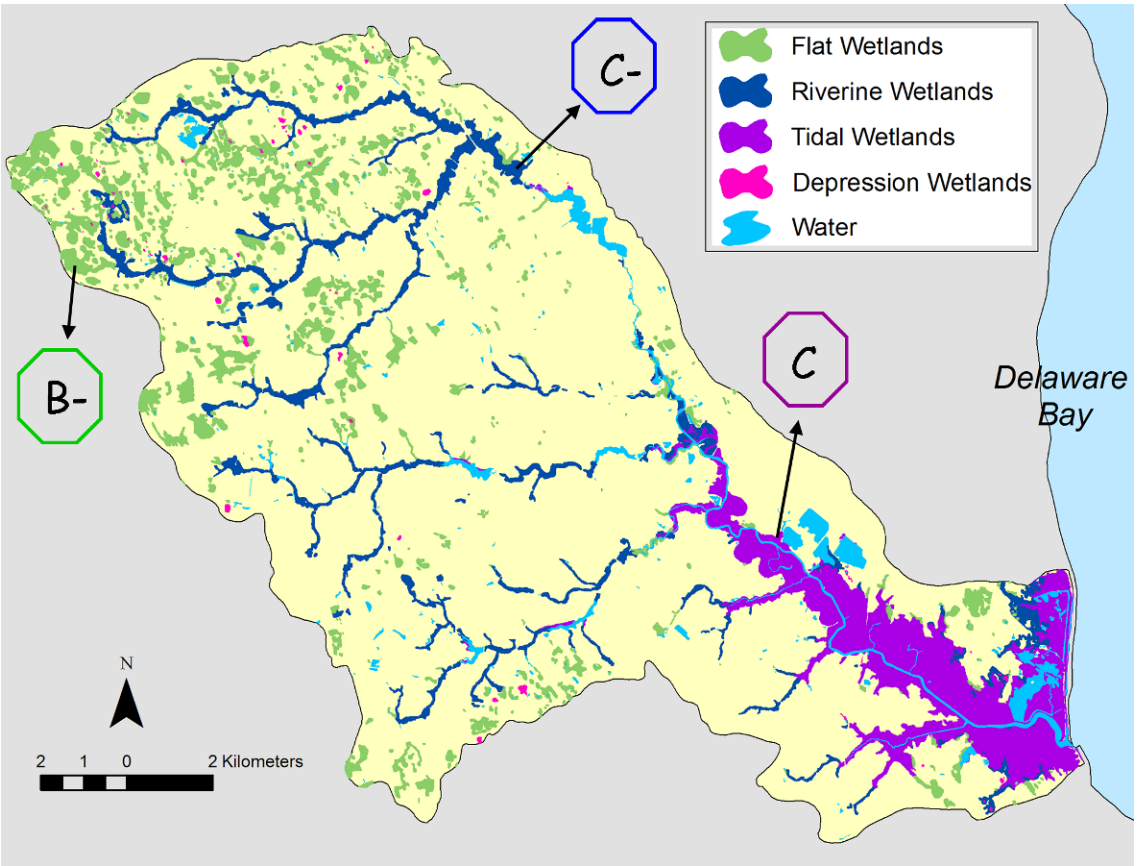
Figure 18. Combined condition of tidal, flats, riverine and depression wetlands in the St. Jones River watershed, Delaware in 2007 based on the DERAP and MidTRAM.

The large proportion of wetlands that have been minimally or not affected by stressors is important because it is the highest percentage that has been documented in the watersheds assessed in Delaware. Protecting high condition wetlands is a proactive approach to conserving our wetland resources. However, the fact that the remaining half are either moderately or severely stressed indicates that there have been significant impacts to the wetland resources and that enhancement and restoration should be a priority in the watershed to improve the condition of wetlands and the services that they provide.

4.5 Summary

This study has highlighted the history and the status of wetlands throughout the St. Jones River watershed and commented on how future steps can improve these valuable resources. Tidal wetland acreage appears to be stable and a large portion is in good condition, but the impacted portion is reflected in the overall grade for the tidal subclass (Map 6). Although tidal wetlands have state protection, future management must consider broad issues such as sea-level rise and climate change in order to improve tidal wetland resiliency to future stressors.

Riverine wetlands are split across the watershed, with a large portion in good condition and modest acreage loss. Unfortunately, there is also a portion of riverine wetlands that are extremely degraded. Similar to the Inland Bays watershed, riverine wetland condition runs the full range of scoring, wider than flats or tidal wetlands. As a result of this dichotomy, the average riverine wetland condition fell in the middle at 72, or a C- (Map 6). Activity in riverine buffers such as



Map 6. Wetland condition grades based on the subclass condition average for tidal, flat and riverine wetlands in the St. Jones River watershed, Delaware.

development, agriculture and paved roads appears to be linked to wetland stressors such as storm water drains, invasive plants and the prevalence of garbage or

dumping, which makes protecting buffers especially important in future management.

Flat wetlands have been the most affected by land use changes and wetland stressors. Large areas of flats have been lost, mostly to agricultural production and development. The areas remaining have been impacted moderately, which is reflected in their B- grade (Map 6). We related activity within wetlands, such as forest clearing or harvesting, and filling or excavating hydric soils, to a strong presence of invasive plants, ditching and microtopographic disturbances. We also noted a positive relationship between agricultural activity in the buffer and ditching and invasive plants in the wetland, suggesting that multiple sources are increasing stressors in flat wetlands. Due to their status and condition, as well as because of the important role that flats play in providing critical wildlife habitat, storing flood waters, and improving water quality, flat wetlands should be a priority for protection and restoration.

Our small sample of restored wetlands emphasized the importance of protecting natural wetlands. The oldest site that was restored 13 years ago was only just beginning to establish forested cover. Additionally, invasives and nutrient tolerant species were prevalent in the restored sites. Although reestablishing wetlands will increase wetland acreage given time and expertise, wetland functions and services will not be replaced for years after restoration is initiated. Restoring or enhancing natural wetlands is more cost-effective, is often more successful and returns greater function improvements.

Management Recommendations

Based on our study, we offer the following recommendations to improve wetland management, identify additional data needs, and encourage informed decisions concerning the future of wetlands in the St. Jones River watershed.

1. **Improve protection of nontidal wetlands.** Wetlands are a critical component to maintaining the integrity of the St. Jones River watershed. The St. Jones watershed has lost 57% of its nontidal wetland resources, making it critical to protect all remaining wetlands. Recent court decisions, such as Rapanos/Carabell vs. U.S., have created uncertainty in how to determine which wetlands are regulated, and have limited the extent of jurisdiction of the federal government to regulate nontidal wetlands. Additionally, activities in nontidal wetlands are not regulated by the State of Delaware. 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. Improved protection for nontidal wetlands is needed to fill the gaps left by recent Supreme Court decisions (EPA 2008) and to provide a comprehensive and clear means to protect wetlands across the state.
    a. **Enact comprehensive State regulations that fill the gaps created by recent Supreme Court decisions**. 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**. Local regulations can be incorporated into home owner association, municipal and/or county code to protect wetland areas of special significance.
    c. **Protect high quality wetlands using fee simple acquisitions and conservation easements**. Fee simple acquisitions allow the purchase and full ownership of a property for protection. Conservation easements allow an agreement with the landowner that permanently limits the use of the protected land. Priority should be to integrate protection for wetlands that are minimally or least stressed, including their associated buffers into existing land protection plans to ensure that these systems remain intact and continue to provide related functions.

    d. **Perform outreach activities to communities**. Educate the public and decision makers on the importance of wetlands within the watershed to encourage better protection at the state and local level.

2. **Protect tidal wetlands from further degradation through existing regulations and land use planning.** Activities in tidal wetlands are regulated by the State of Delaware and the Army Corps of Engineers. Current state and federal regulations have the ability to control activities within wetlands such as dredging, filling, shoreline stabilization or building structures, but permits are often granted, especially for proposed small impacts. Even small impacts can degrade the condition of the wetlands, and on a watershed scale many small impacts lead to potentially large cumulative impacts. The extent and impact of permitted activities should be tracked spatially in detail by permitting agencies. Interest in residential development within coastal towns along the Delaware Bay has been increasing in recent years. As coastal development increases, the importance of healthy, functioning tidal wetlands also rises. To prevent further degradation of tidal wetlands, impacts should be limited and considered on a larger, landscape scale. Half of the tidal wetlands in the St. Jones River watershed are minimally stressed so action is required now to maintain the condition of the resource.
   a. **Consider permitted activities on a landscape scale to prevent more severe cumulative impacts.** Proactive watershed planning will curb the vulnerability to the cumulative losses and degradation of tidal wetlands. A science-based approach should be used to develop a transparent process for permitting any future impacts.
   b. **Do not allow any impacts to minimally stressed tidal wetlands.** Minimally stressed wetlands should be given the highest level of protection to maintain the integrity of this resource and ensure that they will continue to provide critical services to residents and tourists. Additionally, any activities in or surrounding moderately stressed or severely stressed wetlands should not allow further degradation of their condition.
   c. **Improve coastal development practices to protect tidal wetlands**. Protect tidal wetlands from secondary impacts such as fill, invasive species, restrictions to tidal range and wetland diking. Particularly in coastal towns where development is on the rise, proactive zoning and planning will keep tidal wetlands intact.

3. **Focus on restoring and re-establishing flats**. Our study found that over half of historic wetlands in the watershed have been lost. Flats are the most prevalent wetland type in the watershed and most of the flats acreage lost was attributed to development and agricultural purposes. Land use conversion has and continues to result in the reduction of acreage and fragmentation of large forested blocks into smaller forested wetlands. Large forested flats provide critical habitat for a variety of wildlife and improve water quality from adjacent surface runoff and

precipitation. The strategic restoration of flat wetlands will increase wetland acreage, reinstate wildlife habitat, and over time will result in other returned functions such as wildlife habitat, vegetative biodiversity, habitat corridors, flood water storage and improved water quality.

4. **Improve tidal wetland buffer regulations.** Impacts that occur outside of the wetland in adjacent upland areas also affect the condition of wetlands and their ability to provide nutrient removal and increase biodiversity. Currently, 30% of tidal wetlands in the St. Jones River watershed have shoreline obstructions (e.g. elevated roads, shoreline stabilization, and residential buildings) that will prevent landward migration, causing increased losses of wetlands due to sea level rise. Kent County code[1] protects riparian buffers extending 100ft from the mean high-water shoreline of a tidal water body, stream or marsh from buildings, structures, impervious surfaces except for stairs, ramps, docks (200ft[2]) or fences (Article 11 § 187-78 B1). We have shown that severely stressed tidal wetlands have a strong presence of impacts in adjacent habitat including buildings, shoreline hardening, roads, lawns and agriculture. Protecting natural buffers around tidal wetlands promotes higher condition of the wetlands which leads to increased services that the wetland can provide and also allow for natural migration of wetland to allow for their persistence in the future.
    a. Promote native vegetation in buffers and control invasive plants to improve biodiversity and support native food chains.
    b. Require natural shoreline stabilization in lieu of any hardened surfaces. Natural shorelines will allow the best opportunity for wetlands to adapt with future climate changes.
    c. Enforce buffer regulations to their fullest extent and consistently to provide the best protection to tidal wetlands. Kent Co. Code establishes buffer setbacks that, if implemented and enforced consistently, will protect wetland condition and allow tidal wetlands to adapt to future changes.

5. **Improve nontidal wetland buffer regulations.** Our study showed that riverine wetlands in the St. Jones River watershed commonly have development in adjacent areas. When development in the buffer was present, there was also an increased occurrence of hydrologic stressors in the wetland such as storm water inputs and more impervious surfaces and mowing in the buffer. Activities adjacent to riverine wetlands that disrupt hydrology often lead to a shift from native plant communities and affect the wetlands ability to improve water quality before reaching the waterways. Disrupted hydrology patterns in riverine wetlands can also decrease protection to adjacent upland habitat from flood waters. Nontidal wetland buffer and riparian buffer protection should be

strengthened to preserve the services that wetlands provide including water quality improvement, wildlife habitat, and flood water retention. Kent County code[1] protects riparian buffers extending 100ft from the mean high-water shoreline of a nontidal freshwater water body, lake or pond from buildings, structures, and impervious surfaces except for stairs, ramps, docks (200ft^2) or fences (Article 11 § 187-78 B2). Wide buffers that specify starting at the wetland edge and that protect against more activities should be established and enforced.

a. Update buffer regulations for nontidal wetlands to begin at the wetland-upland boundary to provide optimum protection.
b. Require forested vegetation in wetland and riparian buffers to maximize nutrient removal from groundwater, surface water runoff and in-stream flow while also improving corridor habitat.
c. Update current regulations to oppose landscaping, mowing, stabilization and storm water inputs within this forested buffer.

6. **Broaden wetland stewardship by enhancing education and outreach efforts.** The presence of the Delaware National Estuarine Research Reserve (DNERR) within the St. Jones River watershed has brought attention and awareness to coastal habitats, including tidal wetlands. The DNERR 2004-2009 Management Plan (DNERR 2002) outlines education and outreach goals similar to our own: enhance public awareness and understanding of the value and functions provided by coastal habitats and tidal wetlands. The DNREC/ DWR/ WAS should partner with DNERR and their Coastal Training Program to integrate the results of this report into their education materials and programs to educate the public, professionals and decision makers about the condition and value of tidal wetlands in the watershed.

7. **Design a restoration plan for the St. Jones River watershed.** A comprehensive restoration plan for the watershed will identify the most efficient and effective path towards restoring and protecting wetlands in the St. Jones River watershed. Similar to the Nanticoke River Watershed Restoration Plan (2009) produced by The Nanticoke Restoration Work Group, this would be a science-based process that identifies restoration and protection priority areas pertinent to forestry, agriculture, wetlands, restoration, soils, wildlife and botany branches of state, federal and non-profit organizations. The plan would lead to the implementation of restoration and conservation opportunities on private and public property across the St. Jones River watershed.

8. **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 permittees 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. 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.

9. **Control the spread and extent of invasive plants.** Invasive plants were found in every wetland type assessed in this study. Invasive plants outcompete native plant species for resources and space, produce fruits and greens that many native wildlife and insect species are not able to eat or use, and sometimes create harmful habitat conditions that native species are not adapted to survive in such as thick, impenetrable stands of Phragmites. In order to maintain the rich biodiversity found in our wetland systems, invasive plants need to be controlled and eliminated. Wetlands with disturbances such as ditches, fill, and roads offer an opportunity for invasive plants to move in. For example, invasive plants were dominant (>50% cover) only in the lowest condition riverine wetlands, scoring 66 or less. Once established, they can be difficult and time consuming to remove. Professionals with the expertise to control and remove invasives should be consulted to determine the best means of addressing this problem.

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APPENDIX A: Qualitative Disturbance Rating (QDR) Category Descriptions

Qualitative Disturbance Rating: Assessors determine the level of disturbance in a wetland through observation of stressors and alterations to the vegetation, soils, hydrology in the wetland site, and the land use surrounding the site. Assessors should use best professional judgment (BPJ) to assign the site a numerical Qualitative Disturbance Rating (QDR) from least disturbed (1) to highly disturbed (6) based on the narrative criteria below. General description of the minimal disturbance, moderate disturbance and high disturbance categories are provided below.

Minimal Disturbance Category (QDR 1 or 2): Natural structure and biotic community maintained with only minimal alterations. Minimal disturbance sites have a characteristic native vegetative community unmodified water flow into and out of the site, undisturbed microtopographic relief, and are located in a landscape of natural vegetation (100 or 250 m buffer). Examples of minimal alterations include a small ditch that is not conveying water, low occurrence of invasive species, individual tree harvesting, and small areas of altered habitat in the surrounding landscape, which does not include hardened surfaces along the wetland/upland interface. Use BPJ to assign a QDR of 1 or 2.

Moderate Disturbance Category (QDR 3 or 4): Moderate changes in structure and/or the biotic community. Moderate disturbance sites maintain some components of minimal disturbance sites such as unaltered hydrology, undisturbed soils and microtopography, intact landscape, or characteristic native biotic community despite some structural or biotic alterations. Alterations in moderate disturbance sites may include one or two of the following: a large ditch or a dam either increasing or decreasing flooding, mowing, grazing, moderate stream channelization, moderate presence of invasive plants, forest harvesting, high impact land uses in the buffer, and hardened surfaces along the wetland/upland interface for less than half of the site. Use BPJ to assign a QDR of 3 or 4.

High Disturbance Category (QDR 5 or 6): Severe changes in structure and/or the biotic community. High disturbance sites have severely disturbed vegetative community, hydrology and/or soils as a result of ≥1 severe alterations or >2 moderate alterations. These disturbances lead to a decline in the wetland's ability to effectively function in the landscape. Examples of severe alterations include extensive ditching or stream channelization, recent clear cutting or conversion to an invasive vegetative community, hardened surfaces along the wetland/upland interfaces for most of the site, and roads, excessive fill, excavation or farming in the wetland. Use PBJ to assign a QDR of 5 or 6.

APPENDIX B: Nontidal Rapid Assessment 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
Wditchx	Severe Ditching; >1 ditch .3-.6 m deep or 1 ditch > .6m deep
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
Lrdgrav	Roads (buffer) mostly dirt or gravel
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 C: Nontidal Rapid Assessment IWC Stressors and Weights

Category/Stressor Name*	Abbreviation	Stressor Weights**	
**DERAP stressors excluded from this table are not in the rapid IWC calculation.*		Flats	Riverine
Habitat Category (within 40m radius site)			
Mowing in site	Hmow	-10.8	0
Forestry activity within 16-30 years	Hfor15	-7.4 if either present	-8.4 if any present
Forest activity <10% of site	Hfor10		
Forestry activity within 3-15 years	Hfor2	-20.7	
Clear cut within 2 years	Hforcc		
Excessive Herbivory/Pinebark Beetle/Gypsy	Hherb	-6.8	0
Invasive plants dominating site (>50% of site)	Hinvdom	0	-24.3
Invasives plants not dominating (<50% of site)	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)			
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 site	Wimp75	0	-16.9
Impounding water on >75% of site	Wimp100	0	
Filling, excavation on 10-75% of site	Wfill75	0	-12.5
Filing, excavation on >75% of site	Wfill100	0	
Microtopography altered on 10-75% of site	Wmic75	-15	-11
Microtopography altered on >75% of site	Wmic100		
Buffer Category (100m radius around site)			
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))**			

*** Stressors with weights in boxes were combined during calibration analysis and are counted only once, even if more than one stressor is present.*

APPENDIX D: Tidal Wetland Raw Data and Scored Metrics from MidTRAM for St. Jones River Sites *

Site Number	Condition Category	QDR	H1: Ditching & Draining	(H2): % Cover of Fill	H2: Fill & Fragmenta-tion	H3: Diking & Restriction	H4: Point Source	(B1): % with 5m-buffer	B1: % of AA Perimeter with 5m-Buffer	(B2): Average Buffer Width (m)	B2: Average Buffer Width	(B3): % Develop-ment	B3: Surrounding Development	B4: 250m Landscape Condition
SJ0001	Low	6	12	0	12	3	12	0	3	0	3	0	12	3
SJ0002	High	1	12	0	12	12	12	100	12	235	12	0	12	9
SJ0003	High	2	9	0	12	12	12	100	12	231	12	0	12	12
SJ0004	High	2	12	0	12	12	12	100	12	231	12	0	12	9
SJ0005	Low	6	9	0	12	3	12	100	12	250	12	1	9	3
SJ0006	High	2	12	0	12	12	12	100	12	205	12	0	12	6
SJ0007	Med	4	6	0	12	6	12	100	12	161	9	0	12	6
SJ0008	Med	4	12	0	12	12	12	100	12	242	12	0	12	6
SJ0009	Low	5	6	0	12	3	12	100	12	134	9	3	9	6
SJ0010	Med	2	12	0	12	12	12	100	12	175	9	10	6	6
SJ0011	High	2	9	0	12	12	12	100	12	212	12	0	12	9
SJ0012	Low	3	12	0	12	6	12	100	12	107	6	15	6	6
SJ0013	Med	3	9	1	9	12	12	100	12	250	12	1	9	9
SJ0014	High	2	12	0	12	12	12	100	12	250	12	0	12	6
SJ0015	High	2	12	0	12	12	12	100	12	250	12	0	12	9
SJ0016	Med	2	12	0	12	12	12	100	12	188	9	5	9	9
SJ0017	Low	6	12	0	12	3	12	0	3	0	3	0	12	3
SJ0018	Low	6	12	95	3	3	12	100	12	127	6	25	3	3
SJ0019	High	2	6	0	12	12	12	100	12	250	12	0	12	12
SJ0020	Med	3	12	0	12	12	12	100	12	121	6	10	6	6
SJ0021	High	2	9	0	12	12	12	100	12	220	12	0	12	9
SJ0022	High	2	12	0	12	12	12	100	12	169	9	0	12	9
SJ0023	High	2	12	0	12	12	12	100	12	250	12	0	12	9
SJ0025	Med	5	12	0	12	3	12	60	6	149	9	0	12	9
SJ0026	High	3	6	0	12	12	12	100	12	250	12	0	12	6
SJ0027	High	2	12	0	12	12	12	100	12	213	12	0	12	9
SJ0029	Med	3	12	0	12	12	12	100	12	244	12	2	9	6
SJ0030	High	2	9	0	12	12	12	100	12	250	12	0	12	6
SJ0031	Med	3	12	0	12	12	12	100	12	202	12	6	6	6

SJ0032	High	2	12	0	12	12	12	100	12	250	12	0	12	6
SJ0033	Med	4	12	0	12	3	12	100	12	206	12	0	12	6
SJ0034	High	2	12	0	12	12	12	100	12	250	12	2	9	9
SJ0035	High	1	12	0	12	12	12	100	12	250	12	0	12	9
SJ0036	Low	3	12	0	12	9	12	100	12	178	9	6	6	6
SJ0037	Med	4	6	10	6	12	12	100	12	164	9	0	12	6
SJ0038	High	3	12	1	9	12	12	100	12	141	9	0	12	9
SJ0039	Med	2	3	0	12	12	12	100	12	221	12	0	12	9
SJ0041	Med	6	3	0	12	3	12	100	12	211	12	3	9	6
SJ0042	High	2	12	0	12	12	12	100	12	250	12	0	12	9
SJ0043	High	3	12	0	12	12	12	100	12	250	12	0	12	9
SJ0044	High	3	12	0	12	12	12	100	12	250	12	0	12	6
SJ0045	Med	4	3	7	6	12	12	100	12	250	12	0	12	6
SJ0046	Low	6	3	15	3	3	12	94	9	221	12	3	9	6
SJ0047	High	2	12	0	12	12	12	100	12	173	9	1	9	9
SJ0048	Med	6	12	0	12	12	12	100	12	233	12	10	6	3
SJ0049	Low	5	3	95	3	3	12	100	12	175	9	0	12	3
SJ0050	High	3	12	0	12	12	12	100	12	250	12	0	12	6
SJ0051	High	2	6	0	12	12	12	100	12	181	9	0	12	9
SJ0052	High	4	12	0	12	12	12	100	12	250	12	0	12	6
SJ0053	Med	5	3	0	12	3	12	100	12	154	9	0	12	6

* Green columns indicate scored metric values; Blue columns indicate raw variable values. All sites were assessed in 2008 and scored with MidTRAM version 2.0

APPENDIX D continued

Site Number	Condition Category	QDR	(B5): % Obstructed Shoreline	B5: Barriers to Landward Migration	(HAB1): Avg Bear Cap (cm)	HAB1: Bearing Capacity	(HAB2:) Avg Plant Frag (cc)	HAB2: Plant Fragments	HAB3: Vertical Biotic Structure	(HAB4): Number of Plant Layers	HAB4: Number of Plant Layers	(HAB5): % Co-dominant Invasive Plant Species	HAB5: % Co-dominant Invasive Plant Species	(HAB6): Percent Invasive Plants	HAB6: Percent Invasive Plants
SJ0001	Low	6	0	12	.	3	.	4	3	0	3	0	12	0	12
SJ0002	High	1	0	12	2.56	9	10.75	4	12	2	9	0	12	0	12
SJ0003	High	2	0	12	2.94	9	11.75	8	12	3	9	0	12	0	12
SJ0004	High	2	0	12	6.00	6	11.00	4	12	3	9	0	12	0	12
SJ0005	Low	6	15	6	6.00	3	15.00	8	6	2	9	100	3	100	3
SJ0006	High	2	0	12	5.50	6	5.50	4	12	2	9	0	12	0	12
SJ0007	Med	4	40	3	1.88	9	12.25	8	12	3	9	33	6	20	9
SJ0008	Med	4	0	12	8.44	3	16.25	8	12	4	12	60	3	80	3
SJ0009	Low	5	100	3	5.94	3	2.75	4	6	5	12	25	9	38	6
SJ0010	Med	2	0	12	5.00	6	11.00	4	12	2	9	0	12	0	12
SJ0011	High	2	0	12	2.75	9	6.25	4	9	4	12	25	9	15	9
SJ0012	Low	3	50	3	2.44	9	10.75	4	9	4	12	25	9	5	9
SJ0013	Med	3	1	9	2.81	12	6.50	4	6	3	9	0	12	0	12
SJ0014	High	2	0	12	3.88	9	14.75	8	12	4	12	0	12	0	12
SJ0015	High	2	0	12	2.38	9	17.75	12	12	2	9	0	12	0	12
SJ0016	Med	2	10	6	3.75	9	5.50	4	12	4	12	14	12	3	9
SJ0017	Low	6	0	12	0.00	3	0.00	4	3	1	6	0	12	0	12
SJ0018	Low	6	100	3	0.00	3	0.00	4	3	1	6	0	12	0	12
SJ0019	High	2	0	12	1.75	12	13.75	8	12	3	9	0	12	0	12
SJ0020	Med	3	100	3	3.38	9	6.25	4	12	4	12	33	6	5	9
SJ0021	High	2	0	12	4.00	9	7.25	4	9	2	9	0	12	0	12
SJ0022	High	2	0	12	4.69	6	5.50	4	12	3	9	0	12	0	12
SJ0023	High	2	0	12	3.00	9	16.25	8	12	3	9	0	12	0	12
SJ0025	Med	5	0	12	0.75	12	8.75	4	3	3	9	25	9	10	9
SJ0026	High	3	0	12	2.38	9	20.00	12	12	4	12	0	12	3	9
SJ0027	High	2	0	12	6.50	3	5.50	4	12	3	9	0	12	0	12
SJ0029	Med	3	0	12	6.50	3	11.50	8	12	2	9	25	9	5	9
SJ0030	High	2	0	12	3.06	9	16.75	8	12	3	9	0	12	0	12

SJ0031	Med	3	13	6	1.69	9	18.50	12	12	4	12	40	6	20	9
SJ0032	High	2	0	12	1.75	6	9.75	4	12	4	12	0	12	0	12
SJ0033	Med	4	15	6	3.00	9	8.00	4	12	4	12	25	9	10	9
SJ0034	High	2	20	6	2.38	9	11.25	4	12	3	9	0	12	0	12
SJ0035	High	1	0	12	2.50	12	15.00	8	12	4	12	0	12	0	12
SJ0036	Low	3	100	3	4.50	3	11.00	4	12	4	12	50	3	10	9
SJ0037	Med	4	0	12	2.25	9	5.00	4	9	4	12	50	6	10	9
SJ0038	High	3	0	12	3.63	9	6.50	4	12	4	12	0	12	0	12
SJ0039	Med	2	10	6	5.06	6	10.00	4	6	3	9	0	12	0	12
SJ0041	Med	6	0	12	0.81	12	12.25	8	3	3	9	17	9	3	9
SJ0042	High	2	0	12	4.81	6	14.25	8	12	3	9	0	12	0	12
SJ0043	High	3	0	12	3.56	6	17.50	8	12	4	12	29	9	3	9
SJ0044	High	3	0	12	3.56	6	14.00	8	12	4	12	20	9	7	9
SJ0045	Med	4	0	12	2.56	9	11.00	4	6	4	12	0	12	1	9
SJ0046	Low	6	60	3	7.00	3	8.00	4	9	4	12	25	9	10	9
SJ0047	High	2	0	12	5.44	6	10.50	4	12	4	12	0	12	0	12
SJ0048	Med	6	8	9	3.67	9	17.33	8	9	1	6	100	3	100	3
SJ0049	Low	5	0	12	0.06	3	0.25	4	9	3	9	66	3	15	9
SJ0050	High	3	0	12	1.69	12	19.00	12	12	3	9	66	3	30	6
SJ0051	High	2	0	12	2.63	9	11.00	4	12	4	12	0	12	0	12
SJ0052	High	4	0	12	1.56	9	19.00	12	12	4	12	25	9	15	9
SJ0053	Med	5	0	12	2.25	9	5.75	4	9	4	12	25	9	15	9

APPENDIX E: Bird Survey Data for St. Jones River Tidal Sites 2008

Species	SIMBCI	SJ0002	SJ0003	SJ0004	SJ0006	SJ0008	SJ0009	SJ0010	SJ0011
American goldfinch	4				x		x		
barn swallow	4	x			x			x	
boat-tailed grackle *	9						x		
clapper rail *	12	x	x	x	x			x	x
common yellowthroat	7			x			x		x
marsh wren*	9.5	x	x	x	x	x	x	x	x
red-winged blackbird	5.5	x		x	x	x	x	x	x
seaside sparrow*	13.5	x	x	x	x		x	x	x
semipalmated sandpiper	7						x		
sharp-tailed seaside sparrow*	12		x						
short-billed dowitcher	7.5						x		
song sparrow	4						x		
spotted sandpiper	5						x		
swamp sparrow*	9.5								x
tree swallow	4			x		x	x		
willet*	14		x				x	x	
WIMBCI		7.9	13.2	7.58	7.08	3.33	7.5	9.75	9.5

* Indicates an obligate marsh species

** an 'x' indicates detection of the species (visually or audibly) within 75m of the assessment point.

APPENDIX F: Vegetative Biomass Data for St. Jones River Tidal Sites 2008

Total dry weight (g).

Site #	SJ0002	SJ0003	SJ0004	SJ0005	SJ0006	SJ0007	SJ0008	SJ0009	SJ0010	SJ0011
Above Dead	6.94	19.41	4.15	44.80	7.74	14.97	14.30	17.48	8.78	7.88
Above Live	15.90	15.03	20.64	35.03	13.69	3.76	72.27	0.52	11.94	6.41
Above Total	22.84	34.44	24.79	79.83	21.43	18.73	86.57	18.00	20.72	14.29
Below Dead	168.81	179.89	183.54	104.71	133.92	91.1	171.58	53.93	175.13	177.68
Below Live	17.11	20.65	23.05	40.26	17.93	15.18	24.13	4.12	19.85	11.61
Below Total	185.92	200.54	206.59	144.97	151.85	106.28	195.71	58.05	194.98	189.29
Above Live: Below Live	0.929	0.728	0.895	0.870	0.764	0.248	2.995	0.126	0.602	0.552
Above Dead: Below Dead	0.041	0.108	0.023	0.428	0.058	0.164	0.083	0.324	0.050	0.044
Above : Below	0.123	0.172	0.120	0.551	0.141	0.176	0.442	0.310	0.106	0.075

APPENDIX G: Flat Wetland Nontidal Rapid Assessment Stressors for Sites in the St. Jones River watershed in 2007-2008

Stressor descriptions are listed in Appendix B. '1' indicates the presence of that stressor; '0' indicates the absence.

Habitat and Plant Community stressors

Site #	QDR	Hfor50	Hfor30	Hfor15	Hfor2	Hforcc	Hnorecov	Hpine	Hmow	Hfarm	Hgraz	Hinvdom	Hinvless	Hchem	Hherb	Hburn	Hgarb	Hnutapp	Halgae	Htrail	Hrdlog	Hrdgrav	Hrdpav
SJ0001	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0005	4	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0
SJ0007	6	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0010	4	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0
SJ0011	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0012	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SJ0017	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SJ0020	5	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
SJ0021	2	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
SJ0026	4	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0029	5	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0032	4	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0
SJ0043	3	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
SJ0046	4	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	1	0	0
SJ0052	2	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
SJ0059	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0061	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SJ0071	6	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0073	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
SJ0076	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0080	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
SJ0096	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0103	4	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0104	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SJ0107	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0108	3	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0110	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SJ0123	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SJ0137	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SJ0151	4	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0160	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0167	4	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0

Appendix G continued: *Hydrology stressors*

Site #	Wditchs	Wditchm	Wditchx	Wditchfloodplain	Wchannm	Wchan1	Wchan2	Wdamdec	Wimp10	Wimp75	Wimp100	Wstorm	Wpoint	Wfill10	Wfill75	Wfill100	Wmic10	Wmic75	Wmic100	Wsedchan	Wtidres
SJ0001	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
SJ0005	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
SJ0007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
SJ0010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
SJ0011	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
SJ0012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0020	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
SJ0021	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0026	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
SJ0029	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SJ0032	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
SJ0043	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0046	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
SJ0052	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0059	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
SJ0061	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0071	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
SJ0073	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0076	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0080	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0096	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
SJ0103	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
SJ0104	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
SJ0107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0108	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
SJ0110	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
SJ0123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0151	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
SJ0160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
SJ0167	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Appendix G continued: *Buffer stressors*

Site #	Ldevcom	Ldevres3	Ldevres2	Ldevres1	Lsew	Lsept	Ltrail	Lrdgrav	Lrd2pav	Lrd4pav	Llndfil	Wchan	Lagrow	Lagorch	Lagpoul	Lfor	Ldock	Lmoor	Lgolf	Lmow	Lmine
SJ0001	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SJ0005	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0	0	0
SJ0007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
SJ0010	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
SJ0011	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SJ0012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0020	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0
SJ0021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0026	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
SJ0029	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
SJ0032	0	1	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0	0	0	1	0
SJ0043	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0
SJ0046	0	0	0	1	0	1	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0
SJ0052	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
SJ0059	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0061	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0
SJ0071	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
SJ0073	0	0	0	1	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
SJ0076	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SJ0080	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
SJ0096	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0103	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
SJ0104	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SJ0107	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0108	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SJ0110	0	1	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
SJ0123	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SJ0137	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SJ0151	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SJ0160	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
SJ0167	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0	0	0

APPENDIX H: Riverine Wetland Nontidal Rapid Assessment Stressors for Sites in the St. Jones River watershed in 2007-2008

Stressor descriptions are listed in Appendix B. '1' indicates the stressor presence; '0' indicates stressor absence.

Habitat and Plant Community stressors

Site #	QDR	Hfor50	Hfor30	Hfor15	Hfor2	Hforcc	Hnorecov	Hpine	Hmow	Hfarm	Hgraz	Hinvdom	Hinvless	Hchem	Hherb	Hburn	Hgarb	Hnutapp	Halgae	Htrail	Hrdlog	Hrdgrav	Hrdpav
SJ0002	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SJ0013	3	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0034	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0035	3	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0054	3	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
SJ0058	3	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0078	3	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0094	2	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
SJ0116	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
SJ0155	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
SJ0158	4	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0159	2	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
SJ0166	4	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0
SJ0169	4	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0172	3	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0194	3	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0030	3	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0063	4	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1
SJ0006	3	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0140	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0
SJ0198	4	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
SJ0164	4	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0
SJ0039	5	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SJ0079	4	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
SJ0038	2	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0
SJ0120	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SJ0014	4	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	1	0	0	0
SJ0102	6	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
SJ0070	6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1

Appendix H continued: *Hydrology stressors*

Site #	Wditchs	Wditchm	Wditchx	Wditch floodplain	Wchannm	Wchan1	Wchan2	Wincision	Wdamdec	Wimp10	Wimp75	Wimp100	Wstorm	Wpoint	Wfill10	Wfill75	Wfill100	Wmic10	Wmic75	Wmic100	Wsedchan	Wsedwet	Wsubsid	Wtidres
SJ0002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0034	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0035	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0054	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0058	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SJ0078	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0094	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0155	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SJ0158	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
SJ0159	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0166	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0169	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0194	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0063	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0
SJ0006	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
SJ0140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0198	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
SJ0164	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
SJ0039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SJ0079	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0
SJ0038	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0120	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0014	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0
SJ0102	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
SJ0070	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0

Appendix H continued: *Buffer stressors*

Site #	Ldevcom	Ldevres3	Ldevres2	Ldevres1	Lsew	Lsept	Ltrail	Lrdgrav	Lrd2pav	Lrd4pav	LIndfil	Wchan	Lagrow	Lagorch	Lagpoul	Lfor	Ldock	Lmoor	Lgolf	Lmow	Lmine
SJ0002	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0013	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SJ0034	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SJ0035	0	1	0	0	1	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0
SJ0054	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SJ0058	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
SJ0078	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
SJ0094	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SJ0155	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SJ0158	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0159	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SJ0166	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
SJ0169	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SJ0172	0	0	1	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0
SJ0194	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SJ0030	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
SJ0063	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0
SJ0006	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
SJ0140	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
SJ0198	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
SJ0164	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0
SJ0039	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
SJ0079	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
SJ0038	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0
SJ0120	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SJ0014	0	1	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
SJ0102	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
SJ0070	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0

APPENDIX I: Flats Nontidal Comprehensive Metric and Variable Data from St. Jones River watershed sites *

Site #	SJ0001	SJ0010	SJ0011	SJ0012	SJ0017
% AA Affected by Ditching	40	0	100	0	0
Vdrain	0.60	1.00	0.10	1.00	1.00
Vdisturb	0.50	0.50	0.75	0.75	1.00
Tree Density (trees/ha)	333	360	226	333	306
Vtreeden	1.00	1.00	1.00	1.00	1.00
% FACU Trees >7.5cm dbh	8.88	0.18	4.54	0.11	0.23
Vtreespp	0.50	0.25	0.50	0.25	0.25
Tree Basal Area (m^2/ha)	22.92	21.8	19.28	17.16	29.48
Vtba	0.77	0.73	0.65	0.58	0.99
Vmicro	0.10	0.10	0.75	1.00	1.00
Vherb	0.75	0.75	0.75	0.75	0.75
% of Veg Plots with Rubus	33	66	33	0	33
Vrubus	0.75	0.50	0.75	1.00	0.75
Shrub Density (shrubs/ha)	5387	8361	4373	11028	9321
Vshrubden	1.00	1.00	0.92	1.00	1.00
Vshrubspp	0.75	1.00	1.00	0.75	1.00
% Fill in AA	0	>10% ≤50%	≤10%	≤10%	0
Vfill	1.00	0.50	0.75	0.75	1.00
Volume LDW (m^3/ha)	-	-	-	-	-
Snag Density (snags/ha)	12.93	5.96	4.97	6.96	6.96
Vdeadwood	0.50	0.50	0.50	0.50	0.50
Buffer Tree Basal Area (m^2/ha)	24	23	8	19	13
VbuffBA	0.93	0.90	0.31	0.72	0.51
% Buffer High Impact Land Use	0	15	5	0	0
Vbuffuse200	1.00	0.90	1.00	1.00	1.00
% Buffer Impervious	0	5	2	0	0
Vimp200	1.00	0.85	0.94	1.00	1.00
Buffer % Road Cover	0	0	5	0	0
Vbuffrd200	1.00	1.00	0.71	1.00	1.00

* Unshaded lines denote raw values; Green lines highlight variable scores.
All sites were assessed in 2007 and scored with the Flats protocol version 2.0.

APPENDIX J: Riverine Nontidal Comprehensive Metric and Variable Data from St. Jones River watershed sites*

Site #	SJ0002	SJ0006	SJ0013	SJ0014	SJ0030	SJ0034
Vveg_ history	1.00	0.75	1.00	0.00	0.50	1.00
FACU Tree IV	0.00	0.02	0.00	0.06	0.00	0.04
Vtree comp	1.00	0.75	1.00	0.50	1.00	0.75
Tree Basal Area m²/ha	2.8	42.1	29.5	31.6	27.4	49.7
Vtba	0.07	1.00	0.70	0.75	0.65	1.00
Vmicrotopo	1.00	1.00	0.75	0.58	0.10	1.00
% Veg Plots with Rubus	0	0	33	66	100	66
Vrubus	1.00	1.00	1.00	0.50	0.10	0.50
Shrub Density (shrubs/ha)	5654	12242	17722	5254	2947	5747
Vshrub den	1.00	0.50	0.50	1.00	1.00	1.00
Buffer Tree Basal Area (m²/ha)	20.7	42.6	26.1	42.9	27.9	22.9
VbuffBA	0.58	1.00	0.73	1.00	0.78	0.64
% Buffer High Impact Land Use	52	86	64	63	19	55
Vbuffuse200	0.50	0.10	0.36	0.37	0.89	0.47
% AA Floodplain Alterations	0.00	0.00	0.00	>10 ≤75	0.00	0.00
Vfloodplain	1.00	0.75	1.00	0.25	1.00	1.00
% Invasive Herbs	0.00	0.08	0.45	1.50	2.80	0.75
Vinvasive_understory	1.00	0.75	0.75	0.50	0.25	0.75
% Channelization 500m from AA	0	0	0	0	20	0
Vchannel_out	1.00	1.00	1.00	1.00	0.75	1.00
Vinstream	0.60	1.00	1.00	0.60	0.60	0.60
Average CoC	4.90	4.42	4.35	4.42	3.89	4.27
FQAI'	49.30	40.39	41.89	43.18	35.86	42.13
Vfqai	1.00	0.71	0.80	0.88	0.46	0.79
Distance to Nearest Road (m)	180	23	138	62	60	648
Vdist_to_road	1.00	0.14	0.83	0.37	0.36	1.00
Vhydroalt_out	1.00	0.50	0.10	0.25	0.10	1.00

* Unshaded lines denote raw values; Green lines highlight variable scores.
All sites were assessed in 2007 and scored with the Riverine protocol version 2.0.

APPENDIX K: Depression Nontidal Assessment Data from St. Jones River sites 2007-2008.

Definitions are in Appendix B.

		Habitat Stressors (within 40m radius assessment area)																								
DEP Site #	QDR	Hmow	Hfarm	Hgraz	Hfor50	Hfor30	Hfor15	Hfor2	Hforselect	Hforcc	Hnorecov	Hfor10	Hherb	Hinvdom	Hinvless	Hchem	Hpine	Hburn	Htrail	Hgarb	Hnutapp	Haglage	Hrdlog	Hrdpav	Hrdgrav	Total Basal Area (trees/ha)
SJ0019	4	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	110
SJ0022	3	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	90
SJ0051	4	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SJ0055	3	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	7
SJ0087	2	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	110

		Hydrology Stressors (within 40m radius assessment area)																	
DEP Site #	QDR	Wditchs	Wditchm	Wditchx	Wdamdec	Wimp10	Wimp75	Wimp100	Wstorm	Wpoint	Wfill10	Wfill75	Wfill100	Wmic10	Wmic75	Wmic100	Wsedwet	Wsubsid	Wtidres
SJ0019	4	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
SJ0022	3	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0
SJ0051	4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SJ0055	3	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
SJ0087	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

		Landscape/ Buffer Stressors (within 100m radius from AA edge)																			
DEP Site #	QDR	Ldevcom	Ldevres3	Ldevres2	Ldevres1	Lsew	Lsept	Lrdtrail	Lrdgrav	Lrd2pav	Lrd4pav	Llndfil	Lchan	Lagrow	Lagorch	Lagpoul	Lfor	Ldock	Lgolf	Lmow	Lmine
SJ0019	4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
SJ0022	3	0	0	1	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0
SJ0051	4	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0
SJ0055	3	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0
SJ0087	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix K continued

Comprehensive assessment raw values and variable scores for St. Jones River Depression sites.

Site #	SJ0022	SJ0051
QDR	3	4
Forest sapling density (saplings/ha)	1173	0
Vsapden	1.00	0.10
Canopy tree density trees/ha	240	0
Vtreeden	0.86	0.10
Canopy tree basal area (m^2/ha)	19.77	0
Vtba	1.00	0.10
Shrub density (stems/ha)	4786	0
Vshrubden	1.00	0.10
Shrub richness and composition	8 spp & both indicators	none
Vshrubsp	1.00	0.10
Tree richness and composition	3 spp & both indicators	none
Vtree	0.75	0.10
% Native understory	92%	85%
Vnative	0.50	0.25
Hydrologic alterations	ditching and fill	none
Vhydroalt	0.25	1.00
Buffer canopy tree basal area (m^2/ha)	20.75m^2/ha	0
Vbufferba	0.96	0.10
Distance from wetland to road	25m	50m
Vdisttoroad	0.12	0.25
% Natural vegetation in 240m	20%	0%
Vnatland	0.25	0.10