RAPID ASSESSMENT OF FRESHWATER WETLAND CONDITION
Development of a Rapid Assessment Method for Freshwater Wetlands in Rhode Island

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RHODE ISLAND
NATURAL HISTORY SURVEY
Providing Ecosystem Science and Information

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Executive Summary

The State of Rhode Island Department of Environmental Management (DEM) and the Rhode Island Natural History Survey (RINHS) are working to develop a rapid assessment method (RAM) to characterize freshwater wetland condition and address a set of objectives identified by the *Rhode Island Freshwater Wetland Monitoring and Assessment Plan*. The plan identifies both short-term and long-term objectives focused on enhancing the protection and management of wetlands within the State.

The RAM is being developed under guidance and funding from the USEPA in accordance with the Clean Water Act. It represents the second level of an EPA-recommended three-level approach to wetland monitoring and assessment that includes landscape-level assessment (L1), rapid assessment (L2), and intensive assessment (L3). In 2006, two existing RAMs were chosen and simultaneously piloted in the Woonasquatucket River watershed, a Rhode Island HUC 10 drainage basin; they are the *Ohio Rapid Assessment Method version 5.0, quantitative section* (ORAM) and the *Delaware Rapid Assessment Procedure version 5.0* (DERAP). The ORAM is comprised of 16 metrics and submetrics that are assessed and scored through field and remote investigations. Individual metric scores are totaled to produce an index for each wetland that incorporates wetland characteristics, stressors, and condition. The DERAP is a stressor checklist that is used to identify wetland disturbances.

This report focuses on work completed in 2007 that continues the 2006 work by applying rapid assessment methods in a second set of wetlands in the Upper Pawcatuck River (UPR) basin. The 2007 work was conducted to (1) demonstrate the utility of rapid assessment through the collection and analysis of baseline data in the UPR basin, (2) analyze the relevance and utility of two test-RAMs in addressing State monitoring and assessment objectives, and (3) modify them in structure and content as necessary to produce a valid, relevant, and effective single RAM that can be applied to address those objectives.

The project was orchestrated in stepwise fashion as follows: (1) *a priori* analysis and modification of ORAM and DERAP, (2) data collection, (3) data summarization by original RAM protocols, (4) RAM and metric analysis, enhancement, and reorganization, and (5) development of a RI-specific RAM and other recommendations based on the utility of RAM enhancements.

Before field investigations, the RAMs were reviewed and modified to enhance utility and regional specificity without compromising original scoring or attribute formats. Original field data forms were modified to collect certain additional information for analysis; most notably, (1) stressors to the systems were to be rated rather than checked, (2) more information on wetland communities was to be collected, (3) metrics intended to characterize the effects of groundwater withdrawals were developed and included, (4) rare and invasive community and plant species lists were developed for regional relevance, and (5) specific plant invasive species were to be identified and classified by cover.

Forty-eight sites were selected from public and conserved lands along a gradient of land use intensity within the UPR basin; six more were targeted for pilot validation studies; another four sites not within the UPR basin were targeted to supplement groundwater withdrawal sites. All sites were assessed both in the field and remotely by a team of two investigators according to ORAM protocols, while DERAP was applied as an ancillary stressor checklist. Fifteen of the sites were assessed separately by each investigator before team assessments to facilitate inter-user variability analysis.

Wetlands were assessed at a rate of two per day. In the UPR basin, ORAM scores ranged from 19 to 98 with a mean score of 74 and a median score of 79 (n=54), compared to the much more intensely-developed WR basin wetlands assessed in 2006 having scored a mean of 66 and a median of 69 (n=23). Trends in individual metric scores may be useful for quantifying certain wetland attributes, while others may be too subjective or difficult to determine to produce dependable information. Metric classes themselves are similarly variable in utility but may be useful for certain descriptive purposes. In investigating inter-user variability, summed index scores are more highly correlated than individual metrics between users; this may be the effect of canceling errors.

The ORAM produces an index that incorporates scores rating wetland functions and values, in addition to stressors/condition, which is neither necessary nor desired in the State of RI. To analyze the utility of the RAM in addressing the State's objectives, the metrics were recategorized into discrete sets characterizing the following; (1) wetland ***functional capacity***, (2) ***stressors*** to wetlands, and (3) wetland ***condition***. In inter-metric analyses, the *stressor* and *condition* metric categories are strongly correlated, which suggests proper function of both. Pilot validation analyses of *condition* and *stressor* scores against land use intensity and against amphibian indices of biotic integrity (IBIs), being developed separately at URI, suggest correlations as well. These analyses indicate that metrics intended to characterize aspects of wetland *functional capacity* confound the utility of the RAM in characterizing wetland condition across wetland types. The scoring for these metrics was therefore removed from the developmental RAM and the category was renamed *Wetland Characteristics*.

Several metrics were enhanced to improve the accuracy and functionality of the RAM data. Enhancements to *stressor* metrics show improved correlations with *condition* metric scores and with pilot IBI values. *Stressor* enhancements include the rating and scoring of in-wetland metrics, and changes to buffer-zone metric scoring methods that assure objectivity and accuracy. One buffer-zone metric has been further developed to strongly predict combined RAM *stressor* and *condition* scores (Rs=0.85), when applied in a remote-sensing environment. Field-assessed metrics intended to characterize the effects of groundwater withdrawals did not correlate with any expected variables, but should be retained for further testing.

The proposed metric revisions are presented as ***RIRAM version 1*** in the form of a field data form (see Appendix 3). This prototype RIRAM will directly address many of the objectives outlined in the RI Wetland Plan. A summary is provided that details the developments incorporated into the RIRAM. Recommendations regarding further validation and application, and State-wide implementation of the RIRAM are offered as well.

1. Introduction

1.1 Rhode Island Freshwater Monitoring and Assessment Plan

The State of Rhode Island Department of Environmental Management (DEM) and the Rhode Island Natural History Survey (RINHS) are working to develop a rapid assessment method (RAM) to characterize freshwater wetland condition. The work is being conducted in accordance with USEPA guidelines and the *Rhode Island Freshwater Wetland Monitoring and Assessment Plan* (RI Wetland Plan; NEWIPCC and DEM 2006), and represents a continuation of work initiated in 2006 by DEM and its partners. The work is intended to fulfill expectations of the USEPA, DEM, and the RINHS in the development of a *Rhode Island Freshwater Monitoring and Assessment* protocol, as identified in the 2007 QAPP bearing that title.

The development of the RI Wetland Plan focused on soliciting feedback from wetland partners within the State and USEPA to identify gaps and needs in freshwater monitoring and assessment. The Plan outlines a strategy to meet those needs through the development and application of long-term monitoring and assessment methods that integrate with other monitoring programs in the State. In the RI Wetland Plan, the DEM and its wetland partners identified a number of long-term and short-term objectives (NEIWPCC and DEM 2006). They are as follows:

Long-term objectives

- *Develop a database of information necessary to evaluate trends in wetland condition.*
- *Identify causes and sources of wetland degradation including cumulative impacts to wetlands.*
- *Identify program and policy changes needed to improve overall wetland condition statewide.*
- *Evaluate the effectiveness of wetland management and protection programs with respect to wetland condition.*

Short-term objectives

- *Prioritize wetlands (and adjacent upland habitat) for protection through open space acquisition and other land protection mechanisms.*
- *Develop and implement methods for monitoring impacts to wetlands due to water withdrawals.*
- *Monitor and assess impacts to wetlands due to loss and degradation of adjacent upland habitats (buffer zones).*
- *Monitor location and extent to which invasive species are present and affecting wetland condition.*

EPA Three-Level Approach

The USEPA has recommended that states adopt a three-level approach to wetland monitoring and assessment to address the policies set by the Clean Water Act (USEPA 2006). The approach supports validation and interoperability between various data types

and promotes a comprehensive and coordinated strategy to data collection, storage, analysis, and application. Descriptions and applications of the three levels are outlined in Table 1.

Table 1. USEPA-recommended three-level approach to wetland monitoring and assessment

USEPA Recommended Level
Level 1: Landscape Assessment Use GIS and remote sensing to gain a landscape view of watershed and wetland condition. Typical assessment indicators include wetland coverage (NWI), land use and land cover
Level 2: Rapid Wetland Assessment Evaluate the general condition of individual wetlands using relatively simple field indicators. Assessment is often based on the characterization of stressors known to limit wetland functions e.g., road crossings, tile drainage, ditching.
Level 3: Intensive Site Assessment Produce quantitative data with known certainty of wetland condition within an assessment area, used to refine rapid wetland assessment methods and diagnose the causes of wetland degradation. Assessment is typically accomplished using indices of biological integrity or hydrogeomorphic function.

Source: USEPA 2006

The RI Wetland Plan outlines a strategy to develop and integrate these three levels of monitoring in the State of RI over time. As a central part of that strategy, the plan calls for Level 2, rapid wetland assessment (applying a RAM), to be developed from 2006 through 2010. In an effort to take an evolutionary approach to RAM development, NEIWPPC and DEM researched existing RAM protocols being implemented by other states with the intent of adapting an existing method for use in RI. At least 13 states have developed wetland RAMs. Based on thorough research, including a review of various State RAMs recently published by the USEPA (Fennessy et al. 2004), DEM selected two methods that could best be piloted to assess their utility in addressing the State's monitoring objectives: (1) the Ohio Rapid Assessment Method (ORAM; Mack 2001) and (2) the Delaware Rapid Assessment Procedure (DERAP; Jacobs 2003), which has since been updated (Jacobs 2007).

ORAM

The ORAM is a well-established and comprehensive semi-quantitative RAM developed for the State of Ohio to facilitate regulation of wetlands by allowing the assignment of wetlands to one of three broad regulatory categories. ORAM was designed to incorporate two parts; (1) a set of narrative ranking criteria and (2) a semi-quantitative rapid field assessment. The semi-quantitative section was selected for piloting in RI (henceforth referred to as ORAM). This section allows a relative comparison of wetlands. Using a standard field form, the rater generates a single score by summing scores of grouped metrics and submetrics (Table 2). ORAM scores wetlands according to certain hydrologic and ecological attributes, stressors, and overall wetland condition. The score is intended only to support the state's regulatory categorization. Mack (2001) cautions that ORAM is *not* intended or designed to determine a particular wetland's ecological or human value; however, it has been shown to have some utility in predicting certain ecological functions (e.g. Andreas et al. 2004). ORAM is completed primarily through field surveys, but the use of GIS or aerial photography is recommended to answer certain spatial metrics. For

further clarification of ORAM metrics and formatting, refer to the ORAM field form (App. 1).

Table 2. Metrics and submetrics of the *Ohio Rapid Assessment Method v. 5.0, Quantitative* section (Mack 2001)

Wetland Area (size)
Upland Buffers and Surrounding Land Use ▪ Average Buffer Width ▪ Intensity of Surrounding Land Use
Hydrology ▪ Sources of Water ▪ Connectivity ▪ Maximum Water Depth ▪ Duration of Inundation/saturation ▪ Modifications to Hydrologic Regime (Recovery)
Habitat Alteration and Development ▪ Substrate Disturbance ▪ Habitat Development ▪ Habitat Alteration (Recovery)
Special Wetlands
Plant Communities, Interspersion, Microtopography ▪ Wetland Vegetation Communities Present ▪ Horizontal Interspersion ▪ Coverage of Invasive Plants ▪ Microtopography

DERAP

The DERAP (Jacobs 2007) uses a stressor checklist to characterize wetland condition under the assumption that the combined effects of stressors have a direct, additive influence on wetland condition. The checklist is intended to be completed through a combination of field surveys and office-based investigations. Attributes comprising the checklist characterize stressors to hydrology and habitats within a wetland as well as within a surrounding 100-m buffer zone (Table 3).

Table 3. Attributes comprising the most recent *Delaware Rapid Assessment Procedure v. 5.0* stressor checklist for wetlands (Jacobs 2007).

Habitat Plant Community	
▪ Forest Harvesting	▪ Presence of Invasive Species
▪ Dominant Forest Age	▪ Chemical Defoliation
▪ BAF 10 of Dominant Forest	▪ Burned
▪ Converted from Native Forest	▪ Trails and Roads
▪ Excessive Herbivory	▪ Increased Nutrients
Hydrology (within site)	
▪ Ditching	▪ Filling, Excavation
▪ Stream Alteration	▪ Micro Alterations
▪ Weir/Dam/Road	▪ Excessive Sedimentation
▪ Stormwater Inputs	▪ Soil Subsidence/Root Exposure
▪ Point Source (Non-stormwater)	▪ Tidal Restriction
Buffer (100m surrounding site)	
▪ Development Density	▪ Forest Harvesting
▪ Sewage Disposal	▪ Piers/Docks
▪ Roads	▪ Golf Course
▪ Land Fill/Waste Disposal	▪ Mowed Area
▪ Channelized Streams or Ditches	▪ Sand/Gravel Operation
▪ Agriculture	

The DERAP is intended to be used on a watershed-wide basis to characterize wetland conditions by generating a baseline for subsequent change analysis. It is not intended to be a measure of condition in any one single wetland (Jacobs 2007). For further clarification of DERAP attributes and formatting, refer to the DERAP field form (App. 2).

In 2006, the two RAMs were simultaneously piloted in the Woonasquatucket River (WR) basin, a HUC 10 drainage basin in northern RI. That study comprised the strict application of ORAM protocols, while DERAP was applied only as an ancillary checklist. The RAMs were piloted at 27 sites selected across a range of disturbance intensity. Findings and recommendations of those investigations were applied to the 2007 efforts to enhance and adapt the two methods for use in RI, presented here.

1.2 Project Objectives

This report details work accomplished in the 2007-2008 (Year-2) grant period toward the development of a regionally effective RAM that addresses the monitoring objectives outlined in the RI Wetland Plan (DEM 2005). It demonstrates methods for generating baseline data following a *rotating* (drainage) *basin* approach to wetland monitoring consistent with surface water protocols established in the State. It also outlines several important findings and recommendations representing significant progress in the development and application of a single, appropriate rapid assessment methodology capable of characterizing freshwater wetlands in RI as part of the three-level approach recommended by the USEPA.

The work simultaneously pursues three objectives, (1) the demonstration of a rapid assessment tool, (2) an analysis of its relevance and utility in addressing State monitoring objectives, and (3) the enhancement of its utility and relevance. To collect viable RAM data, modify and enhance the RAM metrics, and analyze the effects of those modifications in a single season, a stepwise approach was followed: (1) *a priori* analysis and modification of RAM methods and protocols, (2) data collection, (3) data summarization by original RAM protocols, (4) RAM metric enhancement, reorganization, and analysis, and (5) development of a single RAM and other recommendations based on the utility of RAM enhancements. Methods are detailed below.

2. Methods

Field work was conducted from September 10 to October 31, 2007 and consisted of applying the two existing RAMs, ORAM and DERAP, to 54 freshwater wetlands within the Upper Pawcatuck River (UPR) basin and four additional sites. Data were collected and recorded on modified ORAM and DERAP field forms and entered into a digital spreadsheet for analysis.

2.1 A Priori Review and Modification of ORAM and DERAP Protocols

Prior to applying them in the field, protocols were internally reviewed to assess their applicability to RI freshwater wetlands and the goals identified by the RI Wetland Plan. The ORAM Quantitative Rating field form (App.1) was modified to enhance, but not disable the protocol for application in RI, while the DERAP (App. 2) was applied to collect complimentary data. Refer to 2007 modified field forms (App. 3) for further clarity on the following protocol adaptations for field surveys conducted in 2007:

- In addition to prescribed identification by HGM class, wetlands were identified by USFWS classification down to *dominance type* (species) of each component community (Cowardin et al. 1979) as well as RI Natural Heritage Program *Natural Community Type* (Enser and Lundgren, 2006). Both of these may be useful for RI database searching and cross-walking, and for calibrating data scores by wetland type, which was strongly recommended by USEPA.
- ORAM Metrics 3 and 4 were enhanced in two ways. First, boxed *stressor* attributes, originally intended as check-off data for answering submetrics 3e and 4c were instead rated on a scale of 1 to 3 with the intent of providing additional information on *stressors* for each wetland and enhancing the capability of comparing specific stressor impacts among wetlands. Ratings replace checkmarks for Metrics 3 and 4 as follows: 1-minor effect on hydrology/habitats, 2-moderate effect on hydrology/habitats, and 3-severe effect on hydrology/habitats. Second, *Historic Alterations* were added as attributes to Metrics 3 and 4 to clarify ambiguity in scoring wetlands that were historically modified and scored as though the modification happened so long ago that it is considered to be the "natural state" of the wetland (Mack 2001). Wetlands with historic modifications (e.g. a historic mill pond impoundment) are identified in new *Historic Alterations* attributes, 3f and 4d. If these are the only observed disturbances, attributes 3e and

4c are classified as both *Recovered* and *None or none apparent* and the scores are averaged.

- ORAM Metric 5, *Special Wetlands* included wetlands unique to Ohio. Therefore, it was necessary to replace wetlands special to Ohio with ecologically important, rare, or sensitive wetlands of RI, as identified by the RINHP and the RI Environmental Monitoring Collaborative (Enser and Lundgren, 2007; NEIWPCC AND DEM 2006, respectively). Wetlands excluded from the original ORAM are: *Lake Erie coastal/tributary wetland-unrestricted hydrology* (10 pts.), *Lake Erie coastal/tributary wetland-restricted hydrology* (5 pts.), *Lake Plain Sand Prairies* (10 pts.), *Relict Wet Prairies* (10 pts.), and *Category 1 Wetlands* (-10 pts). RI wetlands added to Metric 5 are: *Atlantic white cedar swamp* (10 pts.), *Coastal Plain Pondshores* (10 pts.), *Interdunal swales* (10 pts.), and *Vernal pools* (5pts.).
- The ORAM list of characteristic plant species of special wetlands was revised to reflect species occurring for each type in Rhode Island (App. 4). This was compiled from RINHP natural community descriptions (Enser and Lundgren, 2007) and from consultation with local experts (e.g. Frank Golet, personal communication).
- ORAM Metric 6 was modified by the addition of a text box with lines to list (in descending order by cover) the five most influential invasive species noted within the surveyed wetland. In addition, a list of invasive species of RI wetlands (App. 4) was developed to replace the original Ohio list. This adds the necessary information to address the goal of monitoring invasive species occurrences as identified in the RI Wetland Plan.
- As a continuation of 2006 methods, DERAP protocols of determining assessment areas were not implemented because assessment areas were delineated based on ORAM protocols. DERAP data were not scored, but instead were collected to increase the detail in characterizing stressors to each wetland site.
- The DERAP metric *BAF(10)* utilizes a gauge to estimate tree biomass surrounding a given point. This metric was not used because it is inconsequential to RI objectives. The *Soil Subsidence / Root Exposure* metric was enhanced to include three classes for severity of root exposure. It served as a pilot metric intended to determine relative long-term effects of groundwater withdrawals on wetlands. Also added to this metric were *Soil Fissures Obvious* and *Uncharacteristic Ground Cover* as check-off attributes to characterize shorter-term withdrawal effects.
- The DERAP metric *Agriculture* was enhanced to include *Hay fields / Pasture* and *Turf* to reflect regional farming practices.

2.2 Site Selection

Sites were selected to follow the existing DEM *rotating basin* surface water monitoring schedule, which is designed to divide the State into fairly equal areas by drainage basins; one part being monitored per year on a rotating basis. The UPR basin, in central to southern RI, was selected to stagger wetland and surface-water monitoring efforts and, because it is widely studied, generate opportunities for collaboration with other wetland scientists. To alleviate anticipated problems with access to private properties, only

wetlands on public or conserved lands were considered. Utilizing ESRI ArcMap GIS software, wetland sites were randomly selected along a gradient of land use intensity as follows:

- Public and NGO open space within the UPR basin was identified by clipping RIGIS (2007) geospatial vector data-layers *State Conservation and Park Lands* and *Local and NGO Conservation and Park Lands*, to a shapefile delineating the Pawcatuck HUC 10 created from the RIGIS (2007) data-layer *NRCS HUC 12 Drainage Basins for RI*.
- The resulting ~500 polygons (of all documented open space within the basin) were each buffered by 100m, and a shapefile of the buffers was created. This buffer shapefile was used to clip the RIGIS data-layer *1995 Land Use for RI*, which classifies 1995 land use and land cover by the Andersen Classification Scheme.
- The resulting land use buffer polygons were analyzed to determine the proportion of *Urban or Built-up Land* (the remainder being natural lands) within each, and coded accordingly. The coded buffer polygons were then sorted and numbered (ranked) according to these human-use intensity proportions. Proportions ranged from 0.00 to 1.00. Thirty five buffers were selected evenly along that entire gradient from a random starting point between 0 and *n*/35.
- Two wetlands were randomly selected from each of the conserved properties that fell within the respective selected buffers, with the goal of identifying ~50 sites and the expectation of ~ten properties containing no wetlands. If a property did not contain at least two wetlands, one or zero was chosen from the property.

Forty eight sites were selected by the above methods. Six additional sites (A1 to A6) were selected specifically as pilot validation sites to test the RAM protocols against *Indices of Biotic Integrity* (IBIs) being developed by scientists at the University of Rhode Island (URI). These sites had been selected on the basis of size and disturbance intensity (Curtis and Paton, personal communication). Four targeted sites from outside the UPR basin (NK designation) were added to test groundwater metrics, resulting in *n*=54 for UPR basin sites and *n*=58 for groundwater metric testing. Refer to Appendix 5 for site maps and information.

2.3 Determination of Assessment Boundaries

GIS was used to facilitate the delineation of assessment boundaries according to ORAM protocols (Mack 2002). ORAM protocols determine assessment boundaries through a set of rules that differentiate wetland assessment units primarily by hydrologic discontinuity. The entire wetland unit is assessed. This differs from some protocols (e.g. DERAP) that select a standard-sized plot within each wetland unit as an “assessment area”. The existing geospatial wetlands data-layer, *Wetlands of Rhode Island, 1995* (RIGIS 2007) was used as a preliminary wetland identification tool. However, the RIGIS data were insufficient to determine boundaries for most wetlands, so refined delineations were *heads-up* (on-screen) digitized from 2004 leaf-off color digital orthophotography (RIGIS 2007).

2.4 Gaining Site Access

Permission to access wetland sites in 2007 was gained through telephone and email solicitation of fee or easement owners. Wetlands that were not available for access were replaced by the next closest conserved and accessible wetland. Three owners, all farmers, denied access to properties representing five sites, two of which could not be replaced according to replacement rules set *a priori*.

2.5 Site Investigations

Sites were primarily accessed on foot, or by canoe when necessary. Two investigators, a wetlands scientist and a qualified field assistant, assessed the perimeter and multiple transects of each site when feasible. Otherwise assessments were made by accessing as many points as possible.

Field maps of each site, produced using GIS, were utilized for field orientation and determining wetland community and buffer characteristics. Each map contained a backdrop of 2004 leaf-off color aerial photography at a scale sufficient to illustrate wetland habitats and surrounding land uses. A delineation of the assessment unit, a delineation of the boundary of conserved land, a scale bar, and identifying information overlaid were included. A Trimble *GeoXT* cartographic GPS unit was loaded with the same information, primarily for spatial confirmation and ground-truthing site delineations.

An interim field guide to invasive freshwater wetland plants of RI was also utilized in the field (App. 4). The guide was conceived and created by RINHS through searching the Invasive Plant Atlas of New England (IPANE, Mehrhoff et al. 2007) dataset for invasive species occurring in RI that are categorized as *Facultative* or wetter, review and revision by RINHS staff, and comparison to existing RINHS data. The guide was made by utilizing text and photography from the IPANE Database and elsewhere. It represents the most comprehensive list of known invasive freshwater wetland plant species available for the State of RI.

For most wetlands, a single 2007 modified field form (App. 3) was completed per wetland through consensus of both investigators. However, for 15 of the sites, investigators first assessed sites separately to facilitate an analysis of inter-user variability. Sites were assessed according to ORAM/DERAP protocols except as follows:

- ORAM and DERAP data were collected according to modifications listed previously in this report.
- ORAM and DERAP data were collected concurrently during a single site visit.
- DERAP data were applied to the ORAM scoring boundary for each site as opposed to a DERAP-recommended assessment area (*AA*).

2.6 Remote Investigations

Data obtained during field investigations were subsequently updated, complemented, or completed via GIS analysis before data entry. The following GIS operations were undertaken before data entry. Refer to modified field forms (App. 3) for clarification:

- Wetland size was determined to answer ORAM Metric 1.
- The RIGIS (2007) *FEMA Statewide Flood Zone Map* data-layer was overlaid to determine whether each wetland fell within a designated 100-year floodplain to partly answer submetric 3b.
- RINHS (2007) rare species geospatial data were buffered and laid over sites to determine any occurrences of state/federal threatened or endangered species, to partly answer ORAM Metric 5.
- The RIGIS (2007) *Sewered Areas* data-layer was overlaid to determine whether each wetland fell within a sewered area to partly answer DERAP buffer sub-attribute *If Developed, What Type of Sewage Disposal*.
- The RIGIS (2007) *Community Wellhead Protection Areas* and *Non-community Wellhead protection Areas* data-layers were overlaid to determine whether each wetland fell within a known groundwater withdrawal area. These data were used to determine if the modified DERAP metric *Soil Subsidence / Root Exposure* could be utilized to characterize the effects of long-term groundwater withdrawal. Refer to section 4.6 for outcomes.

3. Results of the 2007 Assessments

3.1 Assessment Effort

Field assessments were conducted by a team of two investigators at a total of 58 sites in 32 field days. The sites ranged from 0.08 to 494 acres. Field-times to asses sites ranged from one to seven hours, depending on site size, ease of access, and complexity, but an assessment generally took approximately two hours to complete. Daily driving distances ranged from 3 to 58 miles per day.

The remote assessments were conducted for all 58 sites in two additional office days by a single technician, which brings the total effort for 58 sites to 33 team-days, or 1.8 sites per team-day. Total wetland area assessed was 1250 acres for an assessment rate of 38 acres assessed per team-day.

3.2 ORAM Scores

ORAM scores were calculated for the 54 UPR basin wetlands assessed in 2007. Various statistics derived from the scores are presented below (Tables 4 and Fig. 1).

Table 4. ORAM scores for 54 wetlands assessed in the Upper Pawcatuck River basin in 2007

Site ID	ORAM Score	Site ID	ORAM Score	Site ID	ORAM Score
12c	19	*13*	69	*40*	82
A2	32	*A4*	72	*A5*	82
22	35	*2*	73	*26*	83
A1	43	*11b*	77	*3*	84
A3	43	*20*	77	*44*	85
10	55	*45*	78	*53*	85
51	57	*9*	79	*48*	86
33	58	*23*	79	*35*	87
17	58	*42*	79	*32*	88
5	62	*52*	79	*49*	89
24	62	*30*	80	*4*	90
25	63	*43*	80	*29*	91
8	64	*46*	80	*39*	91
14	65	*47*	80	*15*	92
18	66	*6*	81	*50*	93
10b	66	*38*	81	*1*	95
41	68	16	82	*7*	98
A6	68	*21*	82	28	98

Mean	73.91	Standard Deviation	16.89
Standard Error	2.30	Minimum	19
Median	79	Maximum	98
Mode	79	Count	54

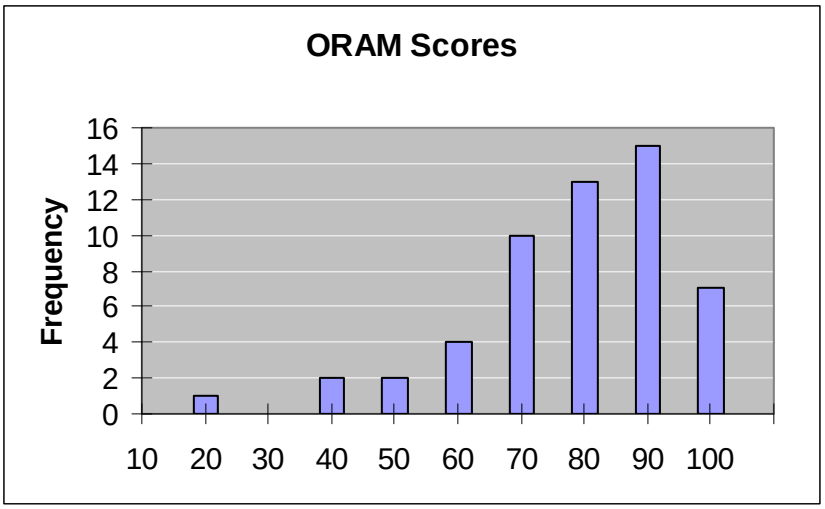

Figure 1. Distribution of ORAM scores for 54 wetlands assessed in the Upper Pawcatuck River basin in 2007

ORAM scores were correlated with the gradient of surrounding land use intensity used in site selection methods described in section 2.2 ($Rs = -0.61$, $P < 0.01$).

3.3 2006 and 2007 Comparisons

The application of ORAM in 2006 and 2007 allows a comparison of wetlands within each watershed through comparison of ORAM total scores (Table 5). The

Woonasquatucket River (WR) basin, sampled in 2006 is considerably more urbanized than the UPR basin, sampled in 2007, as is evident by proxies developed for this report.

Table 5. Proxies for land use intensity in basins studied in 2006 and 2007compared to mean ORAM scores. Data derived from RIGIS 2007. WR basin n=23; UPR Basin n=54

Attribute	WR Basin	UPR Basin
Road Density (ft/ac)	91.4	25.1
% Developed Land	62.9	26.3
ORAM Mean Score	65.5	73.9
ORAM Median Score	69	79

Note that ORAM mean and median scores for these two watersheds are indirectly related to development intensity, which is expected. Notable in Table 6 is the non-linear relationship between ORAM and land use scores. While land use intensity in the WR basin is 3.6 to 2.4 times greater by the two proxies, ORAM scores are only approximately 11% lower. Given that ORAM scores may range from 0 to 100, the apparent lack of sensitivity could reflect any number of possible factors, such as buffer effectiveness, wetland resiliency, strong wetland regulation within the State, threshold effects, or general RAM function.

Individual ORAM metric and submetric scores may also reveal trends for comparisons between watershed basins. The use of metric scores that incorporate and transform ecological data into a numeric format helps clarify the relationships between the two basins (Table 6).

Table 6. Mean scores of various ORAM metrics attributed to wetlands within separate RI HUC 10 drainage basins in 2006 and 2007 RAM investigations. WR basin n=23; UPR basin n=54

Metric / Submetric	Score	WR Basin 2006		UPR Basin 2007		
	Range	*Mean*	*SD*	*Mean*	*SD*	*t-test*
Wetland Area	0 to 6	3.5	1.1	3	1.3	0.29
Average Buffer Width	0 to 7	4.8	2.5	5	2.4	0.58
Surrounding Land Use Intensity	1 to 7	4.6	1.6	5.3	1.7	0.09
Sources of Water	1 to 7	5.9	2.8	6.1	2.4	0.57
Connectivity	0 to 4	2.6	1.0	2	1.2	0.05
Maximum Water Depth	1 to 3	1.6	0.6	2.7	0.6	<0.01
Duration of Inundation/Saturation	1 to 4	2.9	0.9	2.9	0.7	0.53
Hydrologic Modification	1 to 12	9.4	2.9	8.4	3.4	0.18
Substrate Disturbance	1 to 4	3.6	0.9	3.7	0.7	0.62
Habitat Development	1 to 7	5.3	1.4	5.7	1.3	0.19
Habitat Alteration	1 to 9	7.2	2.5	6.8	2.0	0.37
Special Community	0 to 10	2.8	3.6	6.5	3.8	<0.01
Wetland Vegetation Community	0 to 18	6.7	2.5	7.5	2.7	0.06
Horizontal Interspersion	0 to 5	3.3	1.4	3.1	1.6	0.01
Invasive Plant Cover	-5 to 1	-0.2	1.1	0.6	0.7	<0.01
Microtopography	0 to 12	4.4	2.0	7.3	2.9	<0.01

Useful information can be derived from these mean metric scores. For example, invasive plant cover is higher overall in the WR basin (denoted by a *lower* score), while the

average buffer width is nearly the same, suggesting effects of the strict State-wide buffer standards imposed in RI.

Some trends seen in Table 6 are real, while others may be artificial, particularly since a different team of investigators assessed wetlands in 2006 versus 2007. Each team may have interpreted the scoring of certain metrics, especially the more subjective ones, differently. Suspect in that regard are the scores for *Hydrologic Modification*. Scores suggest that wetlands within the far more densely-developed WR basin have the same or lower incidence of hydrologic modification than those of the less-developed UPR basin; this is likely the effect of 2007 investigators consistently (slightly) demoting the scores of wetlands with historic but persistent modifications (e.g. historic impounded mill pond habitats), while 2006 investigators likely used the recommended but subjective "best judgment" approach. Also note that the apparent difference in the scores of *Special Communities* is certainly at least partly due to the development and inclusion of RI *Special Community* types implemented in 2007 that were unavailable in 2006.

3.4 Metrics Classes

Individual metric and submetric classes were determined for each of the sites. Although they were designed specifically for scoring and subsequent summing into a total score, some metric classes may individually be applicable for various analyses including change detection. However, the classes for certain metrics may be too coarsely categorized (e.g. *Intensity of Surrounding Land Use*), too subjective (e.g. *Habitat Development*), or too difficult to accurately assess (e.g. *Sources of Water*) to be applied individually to any single wetland (or set of wetlands, for that matter) with any degree of certainty or utility, especially for comparative analyses.

Some metric class data can still supply specific descriptive information from which inferences can be drawn. To illustrate this, metric class scores from wetlands assessed in 2006 and 2007 are summarized in bar graphs and attached as Appendix 6. These data suggest, for example, that the deeper 2007 wetlands (*Maximum Water Depth* metric) logically contain a higher number of potential amphibian breeding pools (*Microtopography: Amphibian Breeding Pools* metric) than the shallower 2006 wetlands. Certain similarities are also evident. For example, vegetative composition is similar between years, indicating the regional dominance of red maple swamps. For descriptive applications, metric classes can cautiously be utilized as demonstrated in the following profile.

3.5 Upper Pawcatuck River Basin Wetland Profile

The Upper Pawcatuck River (UPR) watershed is a 98,000-acre HUC10 drainage basin located in central RI containing 19,900 acres of freshwater wetlands. The dominant wetland type (by area) is forested deciduous (68%), with forested coniferous (17%), shrub swamp (8%), shrub fens and bogs (3%), open water (3%), and emergent wetlands (2%) comprising the remainder (derived from *Wetlands of RI—1988*, RIGIS 2007).

ORAM-DERAP investigations were conducted on a sample of 54 freshwater wetlands within the basin in 2007. Total area of assessed wetlands is 1,120 acres. The dominant

wetland type (by area) within the sample is forested deciduous (70%), with forested coniferous (15%), shrub swamp (7%), shrub fens and bogs (3%), open water (2%), and emergent wetlands (1%) comprising the remainder (derived from *Wetlands of RI—1988*, RIGIS 2007). The following statements in this section are derived from UPR basin sample data collected in 2007.

When separated into distinct units by hydro-geomorphic (HGM) boundaries, the UPR wetlands sampled range in size from <0.1 to >50 acres with the majority falling between 0.3 and 3 acres. The dominant HGM class is *Depressional* (74%), followed by *Riverine*. The majority (84%) of wetlands are at least partly groundwater fed, while 65% are at least partly surface-water fed. Eighty seven percent of wetlands are part of a natural complex, 43% are within a riparian corridor, 35% buffer surface-waters from land use, and 30% act as floodplain buffers. Most wetlands are >0.7m in maximum depth and the majority are seasonally inundated.

According to RAM data, over 90% of the wetlands contain both a forested and shrub component, 85% contain some emergent component, and 28% contain an aquatic bed component. Sixty one percent of the wetlands contain mature swamps; most are dominated by red maple (*Acer rubrum*), and 9% contain Atlantic white cedar swamps. One third (33%) of all wetlands contain vernal pools, while fens or bogs are component in 20%, and 4% are known to contain threatened or endangered species.

About two thirds of all UPR basin wetlands sampled contain low to moderate amounts of course woody debris while a quarter of them contain high amounts of high-quality course woody debris. Similarly, two-thirds of wetlands contain low to moderate amounts of standing dead snags, while 10% contain high-quality snag habitat. Over half (53%) of the wetlands contain high-quality breeding habitat for amphibians, while another third contain moderate-quality habitat.

Over half of the UPR basin wetlands sampled have a wide average buffer width (>50m according to ORAM methods) and the land use intensity in the 100-m buffer zone is predominantly a mix of very low (component in 67%) and moderately high (component in 43%). The most common hydrologic disturbance to the wetlands is impoundment. Half of all wetlands are hydrologically affected either by road beds or railroad tracks (45%), or by diking (5%). Ditching or dredging affect 20% of wetlands, while 12% are partly filled. About 6% of wetlands are hydrologically changed as the result of historic impoundments created over 100 years ago.

Direct disturbances to habitats are less common; one third of the wetland habitats are recently structurally affected by humans. Woody debris removal in about 10% of wetlands is the most common impact, represented mostly by the dismantling of beaver dams. Toxic pollutants, clear cutting, nutrient enrichment, sedimentation, and shrub removal each occur in about 5% of UPR wetlands, while selective cutting, farming, and mowing are even less common. Approximately 80% of the wetland sites (virtually all forest-dominated sites) have historically been clear cut and/or farmed.

Approximately 40% of UPR wetlands sampled appear to have no signs of hydrologic alterations and another 10 % appear completely recovered from historic impoundments.

Over half of the wetlands are nearly recovered from former clear cutting, while 14% show no signs of direct (structural) habitat disturbance. Habitat development in wetlands rates as very good in 43% and excellent in 28%; only 5% rated as *poor to fair* or *poor*. Invasive species were observed to be absent in 69% of wetlands, nearly absent (<5% cover) in 24%, sparse (5-25% cover) in 5%, and moderate (25-75% cover) in only 2%. The most common invasive species observed in UPR basin wetlands is common reed (*Phragmites australis*), followed by Japanese barberry (*Berberis thunbergii*), mostly growing in intermittent streambeds (Fig. 2, Table 7).

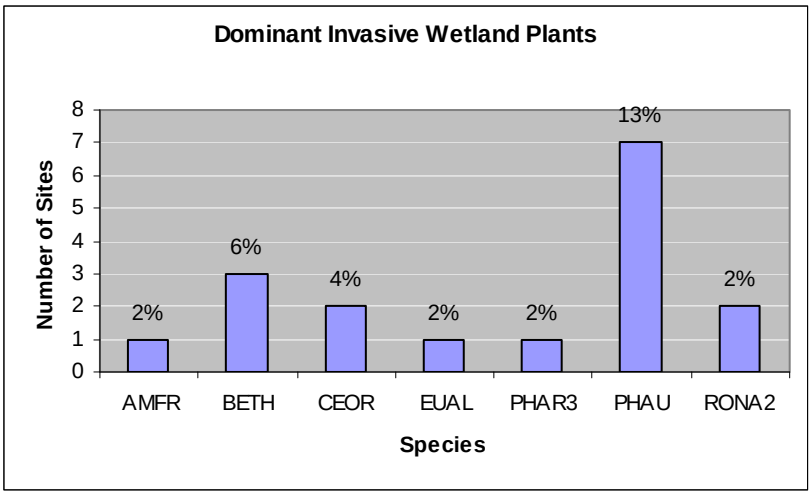

Figure 2. The most dominant invasive plant species observed per wetland unit in 2007 RAM investigations of 54 wetlands within the UPR basin. Refer to Table 7, below for plant codes.

Table 7. Complete list of invasive species observed in UPR basin wetlands in 2007 RAM surveys

Common Name	Scientific Name	NRCS Code
False Indigo	*Amorpha fruticosa*	AMFR
Common Barberry	*Berberris thunbergii*	BETH
Oriental Bittersweet	*Celastrus orbiculatus*	CEOR
Autumn Olive	*Elaeagnus umbellata*	ELUM
Winged Euonomus	*Euonomous alata*	EUAL
Purple Loosestrife	*Lythrum salicaria*	LYSA2
Amur Corktree	*Phellodendron amurense*	PHAM2
Reed Canary-grass	*Phalaris arundinacea*	PHAR3
Common Reed	*Phragmites australis*	PHAU
Japanese Knotweed	*Polyganum cuspidatum*	POCU
Common Buckthorn	*Rhamnus frangula*	RHFR
Multiflora Rose	*Rosa multiflora*	ROMU
True Watercress	*Rorripa nasturtium*	RONA2
Bittersweet Nightshade	*Solanum dulcamara*	SODU

4. Analysis and Enhancement of RAM Utility

Spearman rank correlation analysis was used to calculate all correlation coefficients (r) in this section to accommodate the ordinal nature and skews inherent in RAM data.

4.1 Inter-user variability

As previously indicated, certain ORAM metrics and submetrics may be too subjective or difficult to determine to be utilized individually with any degree of confidence. To investigate this, ORAM scores and individual metric and submetric scores of 15 sites from simultaneous-but-separate assessments of two investigators are compared here to demonstrate inter-user variability in score assignments. The investigators assessed numerous wetlands together in advance of this experiment, so variations in interpretation of methods should be discounted.

Table 8. Correlation and probability values among two investigators separately assessing 15 wetlands by ORAM methods (*df* =14).

ORAM Metric/submetric	Mean 1	(SD)	Mean 2	(SD)	Rs	Mean % Difference	Paired *t*-test (P)
Sources of Water[1, 2]	7.5	(3.0)	7.6	(3.6)	0.37*	21	0.89
Hydrologic Modification[1, 2]	6.9	(2.8)	7.5	(3.0)	0.44*	10	0.30
Habitat Development[2]	5.7	(1.5)	5.9	(1.5)	0.58	8	0.50
Maximum Water Depth[1]	2.7	(0.6)	2.7	(0.6)	0.62	10	1.00
Surrounding Land Use[2]	4.7	(1.6)	4.7	(1.6)	0.71	7	0.81
Average Buffer Width[2]	3.9	(2.1)	4.5	(2.5)	0.73	14	0.19
Substrate Disturbance[2]	3.8	(0.8)	3.7	(0.9)	0.73	3	0.33
Special Wetlands	8.0	(3.7)	8.0	(3.7)	0.75	7	1.00
Habitat Alteration[1, 2]	6.6	(2.4)	6.4	(2.3)	0.77	9	0.64
Vegetation Communities	9.7	(3.2)	9.2	(3.1)	0.80	7	0.20
Duration of Inundatio/Saturation[1]	2.9	(0.5)	2.9	(0.6)	0.81	6	0.83
Connectivity	2.6	(1.1)	2.5	(1.1)	0.82	10	0.43
Horizontal Interspersion	2.9	(1.7)	2.9	(1.9)	0.85	11	1.00
Invasive Plant Cover	0.3	(0.8)	0.3	(0.7)	0.90	3	0.58
Microtopography	8.7	(3.1)	9.1	(3.1)	0.90	7	0.17
Wetland Area	3.9	(1.5)	3.9	(1.5)	1.00	0	1.00
Total ORAM Score	77.7	(17.9)	78.2	(19.8)	0.85	5	0.75

[1]classes are difficult to determine
[2]classes are somewhat subjective
*not a significant correlation

Note that no metrics are scored differently (P<0.05) in a paired *t*-test between investigators; however, Spearman rank correlation coefficients (Rs values) indicate that the precision of their scoring varies among metrics. *Sources of Water* and *Maximum Water Depth* metrics are difficult to accurately determine in the field, as they are estimated by interpretation of past hydrologic effects on vegetation and the landscape; hence the inconsistencies in scoring as indicated by relatively low Rs values. Similarly, metrics characterizing recovery from hydrologic and habitat alterations are highly subjective, requiring the rater to score the wetland on a scale from no-recovery to full-recovery, or as never affected. *Wetland Area* scores were determined through automated

GIS analysis and therefore are entirely objective and precise among users. Other metrics are subject to user-bias as indicated in Table 8.

4.2 Recategorization of Metrics

In a national meta-analysis of RAM utility in assessing wetland *condition*, Fennessy et al. (2004) pointed out that the ORAM contains certain metrics that score wetland *value*, are not specifically indicative of condition, and are therefore somewhat confounding. Although a score incorporating both condition and these *value-added* metrics may be useful in policy for determining the relative protection a particular wetland deserves based on its net value (as ORAM is applied in Ohio), that function is not necessary or even desirable for application in Rhode Island since all wetlands are protected equally. Furthermore, both DEM and USEPA are more interested in quantifying changes in wetland *condition* than determining measures of intrinsic *value*. For the purpose of characterizing wetland condition, it may be more appropriate to separate any metrics characterizing value from measures characterizing condition. Since Mack (2002) intended for certain metrics to characterize the capacity of a wetland to perform certain functions (which are of *value* to humans and wildlife), the term *Functional Capacity* is applied to them here for analysis. ORAM metrics were thus separated into three categories as follows:

- ***Functional Capacity*** metrics: intended to indicate the relative functional capacity of each wetland by size; sources, connectivity, depth, and duration of water; habitat heterogeneity; and conservation status.
- ***Stressor*** metrics: characterizing and evaluating each wetland by buffer degradation and direct and indirect modifications to hydrology and habitats.
- ***Condition*** metrics: characterizing and evaluating habitat health by habitat development and response to *stressors*.

By simply applying and summing existing, tested ORAM metric and submetric scores, total scores for each metric category can be determined for each wetland, resulting in three separate scores for each wetland's *Functional Capacity*, *Stressor* occurrence, and *Condition*. Categorization of ORAM metrics and submetrics under this strategy are as outlined in Table 9.

Table 9. Preliminary recategorization of metrics and submetrics of the ORAM for analysis of application in RI

Functional Capacity Metrics Wetland Area (size) Hydrologic Function ▪ Sources of Water ▪ Connectivity ▪ Maximum Water Depth ▪ Duration of Inundation/saturation Habitat Function ▪ Wetland Vegetation Communities Present ▪ Horizontal Interspersion ▪ Microtopography Special Wetlands
Stressor Metrics Upland Buffers and Surrounding Land Use ▪ Average Buffer Width ▪ Intensity of Surrounding Land Use Habitat Stressors ▪ Substrate Disturbance
Condition Metrics Hydrologic Condition ▪ Modifications to Hydrologic Regime (Recovery) Habitat Condition ▪ Habitat Alteration (Recovery) ▪ Habitat Development ▪ Coverage of Invasive Plants

Scoring these categories separately will be more useful to RI managers and decision makers than a computing a single, total (ORAM) score, since certain logical relationships exist between them. As a matter of practicality in RAM applications, general wetland condition is often characterized by the identification and scoring of a combination of both *Stressors* (indirect indicators of wetland condition) and *Condition* (direct indicators of wetland response to those stressors). However, separating the *Stressor* and *Condition* metrics facilitates analyses investigating *Stressors* imposed on an area of interest and determining their relative or cumulative effects on wetland *Condition*.

Because the *Functional Capacity* metrics are intended to compare the functions and values of wetlands, which are largely intrinsic in wetland *type* and *size*, they cannot logically be used to measure wetland condition. Conversely, the *Condition* and *Stressor* metric scores, which do not incorporate measures of intrinsic function and value, can be used to characterize wetlands of any type and size. Since imposing a value score is neither necessary nor desirable in RI, it is highly advantageous to calculate the scores of these metric categories separately and *not* calculate a score combining condition and value, as ORAM prescribes.

4.3 Preliminary Validation of Reorganized Metric Categories

The validity of metric recategorization by utility; *Functional Capacity*, *Stressors*, and *Condition* as outlined above, was examined through inter-metric comparisons as follows. First, *Stressor* scores were plotted against *Condition* scores to evaluate the expected respective cause-and-response relationship between them. Second, *Functional Capacity* scores were plotted against *Condition* scores to determine if a relationship exists between capacity and condition (Fig. 3). This analysis was performed on 2006 and 2007 combined data to create a more robust dataset for analysis (*n*=85) and minimize user effects.

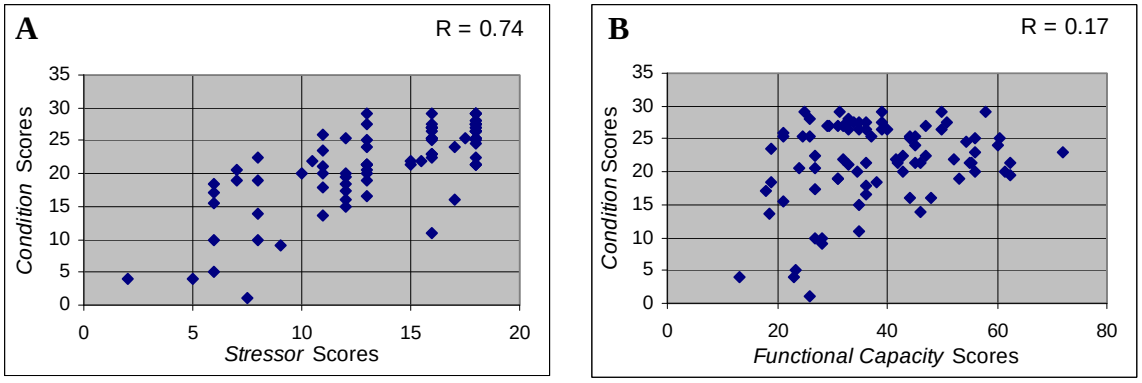

Figure 3. Selected score comparisons of recommended metric categories derived from *ORAM v. 5.0 Quantitative* field data collected at 85 sites in RI (A: P<0.01, B: P=0.28)

Note the strong correlation between *Stressor* and *Condition* scores (Fig. 3A). This indicates a logical cause-and-response relationship between the independent *Stressor* variable and the dependent *Condition* variable (note that a higher *Stressor* score indicates *less* stressor impacts), and suggests the soundness of each individual category through inter-validation. The relationship between stressors and condition is likewise supported in further analyses below.

In contrast, note the weak relationship between *Functional Capacity* and *Condition* scores (Fig. 3B). Although a moderate relationship develops as wetland conditions deteriorate beyond a certain threshold (Rs = 0.54 for sites with *Condition* scores less than 25), the trend supports the validity of separating out *Functional Capacity* metrics to remove any confounding effects they may have on the RAM's utility in characterizing wetland condition, as presumed earlier.

This trend is also evident against an automated GIS land use intensity proxy reflecting the percent cover of natural land within the 100-m buffer zone surrounding each wetland surveyed in 2007. These data were derived from the new RIGIS (2008) Land Use/Land Cover dataset based on 2004 imagery.

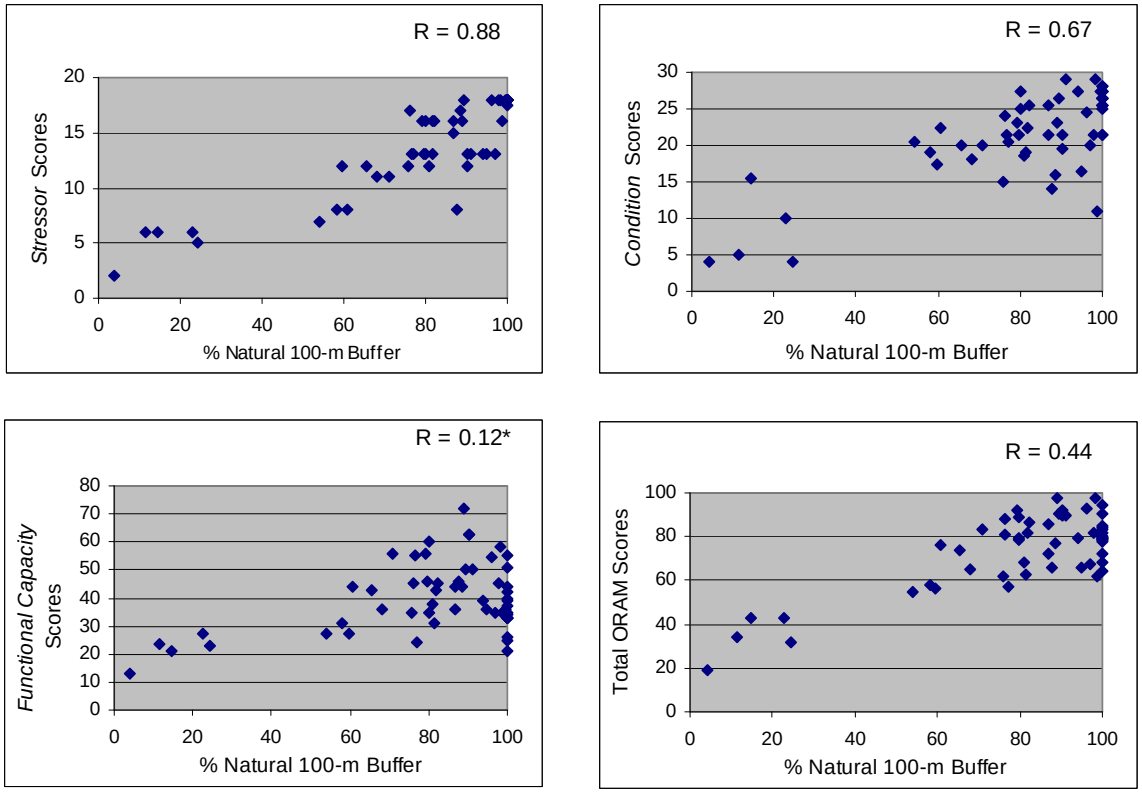

Figure 4. Metric category and total *ORAM* scores derived from *ORAM v. 5.0 Quantitative* field data collected at 58 wetlands in RI compared against GIS-derived LC/LU data (P<0.01 for all except *P=0.42).

There is a logical, strong relationship between the *% Natural 100-m Buffer* and *Stressor* scores (note again that a higher *Stressor* score indicates *less* stressor impacts). *Condition* score correlations are slightly weaker (as expected, since condition is indirectly affected by surrounding landscape stressors), while the addition of the non-correlated *Functional Capacity* metric scores (resulting in ORAM total) lessens the strength of the RAM's correlation considerably. Note: the use of Spearman rank correlation effectively removed the evident gap in the buffer data (*x* axis).

Preliminary evidentiary support for metric recategorization is illustrated below in regression analyses between piloted IBIs (faunal bio-indicators) and RAM scores. Although the low number of data points render this analysis tenuous, the results further suggest that combining the metrics into a total score may weaken the validity and utility of the data for certain applications (Fig. 5).

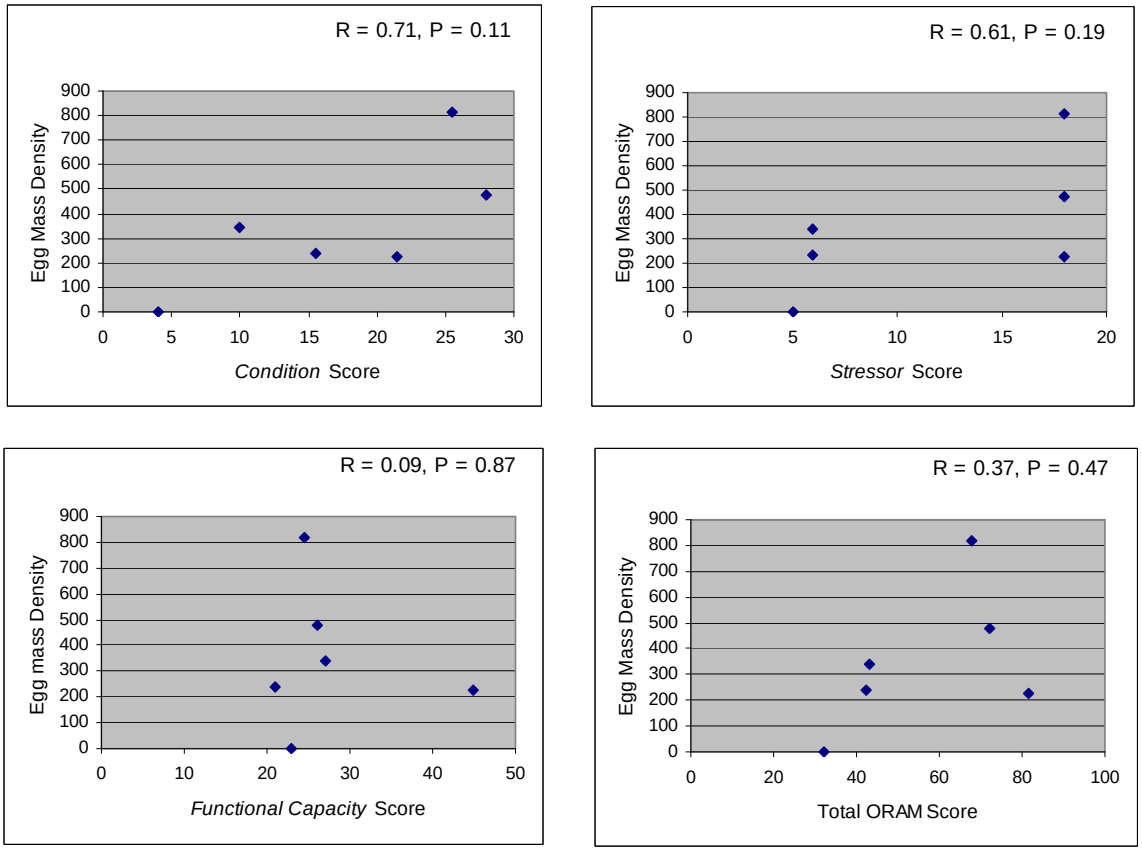

Figure 5. Estimated wood frog egg mass densities shown in relation to various metrics derived from *ORAM v. 5.0 Quantitative* field data collected at six vernal pools in RI. Egg mass data are courtesy of Curtis and Paton (unpublished data 2007).

Note that the pilot data suggest that wood frog (*Rana sylvatica*) egg mass densities may correlate with *Condition* metric scores and likewise show a positive trend with *Stressor* effects (note again that a higher *Stressor* score indicates *less* stressor impacts; Fig. 5). No trend is indicated with egg mass densities versus *Functional Capacity* metrics, and the summation of these into a *Total* ORAM score weakens the apparent relationship with *Condition* and *Stressors*. This mirrors trends shown in Figure 4. The trend is further supported in analyses versus other pilot IBI indicators (Table 10).

Table 10. Spearman rank correlation coefficients of wood frog percent presence (density) and amphibian richness in relation to metrics derived from *ORAM v. 5.0 Quantitative* field data collected at six vernal pools in RI (*df*=5). All amphibian data are courtesy of Curtis and Paton (unpublished data 2007).

Variables	Rs value	P value
Wood Frog % Presence versus *Condition*	0.83	0.02
Wood Frog % Presence versus *Stressors*	0.62	0.13
Wood Frog % Presence versus *Functional Capacity*	0.09	0.84
Wood Frog % Presence versus *Total Score*	0.37	0.38
Amphibian Richness versus *Condition*	-1.00	<0.01
Amphibian Richness versus *Stressors*	-0.93	<0.01
Amphibian Richness versus *Functional Capacity*	-0.26	0.55
Amphibian Richness versus *Total Score*	-0.77	0.04

Table 11 shows inter-user variability in rating metric categories compared with the total ORAM scores. Correlation coefficients (Rs) indicate the relative extent that precision between users is preserved when metrics are categorized; none is lost when *Stressor* and *Condition* metric scores are recombined without *Functional Capacity*.

Table 11. Spearman rank correlation (Rs) and probability (P) values among two investigators separately assessing 15 wetlands by modified ORAM methods (*df* =14, P<0.05 for all correlations)

Metric Category	Mean Score 1	(SD)	Mean Score 2	(SD)	Rs value	Paired *t*-test (P)
ORAM Total	77.0	(17.9)	78.2	(19.8)	0.85	0.75
Functional Capacity	48.7	(15.3)	49.0	(13.3)	0.94	0.87
Stressors	12.9	(4.3)	12.5	(4.0)	0.78	0.47
Condition	20.1	(5.8)	19.5	(5.2)	0.55	0.50
Stressors + Condition	32.9	(9.4)	32.0	(8.3)	0.87	0.25

Combined results of the pilot IBI data analyses, inter-metric analyses, and inter-user variability analyses presented here supply preliminary evidence to validate the ORAM protocols and support the logic presented in recategorizing its metrics. It is therefore recommended that metrics are reorganized into *Functional Capacity*, *Stressor*, and *Condition* categories for further testing and subsequent application in Rhode Island.

Finally, since the scoring of wetland functions and values is undesirable in Rhode Island, metrics intended to indicate wetland *Functional Capacity* may instead be viewed strictly as intrinsic wetland characteristics. It is therefore recommended that scoring be removed from these metrics and that they are henceforth referred to as ***Wetland Characteristics***.

4.4 Enhancement of Stressor Metrics

Within-Wetland Metrics

Although *Stressor* metrics have been shown to correlate with *Condition* metrics (Fig. 3), it is notable that, according to strict ORAM protocols, scoring for *Stressors* is limited to a semi-quantitative characterization of the upland buffer and a single metric scoring substrate disturbance. Other stressors are denoted in a checklist box intended to influence the scoring of *Condition* metrics 3e and 4c, but are not scored (App. 1). As discussed in section 2.1, a scoring system was developed for application in 2007 site investigations, where a score of zero to three was applied to quantify the apparent intensity of each stressor. In an effort to enhance the power and utility of the *Stressor* category, these scores were combined with existing *Stressor* metric scores as follows. For clarification, refer to Appendix 7, proposed *RIRAM v.1* field form.

- ORAM submetric 4a *Substrate disturbance* was incorporated into stressor boxes for equal scoring with other in-wetland stressors
- New enhanced intensity scores for boxed stressor attributes were summed for each wetland
- The sum of the stressor intensity scores was subtracted from seven (7) for each of the two metrics *Hydrologic Stressors* and *Habitat Stressors*
- These metric scores were added to existing buffer stressor metric scores to produce a *New Stressor* metric score

The new scores were plotted against *Condition* metric scores for 2007 sites with the following results (Fig. 6).

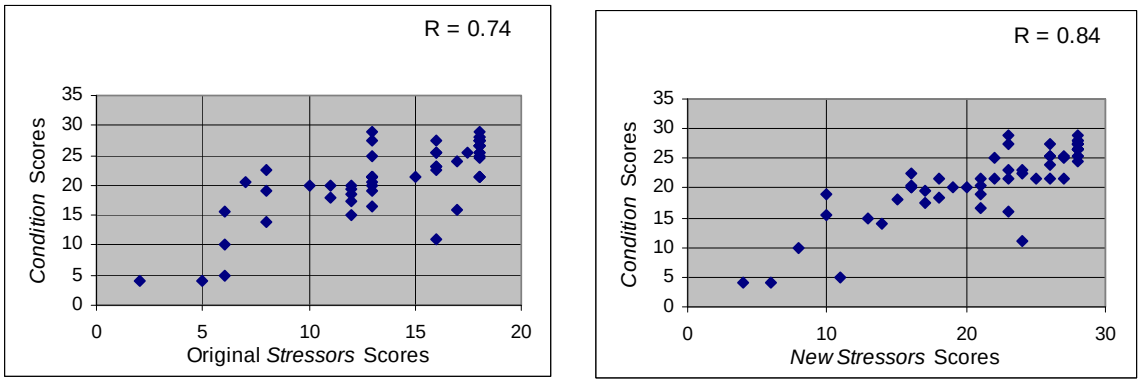

Figure 6. Score comparisons of original and enhanced *Stressor* metric categories derived from enhanced *ORAM v. 5.0 Quantitative* field data collected at 58 sites in RI (P<0.01 for both).

Note that the enhanced *New Stressor* metric scores show a stronger relationship to *Condition* metric scores than original *Stressor* scores. This indicates that, in addition to adding more information to the assessment, the rating of within-wetland stressors enhances the analytical utility (e.g. predictive power) of the data. This is supported by analysis of these metrics versus pilot IBI data as follows:

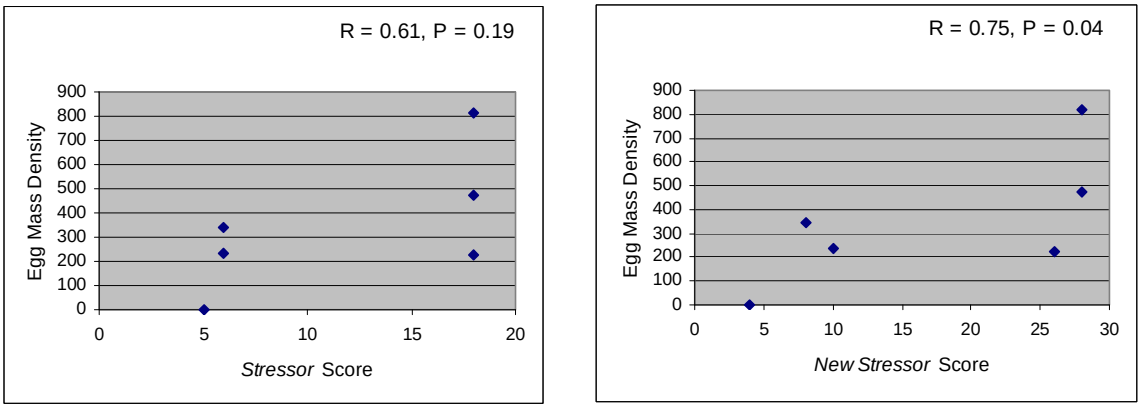

Figure 7. Original and enhanced *Stressor* metric categories derived from enhanced *ORAM v. 5.0 Quantitative* field data versus pilot IBI data collected at 6 sites in RI. Egg mass data are courtesy of Curtis and Paton (unpublished data 2007).

The increase in the apparent relationship between *New Stressors* scores and wood frog egg mass densities compared with original *Stressor* scores (Fig. 7) shadows the change in relationship indicated in Figure 6. This trend is further mirrored in the relationships of original *Stressors* and *New Stressors* scores versus other pilot IBIs as follows (Table 12):

Table 12. Wood frog percent presence (density) and amphibian richness shown in relation to standard and enhanced *Stressor* metric scores derived from *ORAM v. 5.0 Quantitative* field data collected at six vernal pools in RI (df=5). All amphibian data are courtesy of Curtis and Paton (unpublished data 2007).

Variables	Rs value	P value
Stressors versus Wood Frog % Presence	0.62	0.10
New Stressors versus Wood Frog % Presence	0.81	0.02
Stressors versus Amphibian Richness	-0.93	<0.01
New Stressors versus Amphibian Richness	-0.99	<0.01

The above analyses provide reasonable evidence that the proposed enhancements will improve the utility of these data. The rating and scoring of within-wetland *stressor* metrics (this enhanced method discussed) also provides a more information and utility than the original ORAM checklist by identifying the stressors that are least and most likely to contribute to wetland degradation. Their use is thus recommended here for application in RI.

Buffer Metrics

In a draft report on RAM evaluation in 2006, DEM noted that the ORAM buffer submetrics (App. 1, metric 2) were difficult to determine in the field and are somewhat qualitative (DEM 2006). Specifically, the *Buffer Width* submetric (metric 2a) is difficult to determine by average and the *Surrounding Land Use* submetric (metric 2b) is partly subjective. These same conclusions were independently reached during the 2007 field investigations. To address these issues, a series of trial metrics was developed and tested using GIS and 2004 DOQ aerial photography (RIGIS 2007).

First, a submetric was developed to be tested against ORAM metric 2a (*Buffer Width*). The original Buffer Width metric required the user to estimate the average width of natural buffer directly adjacent to the wetland. Although the concept is simple and functional, in practice the determination of "average" width is perplexing and somewhat subjective since the user must decide how many widths to use to estimate average based on the variations of wetland shape and land cover within the buffer. To alleviate this, the following metric was devised under the logic that a more highly developed 50-m buffer-zone will possess a narrower effective buffer width than a less developed zone:

> *Estimate % cultural cover within 50-m buffer* (*% Cultural 50-m*): This proposed submetric uses GIS to delineate a 50-m buffer around each site. The investigator estimates the percent of cultural (non-natural) cover within the buffer area by examining leaf-off aerial photography of the landscape and assigning a proportion by the predetermined classes. Classes are scored with analogous intensity to ORAM 2a (maximum 7 points). The original and prototype submetrics (*Buffer Width* and *% Cultural 50-m*, respectively) were regressed against *Condition* metric scores resulting as follows (Fig. 8):

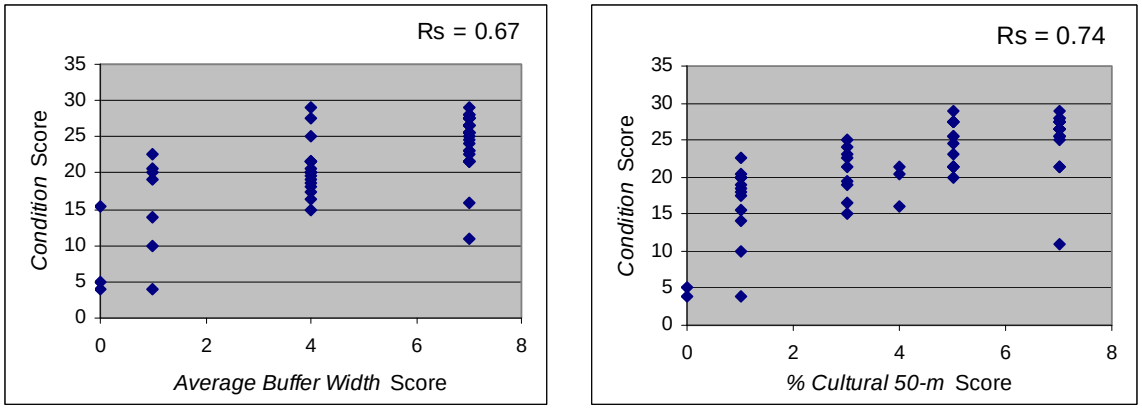

Figure 8. Score comparisons of standard and enhanced buffer *Stressor* metric categories derived from enhanced *ORAM v. 5.0 Quantitative* field data collected at 58 sites in RI (P<0.01 for both).

The strength of the relationship is higher than the original and the proposed method is more quantitative since it is based on well-accepted and more objective estimations of percent cover than the estimation of *average* width (Fig. 8). This metric is also highly correlated with (Rs=0.83) and logically analogous to the original *Buffer Width* metric; ranging from *<1% cultural cover* scoring the same as *Wide* (>50-m) *average buffer* (7 pts) to *>75% cultural cover* scoring the same as *Very narrow average buffers* (0 pts). The prototype method necessitates the interpretation of recent, high-resolution aerial imagery; but in 2007 assessments the investigators relied almost exclusively in aerial images to score the original metric as well. The change in this submetric from ORAM *Buffer Width* (App. 1, submetric 2a) to *% Cultural 50-m* (App. 7, submetric 5a) is therefore recommended for future application in RI.

The semi-quantitative ORAM *Surrounding Land Use* submetric (App. 1, submetric 2b) is similarly subjective. The rater is asked to determine the intensity of land use within a 100-m buffer-zone by choosing the best fit of four scenarios (*Very Low*, *Low*, *Moderately High*, or *High*) and scoring accordingly; or to chose two of them and average. Many buffer-zones contain a variety of land cover intensities distributed throughout the zone, which makes choosing one or two representative categories perplexing. To address this, three initial alternate, more objective GIS-based submetrics were tested against submetric 2b; the results were unsatisfactory (Table 13).

Table 13. Various original and prototype buffer submetrics compared with *Condition* metrics derived from *ORAM v. 5.0 Quantitative* field data collected at 58 sites in RI.

Variables	Rs value	P value
Surrounding Land Use (original 2b) versus *Condition*	0.66	<0.01
Primary Land Cover versus *Condition*	0.60	<0.01
% Cultural Land Cover versus *Condition*	0.63	<0.01
Characteristic Cultural Land Cover versus *Condition*	0.55	<0.01

Explanations for the above trial metrics are as follows:

- *Primary Land Cover* rates each wetland according to the *dominant land cover* in the 100-m buffer
- *% Cultural Land Cover* rates each wetland according to the percentage of non-natural lands within the 100-m buffer
- *Characteristic Cultural Land Cover* rates each wetland according to the *dominant* type of *non-natural* land cover within the 100-m buffer

Note that trial buffer metrics are somewhat inferior to the original buffer submetric *Surrounding Land Use* in predicting *Condition* scores. In an attempt to create a *better* metric than the original, wetland buffers were reevaluated by proportioning each existing class in the *Surrounding Land Use* submetric per wetland. Each class score was weighted by proportion of cover it represented within each 100-m buffer to the nearest tenth to produce a weighted average. For example, a 100-m buffer with estimated 60% *Very Low* (7pts), 10% *Low* (5pts), 20% *Moderately High* (3pts), and 10% *High* (1pt) land uses would be scored as follows:

$$(0.6\times7) + (0.1\times5) + (0.2\times3) + (0.1\times1) = 5.4$$

The method was made further quantitative by specifically identifying the types of land uses and covers comprising each class. This method was implemented for the 2007 sites; 58 wetland buffers were assessed, input, and computed using GIS and Excel in less than three hours. Aerial photos would be entirely suitable as a substitute for GIS. Using these more quantitative weighted average values enhances the submetric's prediction of wetland *Condition* (Fig. 9).

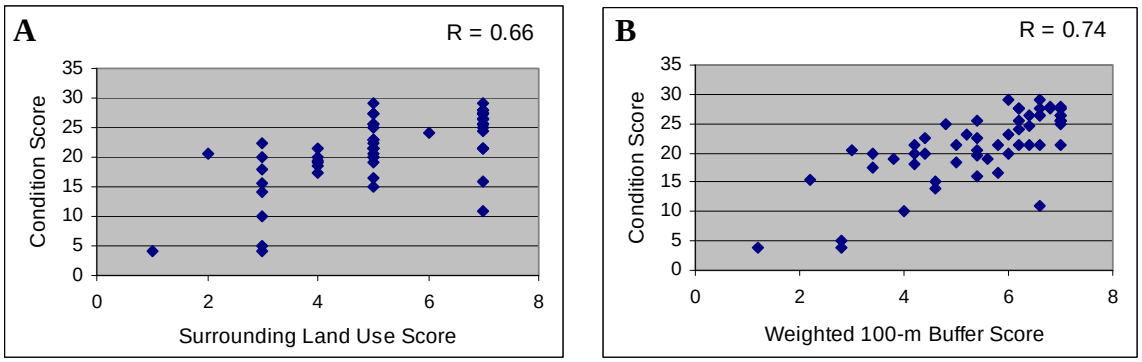

Figure 9. Original and prototype land use submetrics compared with *Condition* metrics derived from *ORAM v. 5.0 Quantitative* field data collected at 58 sites in RI (P<0.01 for both).

An enhanced, strong correlation is evident between the *Weighted 100-m Buffer* scores and the (independently assessed) *Condition* scores compared to that of the original metric versus *Condition*. This clarifies the relationship between buffer stressors and wetland condition, and provides more quantitative data. The improved metric also documents more information in the raw data for each wetland, including a high-resolution proxy for the proximate land use intensity and the estimated areal cover of the various land use classes. The use of this *Weighted 100-m Buffer* submetric is therefore recommended for use in RI RAM applications.

Notable is the fact that buffer and *Condition* metrics compared here are assessed independently, indicating that *Weighted 100-m Buffer* alone may serve as a useful proxy for predicting *condition* in a remotely-sensed setting for application in Level 1 landscape assessments. To investigate its utility in remote application, *Inclusive 100-m Buffer* was further applied to 2007 sites (Fig. 10).

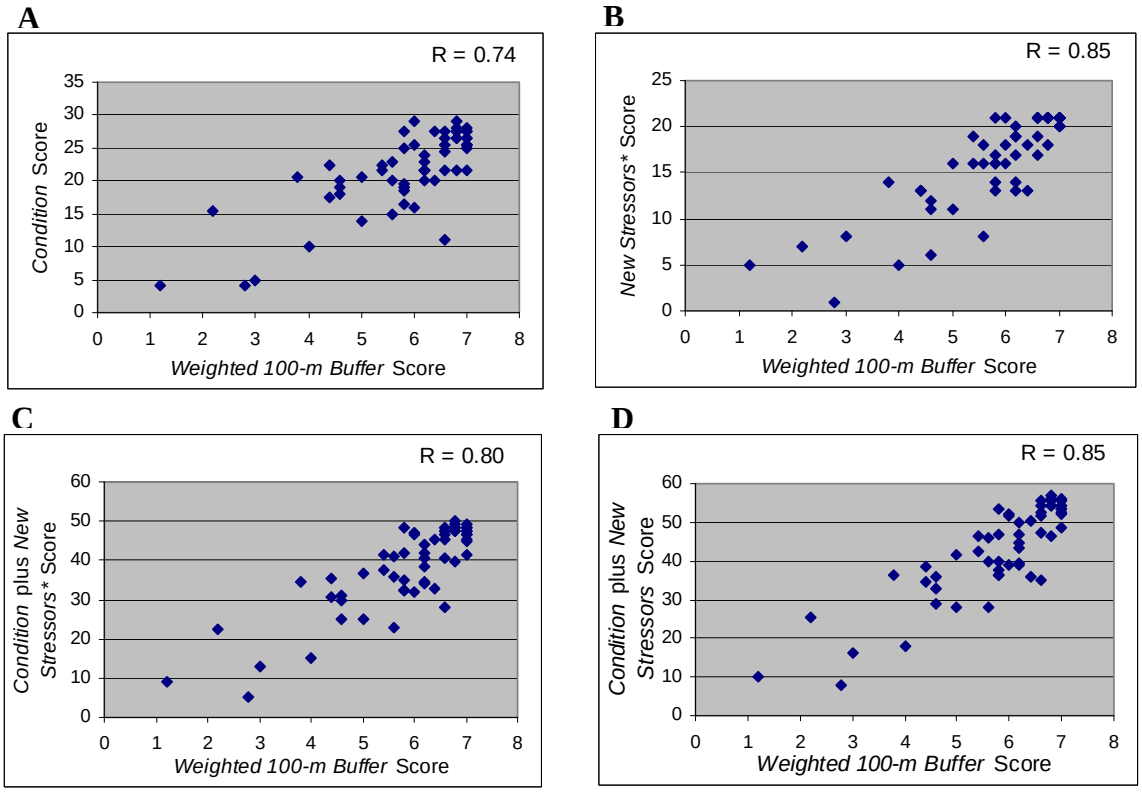

Figure 10. *Weighted 100-m Buffer* submetric compared with *Condition* and *Stressor* metrics derived from *ORAM v. 5.0 Quantitative* field data collected at 58 sites in RI (P<0.01 for all). *Minus *Intensity of LU* metric

Note the metric's strong prediction of *New Stressor* scores (Fig. 10B) and of combined *Condition* and *Stressor* scores (Figs. 10C and D). *Intensity of Land Use* metric was removed from *New Stressors* scores in 10B and C to eliminate any effect of data redundancy on those regressions, and reincorporated for a prediction of the total RAM score in 10D. The analyses indicate that remote application of *Weighted 100-m Buffer* may be a reasonable substitute for RAM indices when field assessments are not possible.

4.5 Assessment of Groundwater Withdrawal Effects

One short-term objective identified in the RI Wetland Plan is to monitor the effects of groundwater withdrawals on nearby wetlands. In an attempt to address this objective, a metric derived from the DERAP was enhanced and applied at the 54 UPR basin sites and at four additional sites containing active municipal wells elsewhere in RI. The metric, *Soil Subsidence / Root Exposure*, was enhanced with a rating system that ranked the severity of soil subsidence by the amount of associated root exposure observed in the field. The tops of roots were measured in inches above the soil at 12" from the base of the trunk or stems of woody vegetation to characterize long-term effects of groundwater withdrawals. Two additional submetrics, *Soil Fissures Obvious* and *Uncharacteristic Ground Cover*, were incorporated into the metric to characterize moderate-term effects of water withdrawals. A rating system was applied to this test-metric as follows:

Table 14. Metrics intended to characterize effects of groundwater withdrawals in 2007 RAM investigations in RI

Attribute		Rank
Severe Root Exposure	*> 6”*	3
Moderate Root Exposure	*3” – 6”*	2
Slight Root Exposure	*1” – 3”*	1
Soil Fissures Obvious		1
Uncharacteristic Ground Cover		1
None		0

The metric was tested against known wellhead withdrawal sites identified by RIGIS (2007) data layers *Community Wellhead Protection Areas* and *Non-community Wellhead Protection Areas*. Using GIS, sites were ranked according to juxtaposition to wellhead groundwater withdrawal areas as follows:

Table 15. Ranking system proxy for intensity of groundwater withdrawals

Juxtaposition	Rank
Wetland falls entirely within wellhead area	3
Wetland falls mostly within wellhead area	2
Wetland falls only partly within wellhead area	1
Wetland does not fall within wellhead area	0

A regression was run on the 58 sites to determine any correlations between the metrics and wetland juxtaposition to wellheads; the results are as follows:

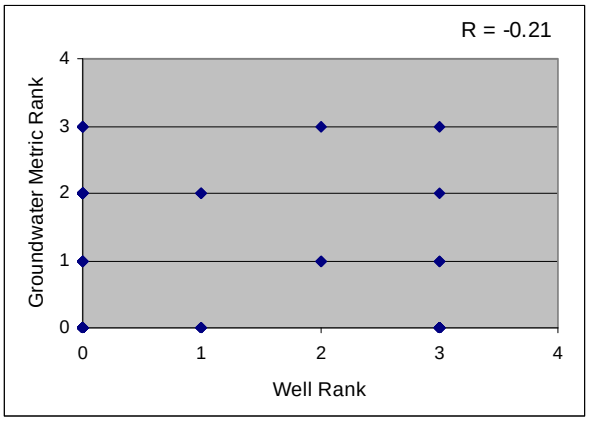

Figure 11. Prototype *Soil Subsidence / Root Exposure* metric versus groundwater withdrawal intensity ranks of scores derived from ORAM surveys of 58 wetlands in RI (P = 0.06).

Figure 11 indicates that there is no correlation between the test-metric rank and the wetlands’ juxtapositions to groundwater withdrawal areas, which is contrary to expectations of observing a positively-correlated test-metric signal within wellhead areas.

The data were further analyzed by comparing sites with and without any positive test-metric signal to sites containing or not containing well withdrawal areas as follows:

Table 16. Simplified binary analysis of metrics intended to indicate effects of groundwater withdrawals

Number of Sites	%	Result
18	31	No well area, metric signal
15	26	Well area, no metric signal
9	16	Well area and metric signal
16	28	No well area, no metric signal

The top two rows of Table 16 represent findings inconsistent with expectations, while the bottom two rows represent consistent findings, further indicating a lack of correlation between the test-metric and the presence of well withdrawal areas.

Inconsistent findings represent 57% of the sample and negative correlations are indicated in regressions. But this does not definitively show that the metric cannot indicate hydrologic impacts to wetland systems because it is not well understood how groundwater withdrawals affect hydrology at or near the surface. Other factors may be more influential; for example, major wellheads might generally be located under substantially larger and more stable sites that are inherently *less* likely to experience soil subsidence than smaller (e.g.) ditched or drained sites.

Further investigations versus ORAM-derived indices reveal similar results as follows:

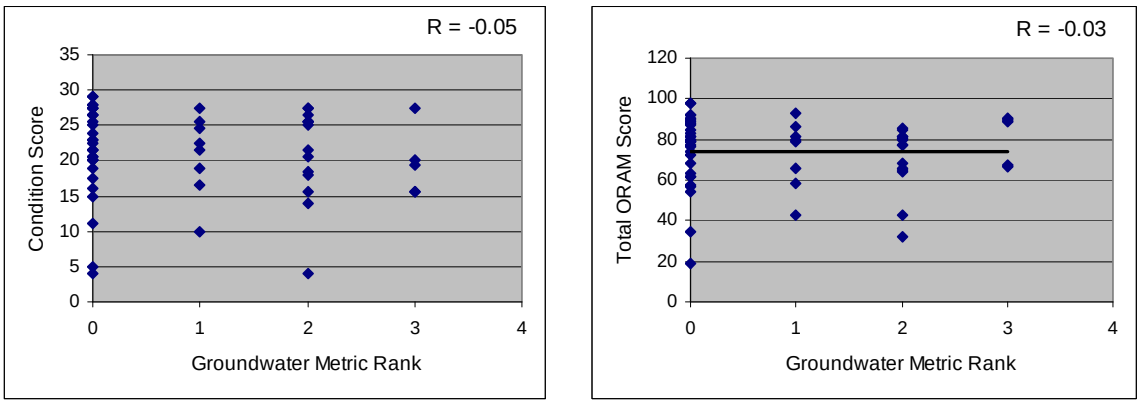

Figure 12. Prototype metrics intended to indicate effects of groundwater withdrawals versus scores derived from ORAM surveys of 58 wetlands in RI ($P > 0.05$ for both).

No correlations are evident between the test-metric rank and scores derived from ORAM that contain independent metrics evaluating hydrologic and habitat *Condition* (Fig. 12). This indicates that the metric does not predict overall wetland condition. The metric also does not correlate with the overall ORAM score.

Metrics for soil subsidence, root exposure, soil fissuring and uncharacteristic groundcover (test-metric attributes) are not incorporated into the scoring of standard ORAM metrics and the metrics indicating *Condition* may be deficient in characterizing hydrologic impacts to the substrate. However, it was expected that the test-metric would indicate stresses that would also affect other indicators of wetland condition and thus correlate with the *Condition* scores; but this was not observed.

Although it is well documented in scientific literature that soil subsidence can directly result from draining wetlands and is indicative of wetland hydrologic degradation, the 2007 data seem to refute the utility of integrating this metric into the RAM scoring. However, it still seems logical that if soil subsidence is observed within an assessment site, it should be incorporated into the RAM. It is therefore recommended here that utility of the test-metric be further investigated by applying a similar metric in RAM assessments in 2008 (including proposed IBI validations) and running further analyses.

4.6 Development of RIRAM v. 1

Methodological developments, metric enhancements, and the recategorization of the metric scoring process described in this report have been coordinated to produce a new rapid assessment tool *Rhode Island Rapid Assessment Method version 1* (**RIRAM v. 1)**, which is presented here in the format of a field form as Appendix 7. This RAM is State-specific and is capable of addressing the objectives outlined in the RI Wetland Plan. This report presents preliminary evidence that the modifications and enhancements recommended here are valid and will lend greater utility to the data and standardization to the collection process compared to the original RAM versions. Refer to Table 18 for a summary of the metric recategorization and enhancements comprising the proposed RIRAM v. 1.

Table 17. Recommended categorization and enhancements of metrics and submetrics comprising RIRAM v.1

Wetland Characteristics Wetland Area (size) Hydrologic Characteristics ▪ Sources of Water ▪ Connectivity ▪ Maximum Water Depth ▪ Duration of Inundation/saturation Habitat Characteristics ▪ Wetland Vegetation Components Present ▪ Horizontal Interspersion ▪ Microtopography Special Wetlands[1]
Stressor Metrics Upland Buffers and Surrounding Land Use ▪ % Cultural Cover 50m[1] ▪ LU Intensity: Weighted 100-m Buffer[1] Hydrologic Stressors (within wetland) [1] Habitat Stressors (within Wetland) [1] Historic Modifications[1]
Condition Metrics Hydrologic Condition ▪ Modifications to Hydrologic Regime (Recovery) Habitat Condition ▪ Habitat Alteration (Recovery) ▪ Habitat Development ▪ Coverage of Invasive Plants[1]

[1]Enhanced metric / submetric

5. Discussion

Implications of specific RAM advancements, in the context of a comprehensive freshwater wetland monitoring and assessment program, are detailed below.

5.1 Suitability of Methods

RAM Modifications

A priori modifications to the ORAM and DERAP protocols enhanced the detail of data collected and facilitated development of the protocols into a RAM specifically applicable in RI. Metric enhancements made it possible to identify wetland types and relevant special communities, document the intensity of specific stressor effects, and identify invasive plant incursions by species and intensity per site. Advancements in data-collection techniques improved standardization and efficiency. At a negligible expense of increased assessment effort, these improvements largely contributed to 1) the improvement of stressor metrics in predicting wetland condition response, 2) the regional specificity needed to create relevant and useful data, and 3) the ability of the RAM to address the goals of the RI Wetland Plan.

Determination of Assessment Boundaries

Methods for determining assessment boundaries are detailed in ORAM v.5.0 (Mack 2001). During the 2007 field investigations, these were generally followed, but with some flexibility employed to differentiate the long, continuous wetland complexes that exist in the expansive, glacial-driven wetland systems so common in RI; such flexibility has been employed in Ohio (John Mack, personal communication). Although separating each scoring unit by hydro-geomorphic (HGM) class, as outlined in the ORAM, generally seemed appropriate, a set of standardized rules or detailed classes may be needed to determine breaks in contiguous systems because lumping versus splitting units could affect scoring. This will be considered during 2008 field preparations and methods may be revised.

A major challenge in determining assessment boundaries for the sites was the lack of accurate baseline wetland data in the state. Two geospatial wetland datasets are available for RI. Both are based on the Cowardin et al. (1979) classification: the first is an NWI survey based on data collected between 1971 and 1997 at 1:24,000 to 1:80,000 spatial resolutions (USFWS 2007), and the other is a survey conducted by DEM to determine a landfill site for the State in 1988, based on 1:24,000 imagery (RIGIS 2007). Both of these datasets were found to be too coarse to act as sighting and base map sources for RAM investigations. Selecting and processing wetland boundaries based strictly on these data was not reasonable. Consequently, most wetland sites selected in 2007 were re-delineated (by aerial photo-interpretation) in-house and ground-truthed during the RAM field investigations to reflect assessment boundaries. This process will need to be repeated for future boundary determinations until a more accurate geospatial wetlands inventory is available.

RI DEM is a member of the RI Environmental Monitoring Collaborative, which is investigating strategies to update the geospatial inventory of wetland habitats in the State. Although this is a State priority (e.g. Miller et al. 2001), funding has not been secured to implement it. An updated and accurate geospatial wetland inventory would facilitate the determination of RAM assessment boundaries and ease the site selection process. It would also provide a stronger characterization of wetland condition and change for the State than RAM data alone. Furthermore, a geospatial wetland inventory would facilitate landscape (L1) and intensive (L3) monitoring efforts.

It may be efficient to collect geospatial data and RAM data simultaneously on a *rotating basin* schedule if resources will allow, because both require a selection of sites representing the same sample population (i.e. all wetlands within a particular basin). Wetlands could be delineated and inventoried via remote sensing in the winter and ground-truthed during RAM field investigations.

Field Preparations

Field maps based on DOQ aerial photography and created in GIS were useful in the field and should be incorporated into field investigation protocols. To enhance their utility in determining buffer scores, field maps should include a delineation of 50-m and 100-m buffer boundaries around each site in addition to the scoring boundaries, property boundaries, and scale bars included in 2007 field maps. Also, the field guide that RINHS developed for freshwater invasive plants known to occur in RI wetlands was useful. The development of an official manual, designed for RAM use and general distribution, should be investigated by working with IPANE.

Data Collection

Due to time constraints in 2007, data were collected first in the field and then remotely via GIS analysis. The reverse order of this would be more efficient as investigations in the field could be used to field-check and confirm data collected remotely. Also, this would require less computer time because determinations and delineations of scoring units, creation of buffers boundaries, production of site maps, and remote RAM investigations could be conducted together for each site.

Investigators should allow one-half day of field work per wetland. Wetlands should be clustered by proximity in advance of the field work if possible.

5.2 ORAM and DERAP Scores and Metrics

ORAM Score

As previously noted, ORAM contains metrics that characterize and score value-added characteristics, stressors, and condition of freshwater wetlands. It was designed to produce a single index that may be described as a *net value*, a measure of the functional capacity of a wetland minus the effects of stressors and wetland response. The index was specifically designed to allow Ohio to categorize wetlands by three levels of protection. In RI, the scoring of wetlands by functions and values is commonly perceived as unnecessary and subject to misuse and, in 1994, a RAM designed to assess relative wildlife value for freshwater wetlands (based on Golet 1976) was removed from DEM regulations. For mitigation and planning purposes, RI now generally characterizes

wetland functions and values on a case by case basis using The Highway Methodology (USACOE 1993), which does not include a scoring component.

ORAM metrics have been recategorized and enhanced here (partly by the incorporation of DERAP attributes) specifically to generate relative measures of wetland *Condition* and *Stressors* to address RI and EPA objectives. ORAM metrics intended to characterize functional capacity have been retained as *Wetland Characteristics* and will not be scored or incorporated into the RAM index.

Individual and Summed Metrics

Certain metrics contain classes that may be too coarsely categorized, subjective, or difficult to accurately assess for their individual application with any degree of certainty or utility. This is not surprising, since the metrics were never designed to alone characterize a wetland or any set of wetlands (Mack 2001, Jacobs 2006). While certain metrics and attributes detailed in this report are fairly obvious and objective (e.g. *Wetland Size*) or have been specifically developed and validated (e.g. *Weighted 100-m Buffer*), many are of limited utility for inter-wetland or change analyses due to subjective or difficult class determinations.

The incorporation of metrics into a numeric model (such as a RAM index) may act to buffer inconsistencies in scoring individual metrics (see Table 8). Although caution must be used in interpreting data based on single metrics, sets of RAM metric scores, such as the categories recommended in this report, may be a precise and effective way to rapidly characterize overall wetland condition.

5.3 Utility of RIRAM v. 1

Metric Recategorization and Enhancement

The analyses presented in this report provide reasonable evidence that reorganizing and enhancing ORAM and DERAP metrics increases the validity and utility of the data for application in RI. A field form reflecting all recommended organizational changes and enhancements discussed above has been developed to facilitate collection of data in that format (App. 7).

Historic Modifications

Many of wetlands in Rhode Island have been historically altered by human activities. Hydrological modifications occur as impoundments; either intentional, to store hydro-power for milling; or incidental, such as in the development of transportation systems. Also, direct structural alterations of wetland habitat have been widespread. For example, the majority of forested wetlands were at one time cleared for wood production, grazing, or farming. But not all wetlands were modified by humans. Thus, it seems reasonable that wetlands retaining a historically accurate natural state (e.g. natural hydrology or old-growth vegetation) are closer to natural baseline. It is these wetlands that are fundamentally in better condition than those that have been historically modified and either reestablished as a different wetland type or recovered to a less mature or degraded wetland.

Regarding hydrology, Mack (2001) addresses, but does not offer definitive guidance on this matter in ORAM v. 5.0 as follows:
Once the Rater has listed all possible past and ongoing disturbances, the Rater must determine whether any of the observed disturbances caused more than trivial alterations to the natural hydrologic regime, or have occurred so far in the past that current hydrology should be considered to be "natural." …If the Rater is unsure whether the alterations were more than trivial or did not occur so far in the past that the current conditions are "natural," 7 and 12 should be double-checked and a score of 9.5 assigned.

To standardize scoring, the *Historic Modifications* attribute was developed for 2007 assessments to prompt the rater to assign the metric an ORAM score of 9.5 if historic alterations are the only stressors observed. The term *historic* was further defined as >100 years for hydrologic modifications and >50 years for clearing/farming. If other modifications were observed, the wetland was scored by the cumulative effects of all stressors. This approach improved objectivity in metric scoring. This concept will continue to be developed in future RIRAM investigations.

Applications of Remotely-sensed Metrics

Several of the metrics analyzed in this report are discernable through remote interpretation of high resolution aerial photography. Most notably, the enhanced buffer metric *Weighted 100-m Buffer* (Section 4.4) may be useful for application in wide-scale Level 1 Landscape Assessment. The modified metric produces a strong prediction of wetland *Condition* scores (Rs = 0.74) and of combined *Condition* and *Stressor* scores (Rs = 0.85) with an approximate effort rate of one wetland site (scoring unit) per man-minute. Furthermore, with a new and accurate land use dataset available this year (RIGIS 2008), this metric could be automated for large areas at a far lower effort rate, once assessment units are identified. *Weighted 100-m Buffer* offers a reasonable proxy for expected wetland condition with minimal effort. This metric could be particularly useful in wide-scale analyses and informing policy regarding buffer development.

RIRAM Applications in Addressing State Objectives

In its recommended format, the *RIRAM* will address several of the objectives identified by the RI Wetland Plan as follows (DEM 2006):

Short-term objective: *Prioritize wetlands (and adjacent upland habitat) for protection through open space acquisition and other land protection mechanisms.*

- ✓ This report demonstrates the validity of the separation and recategorization of metrics. The metric categories can be applied to prioritization in management and management planning by identifying wetlands in need of restoration. RIRAM v.1 will allow wetlands to be prioritized by type, the intensity and types of stressors acting on them (using the stressor index), and their response to stress (using the condition index). The *RIRAM v.1* can be applied to characterize the *Stressors / Condition* of a specific area or set of wetlands of particular interest.

Short-term objective: *Monitor and assess impacts to wetlands due to loss and degradation of adjacent upland habitats (buffer zones).*

- ✓ The efficacy of ORAM buffer metrics has been enhanced to provide more quantitative, detailed, and accurate data to indicate impacts resulting from various land uses surrounding wetland sites. The methods recommended in this report provide the State with a set of flexible buffer assessment tools that have been shown to strongly correlate with condition and stressor indicators (Section 4.4).

Short-term objective: *Monitor location and extent to which invasive species are present and affecting wetland condition.*

- ✓ Recommended enhancements to the collection of invasive wetland plant species data, specifically the identification of the five most prominent species and the cover class of each, will improve the State's knowledge of their location and extent.

Short-term objective: *Develop and implement methods for monitoring impacts to wetlands due to water withdrawals.*

- As discussed in section 4.6, RAM metrics designed to assess groundwater withdrawal impacts on wetlands were not successfully validated and further testing is recommended. Scientists at URI are currently investigating various specific indicators of wetland impacts due to groundwater withdrawals (Narcisi and Golet, personal communication) and results of those data may be incorporated into the RIRAM if applicable.

Long-term objectives: *(1) Develop a database of information necessary to evaluate trends in wetland condition. (2) Identify causes and sources of wetland degradation including cumulative impacts to wetlands.*

- ✓ RAM data collected according to the recommendations in this report will produce a meaningful electronic dataset capable of characterizing wetland condition, archiving those data, and formatting those data into a system that allows various comparative analyses (including change analyses) of wetland *stressors*, and *condition*. Over time, the data will allow analyses capable of indicating which stressors and stressor combinations are affecting the condition of various wetland types and sizes.

Long-term objective: *Evaluate the effectiveness of wetland management and protection programs with respect to wetland condition.*

- ✓ RIRAM v.1 could be applied to managed or protected sites for comparison to control sites or to mean index scores from regional inventories. This would indicate their relative condition and help to determine program effectiveness.

Long-term objective: *Identify program and policy changes needed to improve overall wetland condition statewide.*

- ✓ Collection and analysis of RIRAM data over a period of time will inform decision-makers on policy surrounding wetland protection. For example, the data from 2007 indicate a strong correlation between condition / stressor impacts to wetlands and the intensity of land use in the 100-m surrounding buffer (Rs=0.80), a strong correlation between wetland condition and within-wetland stressors

(Rs=0.74), and suggest relationships between wetland condition and amphibian use. Investigating the effects of land use within various buffer widths, identifying the relative effects of specific stressors at varied intensities, and refining knowledge of human-wildlife interactions are all within the capacity of RIRAM data's basic, yet broad utility. This type of information can inform and affect policy.

5.4 RIRAM in the Context of State-wide Monitoring

Three-level Approach

RAM investigations represent the second level of a three-level approach recommended by the USEPA for a complete program of wetland monitoring on a State-wide basis. Level 1of this approach involves the landscape-level assessment of wetlands (section 5.3) while Level 3 involves the application of IBI and other more intensive research, as currently being investigated at URI by Curtis and Paton, and Narcisi and Golet (sections 4.3, 4.4, and 4.6). An ideal wetland monitoring and assessment program incorporates and integrates these levels into a robust system that is self-validating, coordinated, and inter-operable. Steps have already been taken in the inter-validation of these data using this 3-level approach, and opportunities exist to augment validation through further IBI-RAM investigations. In a subsequent report, RINHS will make recommendations to ensure that data entry and storage formats will be designed to enhance the analytical capacity and interoperability of these three levels of data. Finally, strategies for an integrated approach to data collection and analysis are currently being discussed and investigated by RINHS, DEM, and other partners.

Sampling Design

Access to privately-owned land can be a logistical challenge for collecting RAM data. Even among conserved lands, it was evident that private landowners are wary of how data collected for monitoring purposes will be used. Even though DEM has the authority to access private wetlands within the State, accessing private property would be time-intensive and require additional effort and resources. Thus, the data from assessments conducted in 2006 and 2007 were collected on public or conserved lands to avoid potential constraints to accessing privately owned land.

The bias associated with collecting data on public and conserved lands is that conserved lands are often, by definition, protected from certain development pressures that burden the "average" wetland. Baseline data are somewhat removed from this effect by the selection of sites along a gradient of land use intensity, but change analysis would likely give biased results. However, for conserved sites that are restricted to the wetlands, buffer stressors could certainly have impacts on them.

Coordination with Tidal RAM approaches in RI

RINHS has met with USEPA Atlantic Ecology Division to discuss the possibilities for the integration or coordination of these RAM freshwater wetland investigations with RAM investigations being developed to characterize condition in marine and estuarine wetlands within RI. There may be advantages and disadvantages to unifying State RAMs.

This will be further investigated in the course of this project for 2007-2008. Any significant developments of this collaboration will be presented in a subsequent report.

5.5 Data management

Given the recommendation that data be reorganized and enhanced to meet the requirements identified for the State by the RI Wetland Plan (NEIWPCC and DEM 2006), data will need to be entered into an electronic format that is organizationally compatible and facilitates the types of analyses that the protocol enhancements allow. The format must also be WQX compatible to allow data to be incorporated into a national database. In a separate effort, the RINHS will deliver a subsequent report outlining such recommendations as well as a pilot dataset populated with RAM data collected in 2007.

5.6 Summary of Recommendations

2008 Grant Period

It is recommended that in 2008, data be collected using the *RIRAM v.1* protocols according to the reordered, updated, and improved field form that reflects the enhancements and changes recommended in this document (App. 7). This will be the first version of *RIRAM*, from which detailed supporting documentation will be developed, adapted primarily from ORAM v. 5.0 protocols. The data from *RIRAM v. 1* implementation will be input into a database designed for multiple uses, most specifically those identified as long- and short-term objectives in the RI Wetland Plan (NEIWPCC and DEM 2006).

Each stage of *RIRAM* development presented here has been thoroughly considered and reasonably validated. Further validation of metrics through comparisons with IBIs from a larger sample size would enhance the power of these validations. The opportunity exists to work with URI scientists Annie Curtis and Peter Paton to further investigate the pilot IBIs analyzed in this report by employing similar, enhanced methods in 36 RI isolated wetland sites in 2008. It is recommended that DEM and RINHS seek continued funding to conduct these IBI analyses and continue testing *RIRAM v. 1* on another HUC 10 basin in RI in 2008. Pilot data suggest this could be a significant study in RAM-IBI validation.

In summary, specific recommendations offered throughout this document include:

- RAM protocols are enhanced to create *RIRAM v. 1* (refer to Table 18 and App. 7 for clarification). For a more detailed summary of RAM modifications, their benefits, and consequences, refer to Appendix 8.
    - Wetlands are classified by HGM, Cowardin et al., and RINHP classes.
    - Wetlands are evaluated by the following metric categories: *Stressor*, and *Condition*.
    - The *Special Wetlands* attribute and the associated species list are revised to reflect important or sensitive RI community types.
    - Within-wetland *Stressor* attributes are evaluated and scored to enhance the utility of *Stressor* metrics.
    - DERAP attributes are incorporated into newly rated *Stressor* metrics.

    - *Stressor* metrics associated with buffers are enhanced as outlined to be more quantitative and have higher accuracies in predicting wetland condition.
    - A *Historic Alterations* attribute is added to the *Stressor* metric category to clarify ORAM scoring protocols.
    - Agricultural *Stressor* attributes are modified to reflect RI agricultural practices.
    - Metrics indicating soil subsidence and other effects of water withdrawals are added for further testing.
    - A region-specific handbook of invasive wetland plants will be further developed and utilized instead of the Ohio list.
    - The five most influential invasive species occurrences will be listed and classified for each wetland site.
- *RIRAM v. 1* is reviewed by a technical workgroup.
- RAM assessments are conducted with GIS in the office first and then investigated in the field.
- The use of enhanced field maps depicting 50-m and 100-m buffers are incorporated into RAM protocols.
- Recommended remotely-sensed metrics are tested against full RAM protocols on 30 sites in 2008, to test their efficacy in being applied to complement RAM data (Sections 4.4 and 4.5).
- Data management strategies recommended by RINHS reflect the recommendations in this report.
- RINHS and DEM incorporate more substantial IBI-RAM validation research into the 2008 program season by assessing 36 sites with Curtis and Paton.

Beyond 2008

- Development of *RIRAM v.1* guidance documentation.
- Implementation strategies for wetland monitoring and assessment are further developed and established in the State.
- *RIRAM v.1* is implemented to characterize wetland condition and change in RI on a *rotating basin* schedule.
- RINHS, DEM, and other partners further investigate strategies to implement Level 1 assessments, in the form of an updated geospatial wetland inventory program, for incorporation into RI wetland monitoring and assessment protocols.

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Appendix 1

ORAM v. 5.0 *Quantitative Rating* Field Form

Background Information

Name:
Date:
Affiliation:
Address:
Phone Number:
e-mail address:
Name of Wetland:
Vegetation Communit(ies):
HGM Class(es):
Location of Wetland include map, address, north arrow, landmarks, distances, roads, etc.

Lat/Long or UTM Coordinate	
USGS Quad Name	
County	
Township	
Section and Subsection	
Hydrologic Unit Code	
Site Visit	
National Wetland Inventory Map	
Ohio Wetland Inventory Map	
Soil Survey	
Delineation report/map	
Wetland Size (acres, hectares)	

ORAM v. 5.0 Field Form Quantitative Rating

Site:	Rater(s):	Date:

Metric 1. Wetland Area (size).

max 6 pts. subtotal

Select one size class and assign score.

- [ ] >50 acres (>20.2ha) (6 pts)
- [ ] 25 to <50 acres (10.1 to <20.2ha) (5 pts)
- [ ] 10 to <25 acres (4 to <10.1ha) (4 pts)
- [ ] 3 to <10 acres (1.2 to <4ha) (3 pts)
- [ ] 0.3 to <3 acres (0.12 to <1.2ha) (2pts)
- [ ] 0.1 to <0.3 acres (0.04 to <0.12ha) (1 pt)
- [ ] <0.1 acres (0.04ha) (0 pts)

Metric 2. Upland buffers and surrounding land use.

max 14 pts. subtotal

2a. Calculate average buffer width. Select only one and assign score. Do not double check.

- [ ] WIDE. Buffers average 50m (164ft) or more around wetland perimeter (7)
- [ ] MEDIUM. Buffers average 25m to <50m (82 to <164ft) around wetland perimeter (4)
- [ ] NARROW. Buffers average 10m to <25m (32ft to <82ft) around wetland perimeter (1)
- [ ] VERY NARROW. Buffers average <10m (<32ft) around wetland perimeter (0)

2b. Intensity of surrounding land use. Select one or double check and average.

- [ ] VERY LOW. 2nd growth or older forest, prairie, savannah, wildlife area, etc. (7)
- [ ] LOW. Old field (>10 years), shrubland, young second growth forest. (5)
- [ ] MODERATELY HIGH. Residential, fenced pasture, park, conservation tillage, new fallow field. (3)
- [ ] HIGH. Urban, industrial, open pasture, row cropping, mining, construction. (1)

Metric 3. Hydrology.

max 30 pts. subtotal

3a. Sources of Water. Score all that apply.

- [ ] High pH groundwater (5)
- [ ] Other groundwater (3)
- [ ] Precipitation (1)
- [ ] Seasonal/intermittent surface water (3)
- [ ] Perennial surface water (lake or stream) (5)

3b. Connectivity. Score all that apply.

- [ ] 100 year floodplain (1)
- [ ] Between stream/lake and other human use (1)
- [ ] Part of wetland/upland (e.g. forest), complex (1)
- [ ] Part of riparian or upland corridor (1)

3c. Maximum water depth. Select only one and assign score.

- [ ] >0.7 (27.6in) (3)
- [ ] 0.4 to 0.7m (15.7 to 27.6in) (2)
- [ ] <0.4m (<15.7in) (1)

3d. Duration inundation/saturation. Score one or dbl check.

- [ ] Semi- to permanently inundated/saturated (4)
- [ ] Regularly inundated/saturated (3)
- [ ] Seasonally inundated (2)
- [ ] Seasonally saturated in upper 30cm (12in) (1)

3e. Modifications to natural hydrologic regime. Score one or double check and average.

- [ ] None or none apparent (12)
- [ ] Recovered (7)
- [ ] Recovering (3)
- [ ] Recent or no recovery (1)

Check all disturbances observed

- [ ] ditch
- [ ] tile
- [ ] dike
- [ ] weir
- [ ] stormwater input
- [ ] point source (nonstormwater)
- [ ] filling/grading
- [ ] road bed/RR track
- [ ] dredging
- [ ] other_____

Metric 4. Habitat Alteration and Development.

max 20 pts. subtotal

4a. Substrate disturbance. Score one or double check and average.

- [ ] None or none apparent (4)
- [ ] Recovered (3)
- [ ] Recovering (2)
- [ ] Recent or no recovery (1)

4b. Habitat development. Select only one and assign score.

- [ ] Excellent (7)
- [ ] Very good (6)
- [ ] Good (5)
- [ ] Moderately good (4)
- [ ] Fair (3)
- [ ] Poor to fair (2)
- [ ] Poor (1)

4c. Habitat alteration. Score one or double check and average.

- [ ] None or none apparent (9)
- [ ] Recovered (6)
- [ ] Recovering (3)
- [ ] Recent or no recovery (1)

Check all disturbances observed

- [ ] mowing
- [ ] grazing
- [ ] clearcutting
- [ ] selective cutting
- [ ] woody debris removal
- [ ] toxic pollutants
- [ ] shrub/sapling removal
- [ ] herbaceous/aquatic bed removal
- [ ] sedimentation
- [ ] dredging
- [ ] farming
- [ ] nutrient enrichment

subtotal this page

ORAM v. 5.0 Field Form Quantitative Rating

Site:	Rater(s):	Date:

subtotal this page

Metric 5. Special Wetlands.

max 10 pts. subtotal

Check all that apply and score as indicated.

- [ ] Bog (10)
- [ ] Fen (10)
- [ ] Old growth forest (10)
- [ ] Mature forested wetland (5)
- [ ] Lake Erie coastal/tributary wetland-unrestricted hydrology (10)
- [ ] Lake Erie coastal/tributary wetland-restricted hydrology (5)
- [ ] Lake Plain Sand Prairies (Oak Openings) (10)
- [ ] Relict Wet Praires (10)
- [ ] Known occurrence state/federal threatened or endangered species (10)
- [ ] Significant migratory songbird/water fowl habitat or usage (10)
- [ ] Category 1 Wetland. See Question 1 Qualitative Rating (-10)

Metric 6. Plant communities, interspersion, microtopography.

max 20 pts. subtotal

6a. Wetland Vegetation Communities.
Score all present using 0 to 3 scale.

- [ ] Aquatic bed
- [ ] Emergent
- [ ] Shrub
- [ ] Forest
- [ ] Mudflats
- [ ] Open water
- [ ] Other_____

6b. horizontal (plan view) Interspersion.
Select only one.

- [ ] High (5)
- [ ] Moderately high(4)
- [ ] Moderate (3)
- [ ] Moderately low (2)
- [ ] Low (1)
- [ ] None (0)

6c. Coverage of invasive plants. Refer to Table 1 ORAM long form for list. Add or deduct points for coverage

- [ ] Extensive >75% cover (-5)
- [ ] Moderate 25-75% cover (-3)
- [ ] Sparse 5-25% cover (-1)
- [ ] Nearly absent <5% cover (0)
- [ ] Absent (1)

6d. Microtopography.
Score all present using 0 to 3 scale.

- [ ] Vegetated hummucks/tussucks
- [ ] Coarse woody debris >15cm (6in)
- [ ] Standing dead >25cm (10in) dbh
- [ ] Amphibian breeding pools

Vegetation Community Cover Scale

0	Absent or comprises <0.1ha (0.2471 acres) contiguous area
1	Present and either comprises small part of wetland's vegetation and is of moderate quality, or comprises a significant part but is of low quality
2	Present and either comprises significant part of wetland's vegetation and is of moderate quality or comprises a small part and is of high quality
3	Present and comprises significant part, or more, of wetland's vegetation and is of high quality

Narrative Description of Vegetation Quality

low	Low spp diversity and/or predominance of nonnative or disturbance tolerant native species
mod	Native spp are dominant component of the vegetation, although nonnative and/or disturbance tolerant native spp can also be present, and species diversity moderate to moderately high, but generallyw/o presence of rare threatened or endangered spp
high	A predominance of native species, with nonnative spp and/or disturbance tolerant native spp absent or virtually absent, and high spp diversity and often, but not always, the presence of rare, threatened, or endangered spp

Mudflat and Open Water Class Quality

0	Absent <0.1ha (0.247 acres)
1	Low 0.1 to <1ha (0.247 to 2.47 acres)
2	Moderate 1 to <4ha (2.47 to 9.88 acres)
3	High 4ha (9.88 acres) or more

Microtopography Cover Scale

0	Absent
1	Present very small amounts or if more common of marginal quality
2	Present in moderate amounts, but not of highest quality or in small amounts of highest quality
3	Present in moderate or greater amounts and of highest quality

GRAND TOTAL(max 100 pts)

Refer to the most recent ORAM Score Calibration Report for the scoring breakpoints between wetland categories at the following address: http://www.epa.state.oh.us/dsw/401/401.html

last revised 1 February 2001 jjm

Appendix 2

DERAP v. 5.0 Field Form

DELAWARE RAPID ASSESSMENT Version 5.0

Site # _____ Site Name _____ Date _____

Observers _____ Completed? ☐

HGM Class _____ HGM sub-class _____ Reference or Assessment Site (circle one)

Natural Re-establishment Establishment Rehabilitation Enhancement (circle one)

Watershed _____ Photos _____

lat/long _____ AA size and shape _____

AA moved from original location? yes or no (circle one) If yes, reason _____

Qualitative Condition Rating Least Disturbed 1 2 3 4 5 6 Highly Disturbed (circle one number)

HABITAT/PLANT COMMUNITY (within site) Weight

FOREST HARVESTING w/in 50yrs

☐ Clear Cut
☐ <10% ☐ 11-50% ☐ >50%
☐ Selective Cut

DOMINANT FOREST AGE

☐ 31-50 years
☐ 16-30 years
☐ 3 - 15 years
☐ </= 2 years

BAF(10) (of dominant forest) _____

CONVERTED FROM NATIVE FOREST
check all present

☐ Pine plantations
☐ Mowed
☐ Farmed
☐ Grazed
☐ Other _____

PRESENCE OF INVASIVE SPECIES

☐ < 1% ☐ 6 - 50%
☐ 1 - 5% ☐ > 50%

☐ **CHEMICAL DEFOLIATION**

☐ **EXCESSIVE HERBIVORY**
(e.g. pinebark beetle, gypsy moth, nutria)

☐ **BURNED**

☐ **GARBAGE/ISOLATED DUMPING**

HABITAT/PLANT COMMUNITY (within site) Weight
(CONTINUED)

INCREASED NUTRIENTS

☐ Dense algal mats

Presence of Nutrient Indicator Species (dep. only)
☐ Dominating Site (>50%)
☐ NOT Dominating Site (<50%)

TRAILS AND ROADS

☐ Walking/ horse trails
☐ Non elevated road (Logging, dirt, ATV)
☐ Elevated road (dirt or gravel)
☐ Paved road

☐ **OTHER** _____

COMMENTS ON HABITAT/PLANT COMMUNITY

Assessment Area Sketch

DELAWARE RAPID ASSESSMENT Version 5.0

Site # _____ Site Name _____ Date _____

HYDROLOGY STRESSORS — Weight

DITCHES
(not including main channel for riverine)
- ☐ 1-3 shallow ditches (<.3m deep) within AA
- ☐ >3 shallow ditches in AA or 1 ditch (>.3m deep) in AA OR 1 ditch (>.6m deep) within 25m of AA
- ☐ >1 ditch .3-.6m deep or 1 ditch >.6m deep within AA

STREAM ALTERATION
- ☐ Channelized Stream (If yes)
  - ☐ Not maintained, reverting to natural morphology
  - ☐ Spoil bank only one AA side ☐ Spoil bank opposite AA
  - ☐ Spoil bank both sides
- ☐ Stream Incision

WEIR/DAM/ROAD
- ☐ Decreasing flooding of AA
- ☐ Impounding water <10% AA
- ☐ Impounding water 10-75% AA
- ☐ Impounding water >75% AA

☐ **STORMWATER INPUTS**

☐ **POINT SOURCE (NON-STORMWATER)**

FILLING, EXCAVATION (includes roads not impeding flow)
- ☐ <10% of AA
- ☐ 10-75% of AA
- ☐ >75% of AA

MICROTO ALTERATIONS - plowing, bedding, skidder tracks
- ☐ <10% of AA
- ☐ 10-75% of AA
- ☐ >75% of AA

EXCESSIVE SEDIMENTATION
- ☐ In stream channel
- ☐ In wetland

☐ **SOIL SUBSIDENCE/ROOT EXPOSURE**

☐ **TIDAL RESTRICTION**

☐ **OTHER** _____

COMMENTS ON HYDROLOGY

BUFFER STRESSORS(100m surrounding AA) — Weight

DEVELOPMENT - Density
- ☐ Commercial, industrial
- ☐ Residential >2 houses/acre
- ☐ Residential </=2 houses/acre
- ☐ Residential </=1 house/ acre

IF DEVELOPED, WHAT TYPE SEWAGE DISPOSAL
- ☐ Sewer
- ☐ Septic

ROADS (most intense type, not including trails and logging roads)
- ☐ Mostly dirt or gravel roads
- ☐ Mostly 2-lane paved roads
- ☐ Mostly 4-lane paved roads

☐ **LANDFILL/WASTE DISPOSAL**

☐ **CHANNELIZED STREAMS OR DITCHES (>0.6m DEEP)**

AGRICULTURE

	adjacent	>10m
Row crops or nursery plants	☐	☐
Orchards	☐	☐
Poultry or livestock operation	☐	☐

☐ **FOREST HARVESTING WITHIN LAST 15 YEARS**

PIERS/DOCKS
- ☐ Slips/docks present
- ☐ Moorings present
- ☐ Individual piers # of piers in buffer _____

☐ **GOLF COURSE**

☐ **MOWED AREA**

☐ **SAND/GRAVEL OPERATION**

☐ **OTHER** _____

COMMENTS ON BUFFER

checked: _____
entered: _____

SUM of WEIGHTS: ☐ Refer to protocol to assing weights and calculate total score **TOTAL SCORE:** ☐

Appendix 3

Modified ORAM-DERAP Field Form Applied in Rhode Island 2007

Background Information

Name:
Date:
Affiliation:
Address:
Phone Number:
e-mail address:
Name of Wetland:
Vegetation Communit(ies):
HGM Class(es):
RINHP Community Types Within Wetland
Photos of Area
Component Species of Communities Present

Lat/Long or UTM Coordinate	
USGS Quad Name	
County	
Township	
Section and Subsection	
Hydrologic Unit Code	
Site Visit	
National Wetland Inventory Map	
Ohio Wetland Inventory Map	
Soil Survey	
Delineation report/map	
Wetland Size (acres, hectares)	

ORAM v. 5.0 Field Form Quantitative Rating *Modified for RI 2007 pilot

Site:	Rater(s):	Date:

Metric 1. Wetland Area (size).

max 6 pts. subtotal

Select one size class and assign score.

- [ ] >50 acres (>20.2ha) (6 pts)
- [ ] 25 to <50 acres (10.1 to <20.2ha) (5 pts)
- [ ] 10 to <25 acres (4 to <10.1ha) (4 pts)
- [ ] 3 to <10 acres (1.2 to <4ha) (3 pts)
- [ ] 0.3 to <3 acres (0.12 to <1.2ha) (2pts)
- [ ] 0.1 to <0.3 acres (0.04 to <0.12ha) (1 pt)
- [ ] <0.1 acres (0.04ha) (0 pts)

***Modified for RI 2007**

Metric 2. Upland buffers and surrounding land use.

max 14 pts. subtotal

2a. Calculate average buffer width. Select only one and assign score. Do not double check.

- [ ] WIDE. Buffers average 50m (164ft) or more around wetland perimeter (7)
- [ ] MEDIUM. Buffers average 25m to <50m (82 to <164ft) around wetland perimeter (4)
- [ ] NARROW. Buffers average 10m to <25m (32ft to <82ft) around wetland perimeter (1)
- [ ] VERY NARROW. Buffers average <10m (<32ft) around wetland perimeter (0)

2b. Intensity of surrounding land use. Select one or double check and average. **(100m buffer width)***

- [ ] VERY LOW. 2nd growth or older forest, prairie, savannah, wildlife area, etc. (7)
- [ ] LOW. Old field (>10 years), shrubland, young second growth forest. (5)
- [ ] MODERATELY HIGH. Residential, fenced pasture, park, conservation tillage, new fallow field. (3)
- [ ] HIGH. Urban, industrial, open pasture, row cropping, mining, construction. (1)

Metric 3. Hydrology.

max 30 pts. subtotal

3a. Sources of Water. Score all that apply.

- [ ] High pH groundwater (5)
- [ ] Other groundwater (3)
- [ ] Precipitation (1)
- [ ] Seasonal/Intermittent surface water (3)
- [ ] Perennial surface water (lake or stream) (5)

3b. Connectivity. Score all that apply.

- [ ] 100 year floodplain (1)
- [ ] Between stream/lake and other human use (1)
- [ ] Part of wetland/upland (e.g. forest), complex (1)
- [ ] Part of riparian or upland corridor (1)

3c. Maximum water depth. Select only one and assign score.

- [ ] >0.7 (27.6in) (3)
- [ ] 0.4 to 0.7m (15.7 to 27.6in) (2)
- [ ] <0.4m (<15.7in) (1)

3d. Duration inundation/saturation. Score one or dbl check.

- [ ] Semi- to permanently inundated/saturated (4)
- [ ] Regularly inundated/saturated (3)
- [ ] Seasonally inundated (2)
- [ ] Seasonally saturated in upper 30cm (12in) (1)

3e. Modifications to natural hydrologic regime. Score one or double check and average.

- [ ] None or none apparent (12)
- [ ] Recovered (7)
- [ ] Recovering (3)
- [ ] Recent or no recovery (1)

Rate* all disturbances observed

- [ ] ditch
- [ ] tile
- [ ] dike
- [ ] weir
- [ ] stormwater input
- [ ] point source (nonstormwater)
- [ ] filling/grading
- [ ] road bed/RR track
- [ ] dredging
- [ ] other_____

***3f. Historic Alterations (>100 yrs.)**

- [ ] **historic impoundment**
- [ ] **historic draining**

***Rating:**
1- minor effect on hydrology
2- moderate effect on hydrology
3- severe effect on hydrology

Metric 4. Habitat Alteration and Development.

max 20 pts. subtotal

4a. Substrate disturbance. Score one or double check and average.

- [ ] None or none apparent (4)
- [ ] Recovered (3)
- [ ] Recovering (2)
- [ ] Recent or no recovery (1)

***4d. Historic Alterations (>50 yrs.)**

- [ ] **historic clearcutting evident**
- [ ] **stone walls / historic farming evident**

4b. Habitat development. Select only one and assign score.

- [ ] Excellent (7)
- [ ] Very good (6)
- [ ] Good (5)
- [ ] Moderately good (4)
- [ ] Fair (3)
- [ ] Poor to fair (2)
- [ ] Poor (1)

4c. Habitat alteration. Score one or double check and average.

- [ ] None or none apparent (9)
- [ ] Recovered (6)
- [ ] Recovering (3)
- [ ] Recent or no recovery (1)

Rate* all disturbances observed

- [ ] mowing
- [ ] grazing
- [ ] clearcutting
- [ ] selective cutting
- [ ] woody debris removal
- [ ] toxic pollutants
- [ ] shrub/sapling removal
- [ ] herbaceous/aquatic bed removal
- [ ] sedimentation
- [ ] dredging
- [ ] farming
- [ ] nutrient enrichment

***Rating:**
1- minor effect on habitats
2- moderate effect on habitats
3- severe effect on habitats

subtotal this page

ORAM v. 5.0 Field Form Quantitative Rating *Modified for RI 2007 pilot

Site:	Rater(s):	Date:

subtotal this page

Metric 5. Special Wetlands.

max 10 pts. subtotal

Check all that apply and score as indicated.

*Modified for RI 2007

- Bog (10)
- Fen (10)
- Old growth forest (10)
- Mature forested wetland (5)
- **Atlantic white cedar swamp (10)***
- **Coastal plain pondshore (10)***
- **Interdunal swale (10)***
- **Other**_____
- Known occurrence state/federal threatened or endangered species (10)
- Significant migratory songbird/water fowl habitat or usage (10)

Metric 6. Plant communities, interspersion, microtopography.

max 20 pts. subtotal

6a. Wetland Vegetation **Components***

Score all present using 0 to 3 scale.

- Aquatic bed
- Emergent
- Shrub
- Forest
- Mudflats
- Open water
- Other_____

6b. horizontal (plan view) Interspersion.

Select only one.

- High (5)
- Moderately high(4)
- Moderate (3)
- Moderately low (2)
- Low (1)
- None (0)

6c. Coverage of invasive plants. Refer to Table 1 ORAM long form for list. Add or deduct points for coverage

- Extensive >75% cover (-5)
- Moderate 25-75% cover (-3)
- Sparse 5-25% cover (-1)
- Nearly absent <5% cover (0)
- Absent (1)

6d. Microtopography.

Score all present using 0 to 3 scale.

- Vegetated hummucks/tussucks
- Coarse woody debris >15cm (6in)
- Standing dead >25cm (10in) dbh
- Amphibian breeding pools

6c* List invasive species by dominance:

_____

_____

_____

Vegetation Community Cover Scale

0	Absent or comprises <0.1ha (0.2471 acres) contiguous area
1	Present and either comprises small part of wetland's vegetation and is of moderate quality, or comprises a significant part but is of low quality
2	Present and either comprises significant part of wetland's vegetation and is of moderate quality or comprises a small part and is of high quality
3	Present and comprises significant part, or more, of wetland's vegetation and is of high quality

Narrative Description of Vegetation Quality

low	Low spp diversity and/or predominance of nonnative or disturbance tolerant native species
mod	Native spp are dominant component of the vegetation, although nonnative and/or disturbance tolerant native spp can also be present, and species diversity moderate to moderately high, but generallyw/o presence of rare threatened or endangered spp
high	A predominance of native species, with nonnative spp and/or disturbance tolerant native spp absent or virtually absent, and high spp diversity and often, but not always, the presence of rare, threatened, or endangered spp

Mudflat and Open Water Class Quality

0	Absent <0.1ha (0.247 acres)
1	Low 0.1 to <1ha (0.247 to 2.47 acres)
2	Moderate 1 to <4ha (2.47 to 9.88 acres)
3	High 4ha (9.88 acres) or more

Microtopography Cover Scale

0	Absent
1	Present very small amounts or if more common of marginal quality
2	Present in moderate amounts, but not of highest quality or in small amounts of highest quality
3	Present in moderate or greater amounts and of highest quality

GRAND TOTAL(max 100 pts)

Refer to the most recent ORAM Score Calibration Report for the scoring breakpoints between wetland categories at the following address: http://www.epa.state.oh.us/dsw/401/401.html

last revised 1 February 2001 jjm

DELAWARE RAPID ASSESSMENT Version 5.0

***Modified for RI 2007**

Site # _____ Site Name _____ Date _____

Observers _____ Completed? ☐

HGM Class _____ HGM sub-class _____ Reference or Assessment Site (circle one)

Natural Re-establishment Establishment Rehabilitation Enhancement (circle one)

Watershed _____ Photos _____

lat/long _____ AA size and shape _____

AA moved from original location? yes or no (circle one) If yes, reason _____

Qualitative Condition Rating Least Disturbed 1 2 3 4 5 6 Highly Disturbed (circle one number)

HABITAT/PLANT COMMUNITY (within site) Weight

FOREST HARVESTING w/in 50yrs

☐ Clear Cut
☐ <10% ☐ 11-50% ☐ >50% ☐ None
☐ Selective Cut

DOMINANT FOREST AGE

☐ 31-50 years ☐ >50 years
☐ 16-30 years
☐ 3 - 15 years
☐ </= 2 years

BAF(10) (of dominant forest) _____

CONVERTED FROM NATIVE FOREST
check all present

☐ Pine plantations
☐ Mowed ☐ N A
☐ Farmed
☐ Grazed
☐ Other _____

PRESENCE OF INVASIVE SPECIES

☐ < 1% ☐ 6 - 50%
☐ 1 - 5% ☐ > 50%

☐ **CHEMICAL DEFOLIATION** ☐ None

☐ **EXCESSIVE HERBIVORY** ☐ None
(e.g. pinebark beetle, gypsy moth, nutria)

☐ **BURNED** ☐ None

☐ **GARBAGE/ISOLATED DUMPING**
☐ None

HABITAT/PLANT COMMUNITY (within site) Weight (CONTINUED)

INCREASED NUTRIENTS ☐ None

☐ Dense algal mats

Presence of Nutrient Indicator Species (dep. only)
☐ Dominating Site (>50%)
☐ NOT Dominating Site (<50%)

TRAILS AND ROADS ☐ None

☐ Walking/ horse trails
☐ Non elevated road (Logging, dirt, ATV)
☐ Elevated road (dirt or gravel)
☐ Paved road

☐ **OTHER** _____

COMMENTS ON HABITAT/PLANT COMMUNITY

Assessment Area Sketch

DELAWARE RAPID ASSESSMENT Version 5.0

*Modified for RI 2007

Site # _____ Site Name _____ Date _____

HYDROLOGY STRESSORS — Weight

DITCHES ☐ None
(not including main channel for riverine)
- ☐ 1-3 shallow ditches (<.3m deep) within AA
- ☐ >3 shallow ditches in AA or 1 ditch (>.3m deep) in AA OR 1 ditch (>.6m deep) within 25m of AA
- ☐ >1 ditch .3-.6m deep or 1 ditch >.6m deep within AA

STREAM ALTERATION
- ☐ Channelized Stream (If yes)
  - ☐ Not maintained, reverting to natural morphology
  - ☐ Spoil bank only one AA side ☐ Spoil bank opposite AA
  - ☐ Spoil bank both sides
- ☐ Stream Incision ☐ None

WEIR/DAM/ROAD
- ☐ Decreasing flooding of AA
- ☐ Impounding water <10% AA
- ☐ Impounding water 10-75% AA
- ☐ Impounding water >75% AA
- ☐ None

☐ **STORMWATER INPUTS** ☐ None

☐ **POINT SOURCE (NON-STORMWATER)** ☐ None

FILLING, EXCAVATION (includes roads not impeding flow)
- ☐ <10% of AA
- ☐ 10-75% of AA
- ☐ >75% of AA

MICROTO ALTERATIONS - plowing, bedding, skidder tracks
- ☐ <10% of AA
- ☐ 10-75% of AA
- ☐ >75% of AA
- ☐ None

EXCESSIVE SEDIMENTATION
- ☐ In stream channel
- ☐ In wetland
- ☐ None

SOIL SUBSIDENCE / ROOT EXPOSURE
- ☐ Slight* 1"- 3"
- ☐ Moderate* 3" - 6"
- ☐ Severe* > 6"
- ☐ None

☐ **TIDAL RESTRICTION** ☐ None

☐ **OTHER**

COMMENTS ON HYDROLOGY

BUFFER STRESSORS(100m surrounding AA) — Weight

DEVELOPMENT - Density
- ☐ Commercial, industrial
- ☐ Residential >2 houses/acre
- ☐ Residential <=2 houses/acre
- ☐ Residential <=1 house/ acre
- ☐ None

IF DEVELOPED, WHAT TYPE SEWAGE DISPOSAL
- ☐ Sewer
- ☐ Septic

ROADS (most intense type, not including trails and logging roads)
- ☐ Mostly dirt or gravel roads
- ☐ Mostly 2-lane paved roads
- ☐ Mostly 4-lane paved roads
- ☐ None

☐ **LANDFILL/WASTE DISPOSAL** ☐ None

☐ **CHANNELIZED STREAMS OR DITCHES (>0.6m DEEP)** ☐ None

AGRICULTURE ☐ None

	adjacent	>10m
Row crops or nursery plants	☐	☐
Orchards	☐	☐
Poultry or livestock operation	☐	☐
Hay Fields / Pasture*	☐	☐

☐ **FOREST HARVESTING WITHIN LAST 15 YEARS** ☐ None

PIERS/DOCKS ☐ None
- ☐ Slips/docks present
- ☐ Moorings present
- ☐ Individual piers # of piers in buffer _____

☐ **GOLF COURSE** ☐ None

☐ **MOWED AREA** ☐ None

☐ **SAND/GRAVEL OPERATION** ☐ None

☐ **OTHER** _____

COMMENTS ON BUFFER

checked:_____
entered:_____

SUM of WEIGHTS: _____

- ☐ SOIL FISSURES OBVIOUS*
- ☐ UNCHARACTERISTIC GROUND COVER*

TOTAL SCORE: _____

Appendix 4

Characteristic Plant Species of Rhode Island Freshwater *Special* Wetlands

And

Invasive Plant Species of Rhode Island Freshwater Wetlands

Characteristic Plant Species of Rhode Island Special Wetlands

Fen Species	Bog Species	Atlantic White Cedar Species	Interdunal Swale Species	Coastal Plain Species
Myrica gale	*Chameadaphne calyculata*	*Chamaecyparis thyoides* (dominant)	*Juncus canadensis*	*Eriocaulon aquaticum*
Carex lasiocarpa	*Sphagnum sp*	*Acer rubrum*	*Juncus greenei*	*Gratiola aurea*
Carex rostrata	*Kalmia angustifolia*	*Betula alleghaniensis*	*Rhynchospora capitellata*	*Cyperus dentatus*
Cladium mariscoides	*Vaccinnium macrocarpon*	*Tsuga canadensis*	*Xyris torta*	*Euthamia tenuifolia*
Rhynchospora sp	*Gaylussacia dumosa*	*Nyssa sylvatica*	*Vaccinnium macrocarpon*	*Rhexia virginica*
Vaccinnium macrocarpon	*Gaylussacia baccata*	*Sphagnum*	*Myrica gale*	*Scirpus pungens*
Chameadaphne calyculata	*Sarracenia purpurea*		*Myrica pensylvanica*	*Juncus militaris*
Sphagnum sp	*Drosera rotundifolia*			*Lobelia dortmanna*
	Picea mariana			*Hydrocotyle umbellata*
	Chamaecyparis thyoides (stunted)			*Xyris torta*
	Xyris torta			

<u>Characteristic Invasive Plant Species of Rhode Island Wetlands</u>

Aquatic - Submergent and Floating Leaved
Cabomba caroliniana
Egeria densa
Glossostigma diandrum (1 location)
Myriophyllum heterophyllum
Myriophyllum spicatum (3 locations)
Najas minor (2 locations)
Potamogeton crispus

Aquatic - Emergent
Iris pseudacorus
Lythrum salicaria
Myosotis scorpioides
Phalaris arundinacea
Phragmites australis subsp. australis
Rorippa nasturtium
Rorippa amphibia (1 location)

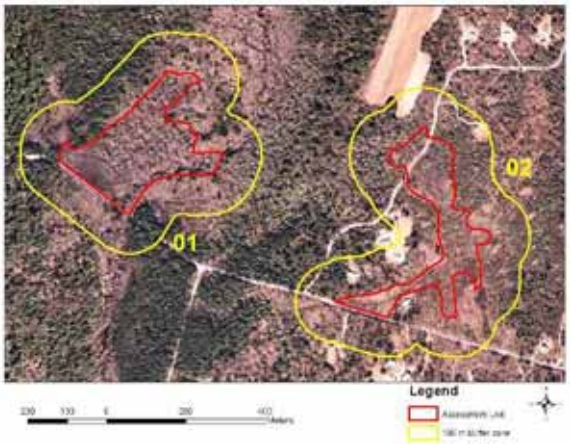
Herbaceous - Facultative (FAC – FACW) Species
Aegopodium podagraria
Epilobium hirsutum (ruderal)
Microstegium vimineum
Polygonum cuspidatum
Polygonum sachalinense
Polygonum caespitosum (ruderal)

Vines - Facultative (FAC – FACW) Species
Celastrus orbiculatus
Lonicera japonica

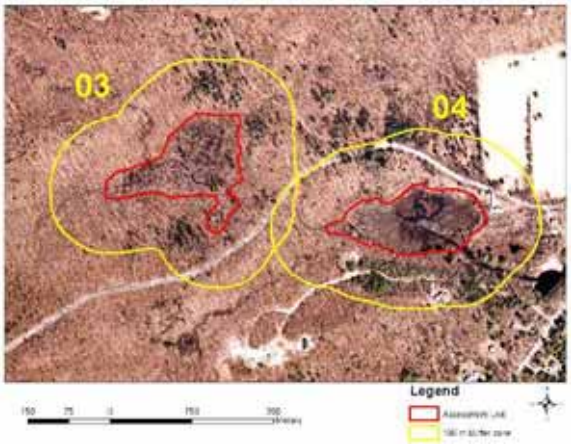
Shrubs and Trees - Facultative (FAC- FACW) Species
Acer pseudoplatanus
Amorpha fruticosa
Berberis thunbergii
Frangula Alnus (syn. Rhamnus frangula)
Ligustrum obtusifolium
Lonicera morrowii
Phellodendron amurense
Rosa multiflora
Salix cinerea

Appendix 5

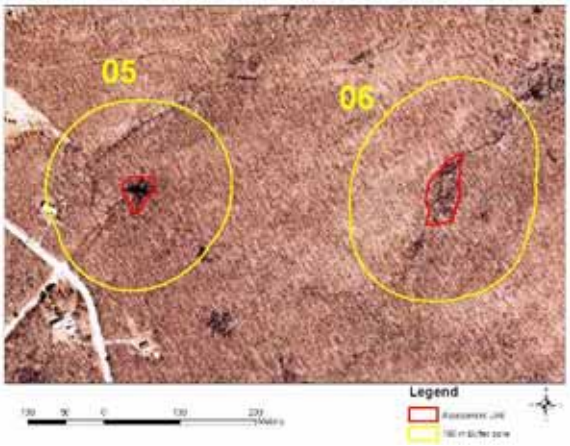
2007 Assessment Areas;
Including Information and Various Standardized Scores



Site Number	01	02
Town	Exeter	Exeter
Owner, Fee / Easment	Private / ASRI	TNC
HUC 12 Location	Queen River	Queen River
Area (acres)	15.6	12.7
Longitude	-71.56805	-71.55862
Latitude	41.54054	41.53874
Standardized Scores - 100 base		
ORAM Total	95	73
Functional Capacity	82	54
Stressor*	89	82
Remote Functional Capacity	70	42
Weighted 100-m Buffer	94	83
Inclusive W. 100-m Buffer	97	89



Site Number	03	04
Town	Exeter	Richmond
Owner, Fee / Easment	RIDEM	RIDEM
HUC 12 Location	Beaver River	Beaver River
Area (acres)	6.6	6.1
Longitude	-71.65659	-71.65148
Latitude	41.56031	41.55957
Standardized Scores - 100 base		
ORAM Total	84	90
Functional Capacity	58	75
Stressor*	100	82
Condition	91	100
Weighted 100-m Buffer	91	86
Inclusive W. 100-m Buffer	94	86

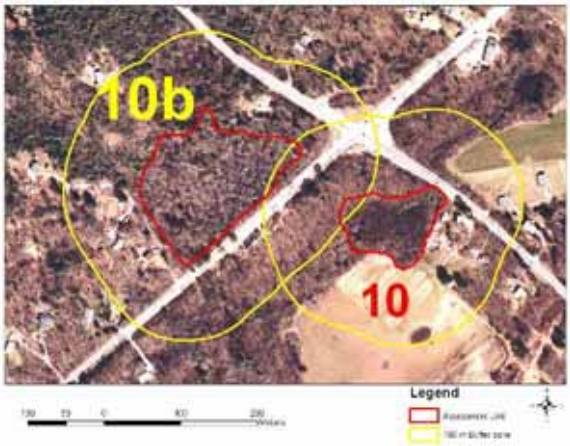


Site Number	05	06
Town	Richmond	Richmond
Owner, Fee / Easment	ASRI	TNC
HUC 12 Location	Beaver River	Beaver River
Area (acres)	0.3	0.7
Longitude	-71.65656	-71.65176
Latitude	41.54544	41.54553
Standardized Scores - 100 base		
ORAM Total	62	81
Functional Capacity	52	55
Stressor*	86	100
Condition	38	88
Weighted 100-m Buffer	94	100
Inclusive W. 100-m Buffer	94	100

Site Number	07	08
Town	Richmond	Richmond
Owner, Fee / Easment	TNC	TNC
HUC 12 Location	Beaver River	Beaver River
Area (acres)	18.8	2.2
Longitude	-71.64245	-71.64743
Latitude	41.54267	41.54024
Standardized Scores - 100 base		
ORAM Total	98	64
Functional Capacity	87	31
Stressor*	100	96
Condition	100	88
Weighted 100-m Buffer	94	100
Inclusive W. 100-m Buffer	97	100

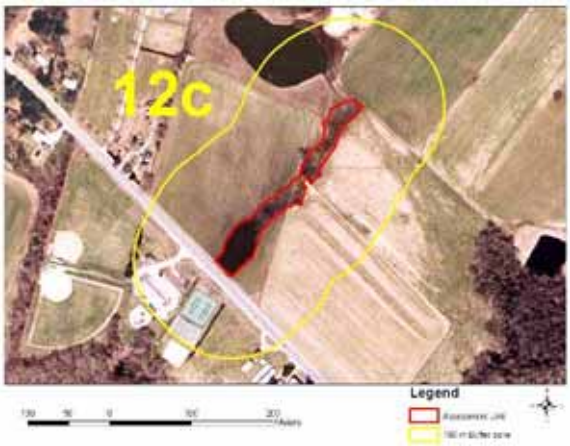
*derived from enhanced metrics

Site Number	09
Town	South Kingstown
Owner, Fee / Easment	Private / SKLT
HUC 12 Location	UPR
Area (acres)	2.7
Longitude	-71.56323
Latitude	41.50625
Standardized Scores - 100 base	
ORAM Total	79
Functional Capacity	52
Stressor*	93
Condition	95
Weighted 100-m Buffer	89
Inclusive W. 100-m Buffer	83



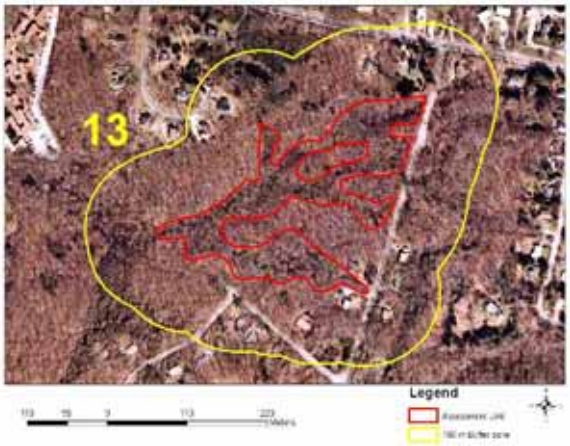
Site Number	10	10b
Town	South Kingstown	South Kingstown
Owner, Fee / Easment	Keah Properties LLC	SKLT
HUC 12 Location	UPR	UPR
Area (acres)	2.3	5.7
Longitude	-71.57302	-71.57572
Latitude	41.49157	41.49206
Standardized Scores-100 base		
ORAM Total	55	66
Functional Capacity	40	69
Stressor*	57	50
Condition	71	48
Weighted 100-m Buffer	43	66
Inclusive W. 100-m Buffer	52	70

Site Number	11b
Town	South Kingstown
Owner, Fee / Easment	SKLT
HUC 12 Location	UPR
Area (acres)	2.5
Longitude	-71.56652
Latitude	41.49815
Standardized Scores-100 base	
ORAM Total	77
Functional Capacity	66
Stressor*	57
Condition	78
Weighted 100-m Buffer	63
Inclusive W. 100-m Buffer	61



Site Number	12c
Town	South Kingstown
Owner, Fee / Easment	SKLT
HUC 12 Location	UPR
Area (acres)	1.5
Longitude	-71.56612
Latitude	41.48937
Standardized Scores-100 base	
ORAM Total	19
Functional Capacity	19
Stressor*	21
Condition	14
Weighted 100-m Buffer	17
Inclusive W. 100-m Buffer	13

* derived from enhanced metrics



Site Number	13
Town	South Kingstown
Owner, Fee / Easment	SKLT
HUC 12 Location	Chipuxet River
Area (acres)	8.4
Longitude	-71.53186
Latitude	41.47907
Standardized Scores-100 base	
ORAM Total	69
Functional Capacity	57
Stressor*	64
Condition	64
Weighted 100-m Buffer	71
Inclusive W. 100-m Buffer	82

Site Number	14
Town	South Kingstown
Owner, Fee / Easment	SKLT
HUC 12 Location	Chipuxet River
Area (acres)	1.9
Longitude	-71.53318
Latitude	41.47491
Standardized Scores-100 base	
ORAM Total	65
Functional Capacity	54
Stressor*	54
Condition	62
Weighted 100-m Buffer	60
Inclusive W. 100-m Buffer	64

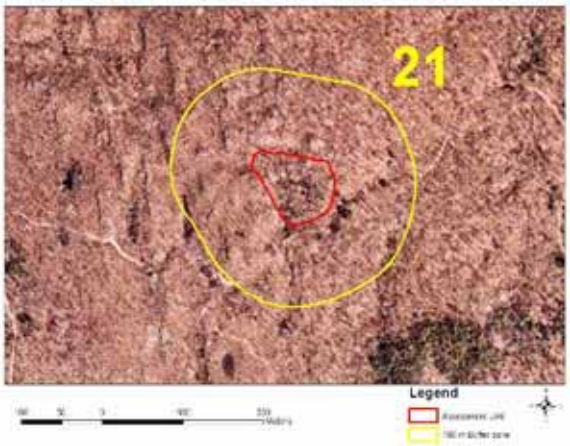
Site Number	15	16
Town	South Kingstown	South Kingstown
Owner, Fee / Easment	RIDEM	RIDEM
HUC 12 Location	Chipuxet River	Chipuxet River
Area (acres)	16.4	13.1
Longitude	-71.55331	-71.56113
Latitude	41.47881	41.47749
Standardized Scores-100 base		
ORAM Total	92	82
Functional Capacity	84	64
Stressor*	82	86
Condition	79	78
Weighted 100-m Buffer	74	77
Inclusive W. 100-m Buffer	79	76

Site Number	17
Town	Richmond
Owner, Fee / Easment	RIDEM
HUC 12 Location	UPR
Area (acres)	5.0
Longitude	-71.64737
Latitude	41.4492
Standardized Scores-100 base	
ORAM Total	58
Functional Capacity	46
Stressor*	36
Condition	66
Weighted 100-m Buffer	54
Inclusive W. 100-m Buffer	64

* derived from enhanced metrics

Site Number	18
Town	Charlestown
Owner, Fee / Easment	Town of Charlestown
HUC 12 Location	UPR
Area (acres)	1.7
Longitude	-71.65682
Latitude	41.43908
Standardized Scores-100 base	
ORAM Total	66
Functional Capacity	54
Stressor*	75
Condition	57
Weighted 100-m Buffer	83
Inclusive W. 100-m Buffer	82

Site Number	20
Town	Charlestown
Owner, Fee / Easment	RIDEM
HUC 12 Location	PR Mainstem
Area (acres)	23.5
Longitude	-71.71301
Latitude	41.42419
Standardized Scores-100 base	
ORAM Total	77
Functional Capacity	66
Stressor*	82
Condition	55
Weighted 100-m Buffer	77
Inclusive W. 100-m Buffer	85



Site Number	21
Town	Charlestown
Owner, Fee / Easment	RIDEM
HUC 12 Location	PR Mainstem
Area (acres)	1.6
Longitude	-71.71091
Latitude	41.41161
Standardized Scores-100 base	
ORAM Total	82
Functional Capacity	63
Stressor*	96
Condition	74
Weighted 100-m Buffer	100
Inclusive W. 100-m Buffer	100

Site Number	22	24
Town	Hopkinton	Hopkinton
Owner, Fee / Easment	Town of Hopkinton	Town of Hopkinton
HUC 12 Location	PR Mainstem	PR Mainstem
Area (acres)	0.6	21.5
Longitude	-71.78786	-71.78574
Latitude	41.421	41.41964
Standardized Scores-100 base		
ORAM Total	35	62
Functional Capacity	35	52
Stressor*	39	46
Condition	17	52
Weighted 100-m Buffer	40	66
Inclusive W. 100-m Buffer	40	79

* derived from enhanced metrics

Site Number	23
Town	Hopkinton
Owner, Fee / Easment	Town of Hopkinton LT
HUC 12 Location	PR Mainstem
Area (acres)	0.6
Longitude	-71.76082
Latitude	41.44972
Standardized Scores-100 base	
ORAM Total	79
Functional Capacity	49
Stressor*	100
Condition	95
Weighted 100-m Buffer	97
Inclusive W. 100-m Buffer	97

Site Number	25
Town	Westerly
Owner, Fee / Easment	The Westerly Land Trust
HUC 12 Location	PR Mainstem
Area (acres)	1.9
Longitude	-71.7995
Latitude	41.41173
Standardized Scores-100 base	
ORAM Total	63
Functional Capacity	46
Stressor*	75
Condition	66
Weighted 100-m Buffer	80
Inclusive W. 100-m Buffer	82

Site Number	26
Town	Westerly
Owner, Fee / Easment	Town of Westerly
HUC 12 Location	PR Mainstem
Area (acres)	493.4
Longitude	-71.79636
Latitude	41.36681
Standardized Scores-100 base	
ORAM Total	83
Functional Capacity	84
Stressor*	57
Condition	69
Weighted 100-m Buffer	49
Inclusive W. 100-m Buffer	91

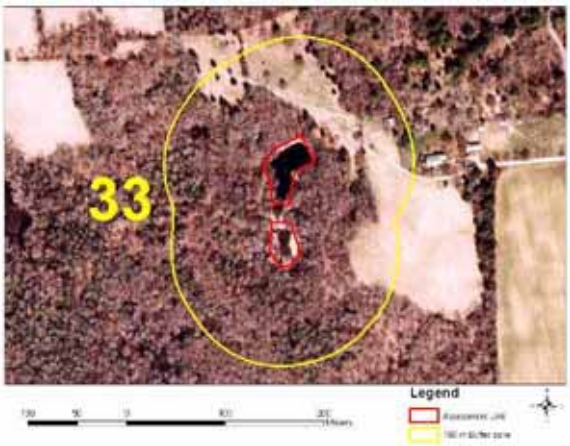
Site Number	28
Town	Westerly
Owner, Fee / Easment	The Westerly Land Trust
HUC 12 Location	PR Mainstem
Area (acres)	90.9
Longitude	-71.77702
Latitude	41.38889
Standardized Scores-100 base	
ORAM Total	98
Functional Capacity	107
Stressor*	86
Condition	79
Weighted 100-m Buffer	86
Inclusive W. 100-m Buffer	88

* derived from enhanced metrics

Site Number	29
Town	Charlestown
Owner, Fee / Easment	TNC
HUC 12 Location	UPR
Area (acres)	12.6
Longitude	-71.62713
Latitude	41.41296
Standardized Scores-100 base	
ORAM Total	91
Functional Capacity	76
Stressor*	100
Condition	95
Weighted 100-m Buffer	100
Inclusive W. 100-m Buffer	100

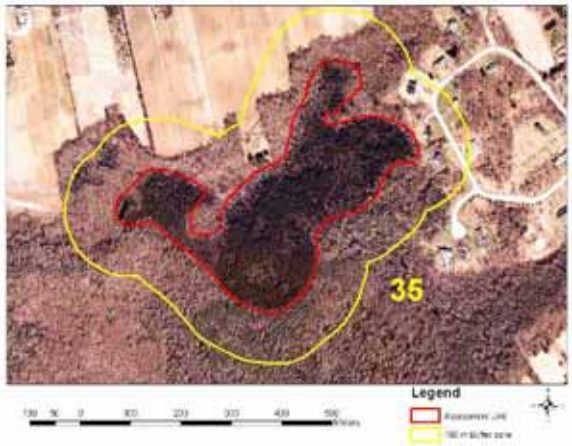
Site Number	30
Town	South Kingstown
Owner, Fee / Easment	SKLT
HUC 12 Location	UPR
Area (acres)	7.5
Longitude	-71.60446
Latitude	41.41438
Standardized Scores-100 base	
ORAM Total	80
Functional Capacity	69
Stressor*	75
Condition	74
Weighted 100-m Buffer	71
Inclusive W. 100-m Buffer	76

Site Number	32
Town	South Kingstown
Owner, Fee / Easment	ASRI
HUC 12 Location	Chipuxet River
Area (acres)	209.0
Longitude	-71.56446
Latitude	41.42293
Standardized Scores-100 base	
ORAM Total	88
Functional Capacity	83
Stressor*	79
Condition	74
Weighted 100-m Buffer	60
Inclusive W. 100-m Buffer	88

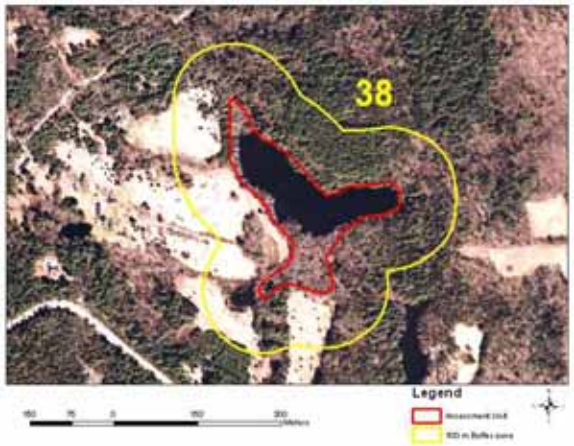


Site Number	33
Town	South Kingstown
Owner, Fee / Easment	Private / SKLT
HUC 12 Location	Chipuxet River
Area (acres)	0.7
Longitude	-71.53508
Latitude	41.43773
Standardized Scores-100 base	
ORAM Total	58
Functional Capacity	36
Stressor*	75
Condition	71
Weighted 100-m Buffer	77
Inclusive W. 100-m Buffer	70

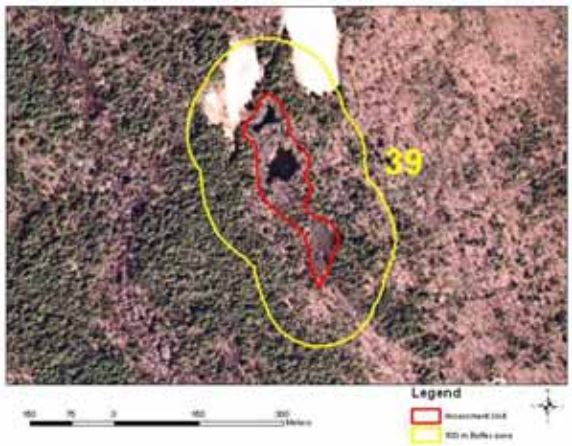
* derived from enhanced metrics



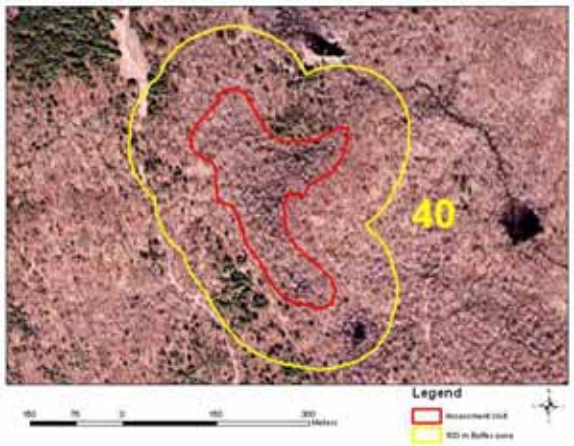
Site Number	35
Town	South Kingstown
Owner, Fee / Easment	SKLT
HUC 12 Location	Chipuxet River
Area (acres)	27.9
Longitude	-71.53533
Latitude	41.42677
Standardized Scores-100 base	
ORAM Total	87
Functional Capacity	67
Stressor*	93
Condition	88
Weighted 100-m Buffer	77
Inclusive W. 100-m Buffer	85



Site Number	38
Town	Exeter
Owner, Fee / Easment	ASRI
HUC 12 Location	Queen River
Area (acres)	9.2
Longitude	-71.57256
Latitude	41.58532
Standardized Scores-100 base	
ORAM Total	81
Functional Capacity	67
Stressor*	93
Condition	83
Weighted 100-m Buffer	89
Inclusive W. 100-m Buffer	88



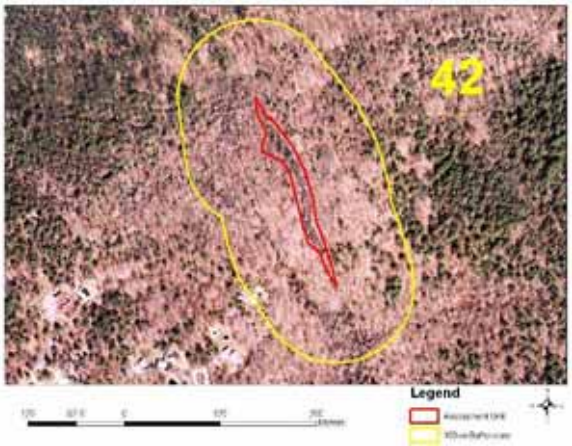
Site Number	39
Town	Exeter
Owner, Fee / Easment	ASRI
HUC 12 Location	Queen River
Area (acres)	5.1
Longitude	-71.57555
Latitude	41.59427
Standardized Scores-100 base	
ORAM Total	91
Functional Capacity	75
Stressor*	100
Condition	91
Weighted 100-m Buffer	94
Inclusive W. 100-m Buffer	97



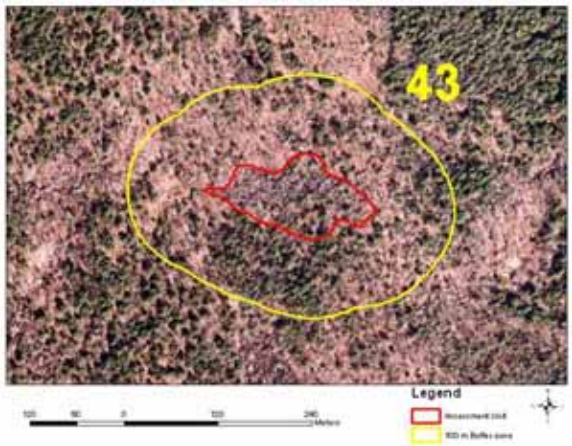
Site Number	40
Town	Exeter
Owner, Fee / Easment	TNC
HUC 12 Location	Queen River
Area (acres)	9.8
Longitude	-71.55136
Latitude	41.59833
Standardized Scores-100 base	
ORAM Total	82
Functional Capacity	54
Stressor*	100
Condition	95
Weighted 100-m Buffer	100
Inclusive W. 100-m Buffer	97

* derived from enhanced metrics

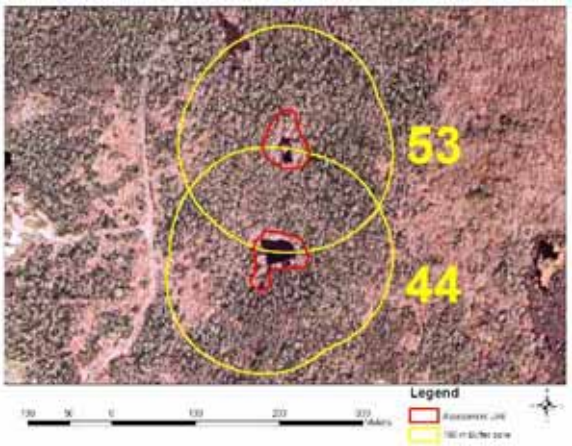
Site Number	41
Town	Exeter
Owner, Fee / Easment	TNC
HUC 12 Location	Queen River
Area (acres)	7.0
Longitude	-71.54951
Latitude	41.57981
Standardized Scores-100 base	
ORAM Total	68
Functional Capacity	51
Stressor*	68
Condition	69
Weighted 100-m Buffer	86
Inclusive W. 100-m Buffer	88



Site Number	42
Town	Exeter
Owner, Fee / Easment	ASRI
HUC 12 Location	Queen River
Area (acres)	1.1
Longitude	-71.5945
Latitude	41.59858
Standardized Scores-100 base	
ORAM Total	79
Functional Capacity	49
Stressor*	100
Condition	95
Weighted 100-m Buffer	100
Inclusive W. 100-m Buffer	100

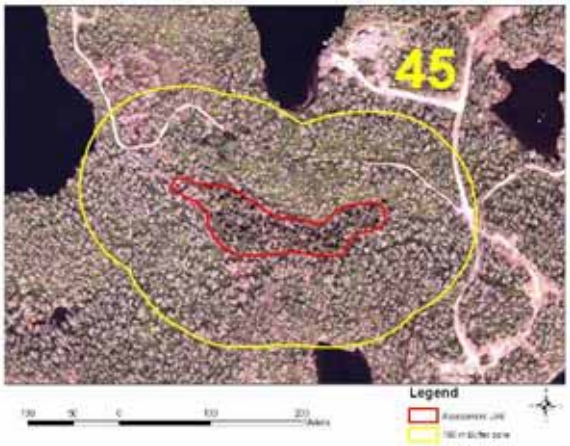


Site Number	43
Town	Exeter
Owner, Fee / Easment	ASRI
HUC 12 Location	Queen River
Area (acres)	3.2
Longitude	-71.58708
Latitude	41.59382
Standardized Scores-100 base	
ORAM Total	80
Functional Capacity	52
Stressor*	100
Condition	91
Weighted 100-m Buffer	100
Inclusive W. 100-m Buffer	100



Site Number	44	53
Town	South Kingstown	South Kingstown
Owner, Fee / Easment	TNC	SKLT
HUC 12 Location	Chipuxet River	Chipuxet River
Area (acres)	0.7	0.7
Longitude	-71.54354	-71.54345
Latitude	41.42121	41.42252
Standardized Scores-100 base		
ORAM Total	85	85
Functional Capacity	60	66
Stressor*	100	96
Condition	91	86
		0
Weighted 100-m Buffer	100	100
Inclusive W. 100-m Buffer	100	100

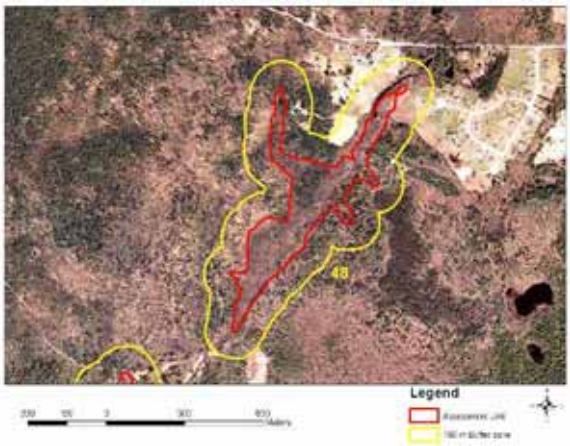
* derived from enhanced metrics



Site Number	45
Town	South Kingstown
Owner, Fee / Easment	TNC
HUC 12 Location	Chipuxet River
Area (acres)	2.3
Longitude	-71.54887
Latitude	41.41821
Standardized Scores-100 base	
ORAM Total	78
Functional Capacity	49
Stressor*	100
Condition	91
Weighted 100-m Buffer	94
Inclusive W. 100-m Buffer	97

Site Number	46
Town	South Kingstown
Owner, Fee / Easment	TNC
HUC 12 Location	Chipuxet River
Area (acres)	1.1
Longitude	-71.59029
Latitude	41.4297
Standardized Scores-100 base	
ORAM Total	80
Functional Capacity	58
Stressor*	82
Condition	95
Weighted 100-m Buffer	89
Inclusive W. 100-m Buffer	91

Site Number	47
Town	Richmond
Owner, Fee / Easment	RIDEM
HUC 12 Location	PR Mainstem
Area (acres)	3.1
Longitude	-71.68971
Latitude	41.47478
Standardized Scores-100 base	
ORAM Total	80
Functional Capacity	51
Stressor*	100
Condition	95
Weighted 100-m Buffer	94
Inclusive W. 100-m Buffer	94



Site Number	48
Town	Richmond
Owner, Fee / Easment	RIDEM
HUC 12 Location	PR Mainstem
Area (acres)	35.0
Longitude	-71.68164
Latitude	41.48167
Standardized Scores-100 base	
ORAM Total	86
Functional Capacity	66
Stressor*	93
Condition	88
Weighted 100-m Buffer	89
Inclusive W. 100-m Buffer	94

* derived from enhanced metrics

Site Number	49	50
Town	Hopkinton	Hopkinton
Owner, Fee / Easment	TNC	TNC
HUC 12 Location	PR Mainstem	PR Mainstem
Area (acres)	14.1	10.7
Longitude	-71.72832	-71.73059
Latitude	41.41348	41.41138
Standardized Scores-100 base		
ORAM Total	89	93
Functional Capacity	90	81
Stressor*	79	100
Condition	86	84
Weighted 100-m Buffer	69	91
Inclusive W. 100-m Buffer	82	94

Site Number	51
Town	Westerly
Owner, Fee / Easment	The Westerly Land Trust
HUC 12 Location	PR Mainstem
Area (acres)	3.1
Longitude	-71.80584
Latitude	41.40089
Standardized Scores-100 base	
ORAM Total	57
Functional Capacity	40
Stressor*	61
Condition	60
Weighted 100-m Buffer	49
Inclusive W. 100-m Buffer	61

Site Number	52
Town	South Kingstown
Owner, Fee / Easment	SKLT
HUC 12 Location	UPR
Area (acres)	2.2
Longitude	-71.57552
Latitude	41.50775
Standardized Scores-100 base	
ORAM Total	79
Functional Capacity	49
Stressor*	100
Condition	97
Weighted 100-m Buffer	100
Inclusive W. 100-m Buffer	100

Site Number	A1	A2	A3
Town	South Kingstown	South Kingstown	South Kingstown
Owner, Fee / Easment	URI	URI	URI
HUC 12 Location	UPR	UPR	UPR
Area (acres)	0.3	1.2	0.3
Longitude	-71.532085	-71.531148	-71.531548
Latitude	41.498324	41.497954	41.497009
Standardized Scores-100 base			
ORAM Total	43	32	43
Functional Capacity	31	34	40
Stressor*	36	14	29
Condition	53	14	34
Weighted 100-m Buffer	31	40	57
Inclusive W. 100-m Buffer	31	40	57

* derived from enhanced metrics

Site Number	A4
Town	Exeter
Owner, Fee / Easment	ASRI
HUC 12 Location	Queen River
Area (acres)	0.1
Longitude	-71.572708
Latitude	41.521628
Standardized Scores-100 base	
ORAM Total	72
Functional Capacity	39
Stressor*	100
Condition	97
Weighted 100-m Buffer	97
Inclusive W. 100-m Buffer	97

Site Number	A5	A6
Town	Richmond	Richmond
Owner, Fee / Easment	TNC	TNC
HUC 12 Location	UPR	UPR
Area (acres)	1.6	0.1
Longitude	-71.648808	-71.647668
Latitude	41.493106	41.49511
Standardized Scores-100 base		
ORAM Total	82	68
Functional Capacity	67	37
Stressor*	93	100
Condition	74	88
Weighted 100-m Buffer	91	100
Inclusive W. 100-m Buffer	94	100

Site Number	NK5
Town	North Kingstown
Owner, Fee / Easment	Town of North Kingstown
HUC 12 Location	Lower West Passage
Area (acres)	35.8
Longitude	-71.48828
Latitude	41.55115
Standardized Scores-100 base	
ORAM Total	90
Functional Capacity	93
Stressor*	61
Condition	67
Weighted 100-m Buffer	77
Inclusive W. 100-m Buffer	82

Site Number	NK6
Town	North Kingstown
Owner, Fee / Easment	Town of North Kingstown
HUC 12 Location	Hunt River
Area (acres)	61.9
Longitude	-71.49328
Latitude	41.60019
Standardized Scores-100 base	
ORAM Total	87
Functional Capacity	92
Stressor*	57
Condition	69
Weighted 100-m Buffer	60
Inclusive W. 100-m Buffer	64

* derived from enhanced metrics

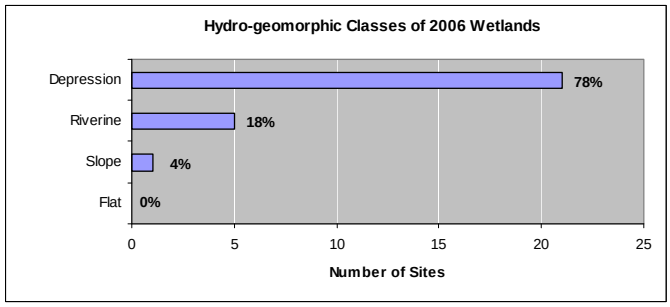
Site Number	NK3-7-8
Town	North Kingstown
Owner, Fee / Easment	Town of North Kingstown
HUC 12 Location	Pettaquamscutt River
Area (acres)	21.2
Longitude	-71.44625
Latitude	41.52291
Standardized Scores-100 base	
ORAM Total	92
Functional Capacity	93
Stressor*	64
Condition	74
Weighted 100-m Buffer	89
Inclusive W. 100-m Buffer	88

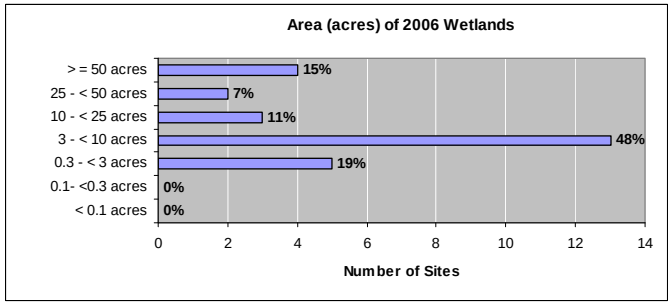
* derived from enhanced metrics

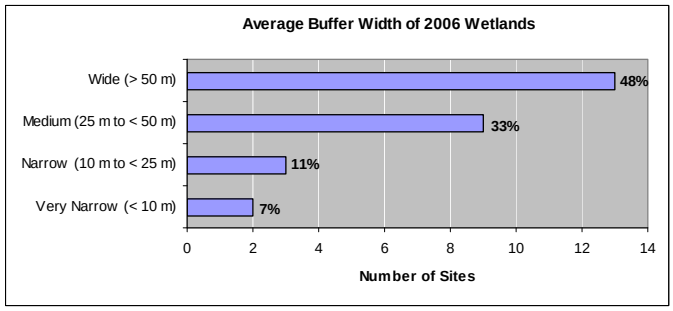
Appendix 6

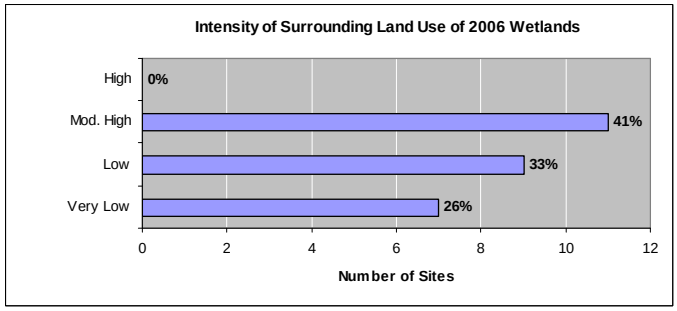
Graphs of ORAM Metric Data collected in 2006 (*n*=27) and 2007 (*n*=58)

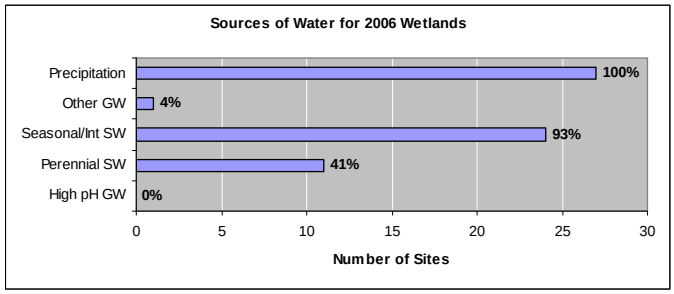
Wetlands assessed in 2006



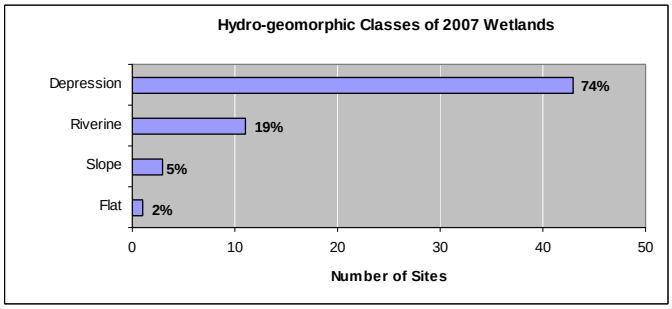


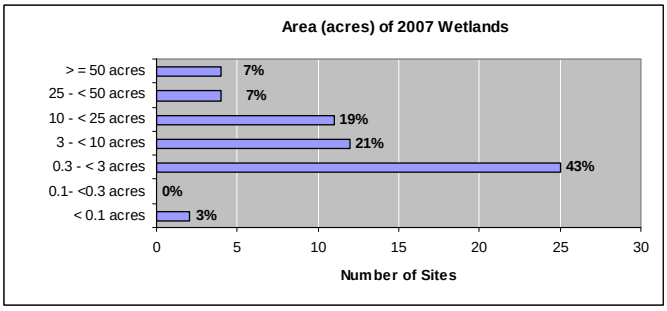


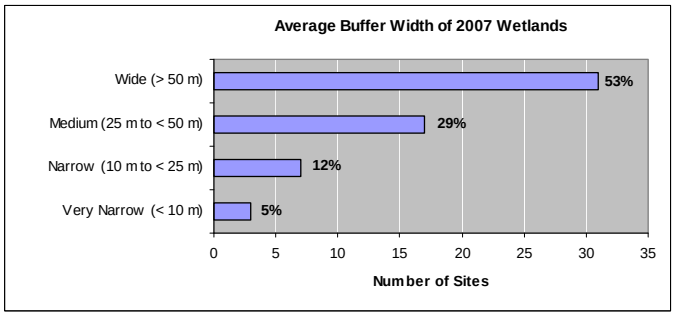


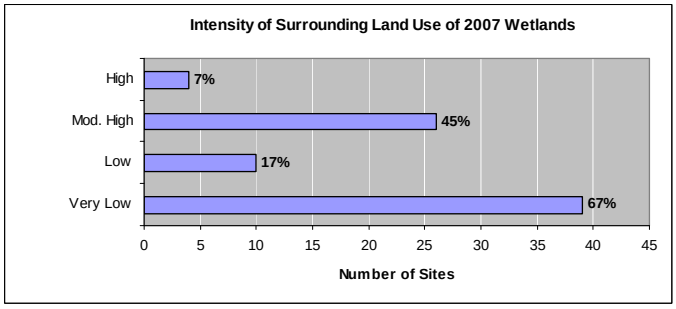


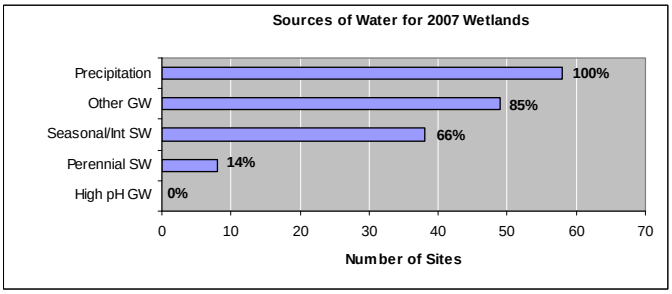
Wetlands assessed in 2007



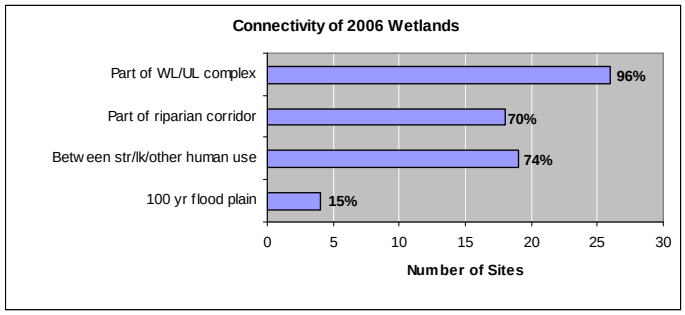


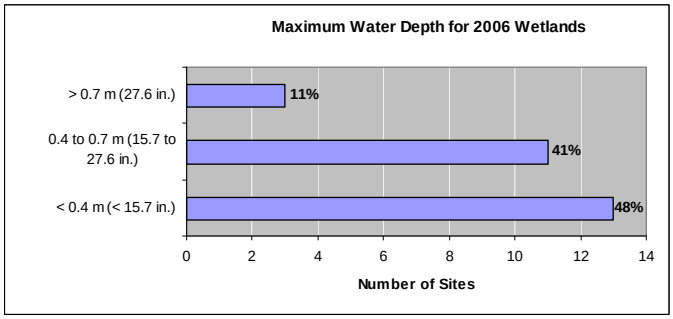


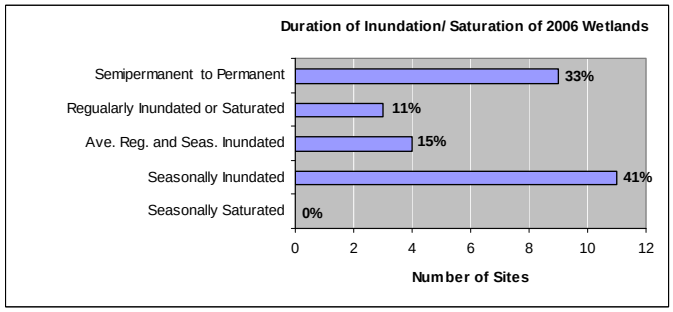


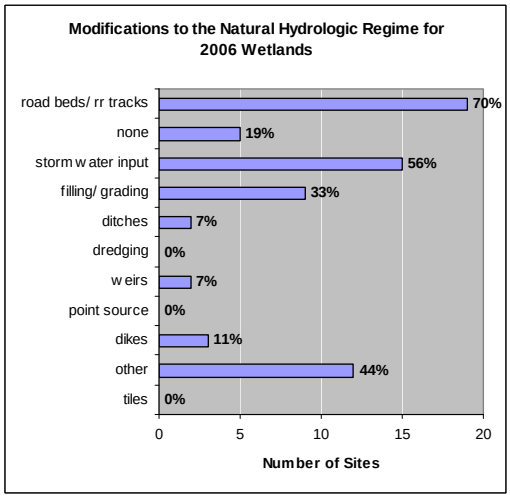


Wetlands assessed in 2006

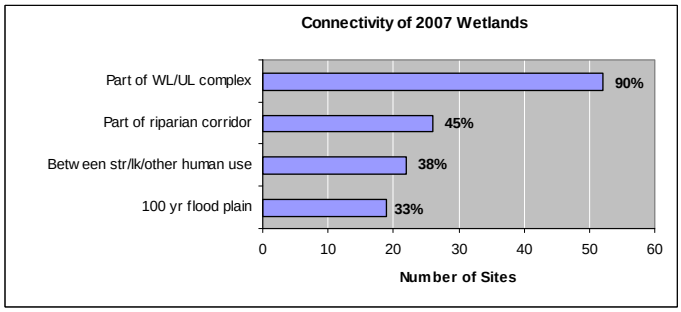


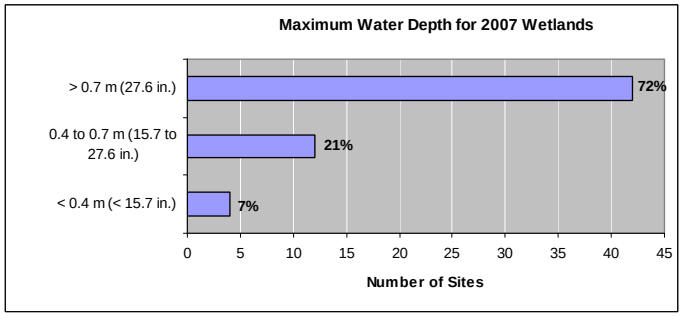


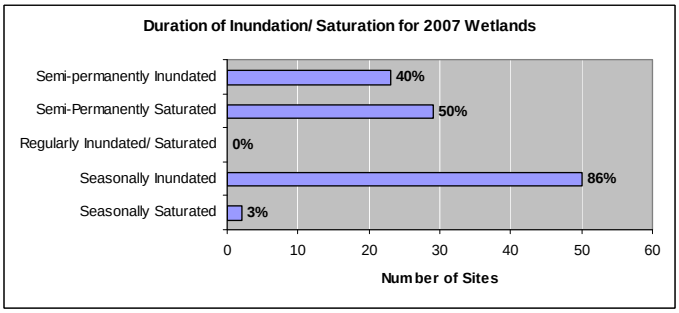


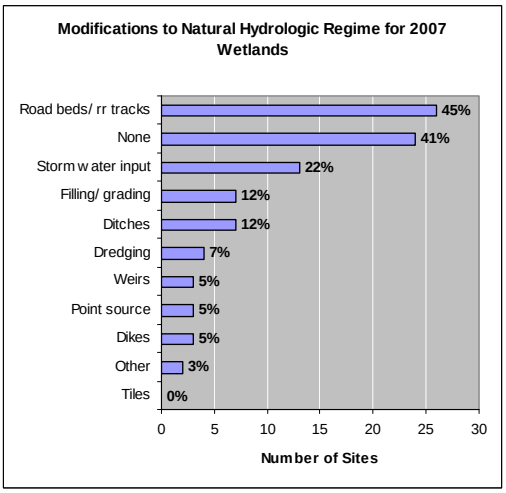


Wetlands assessed in 2007

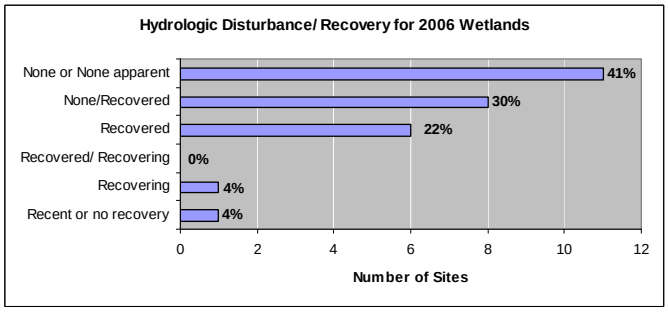


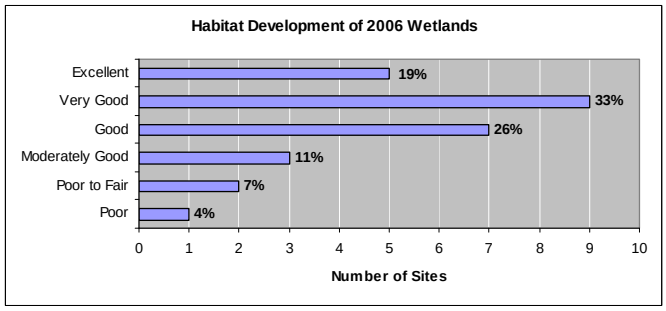


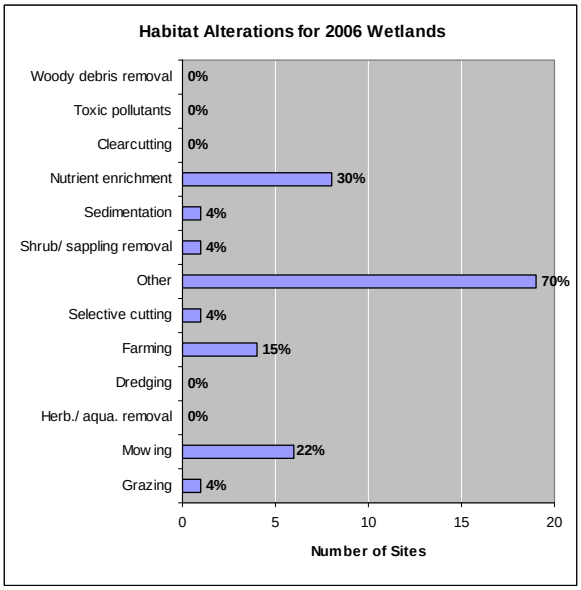




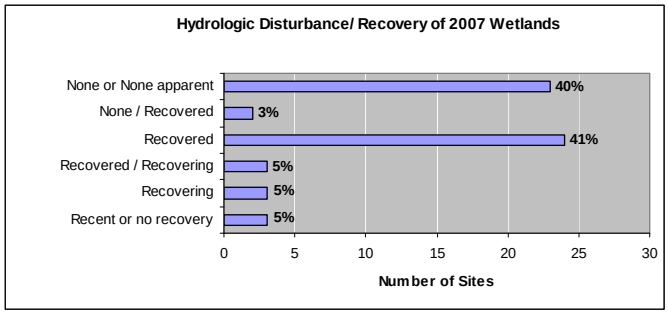
Wetlands assessed in 2006

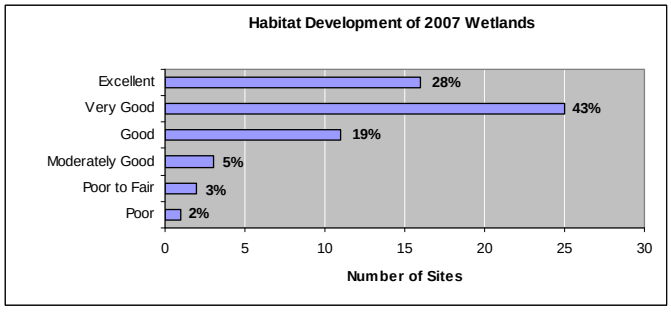


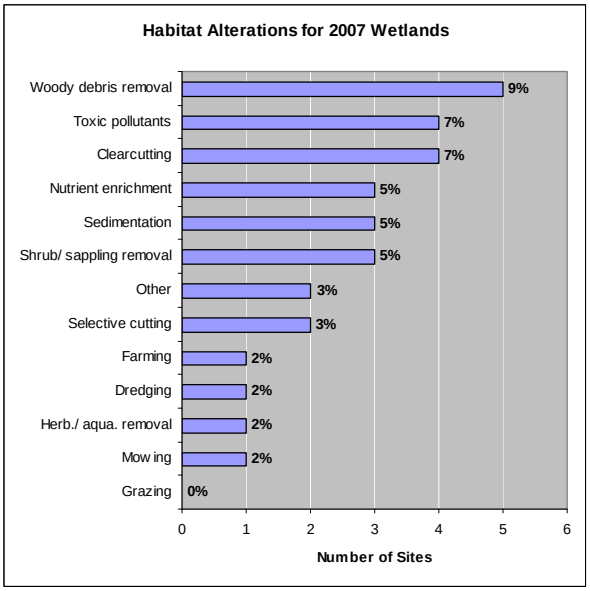


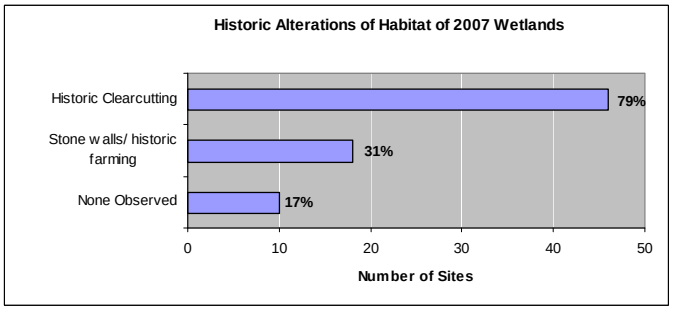


Wetlands assessed in 2007

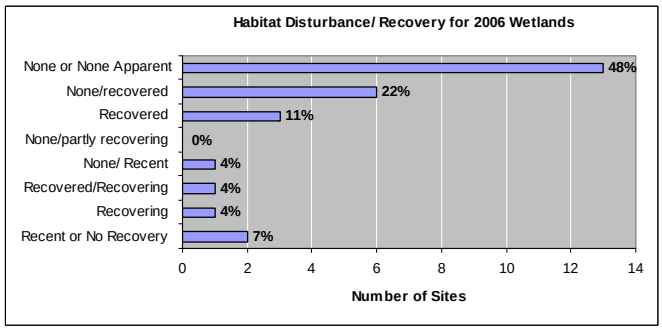


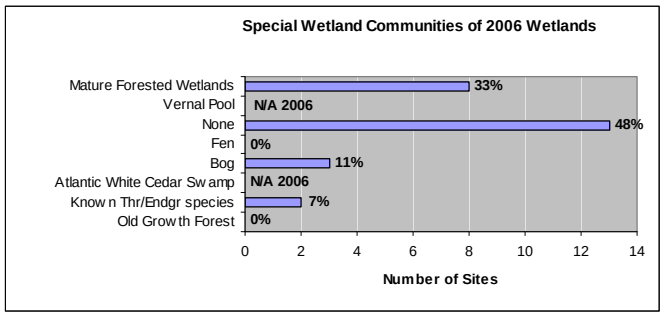


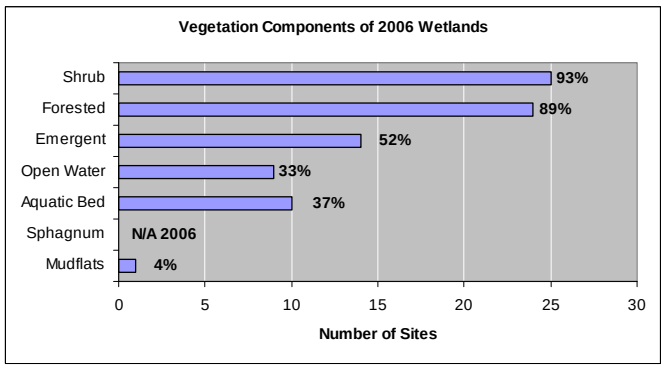


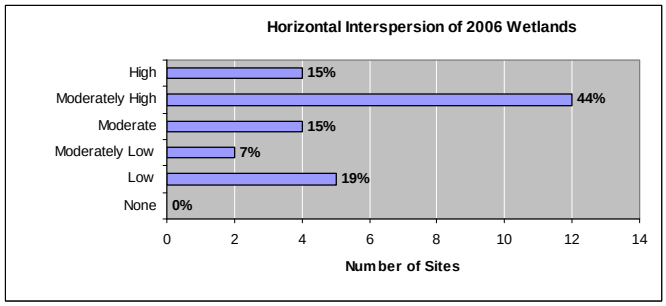


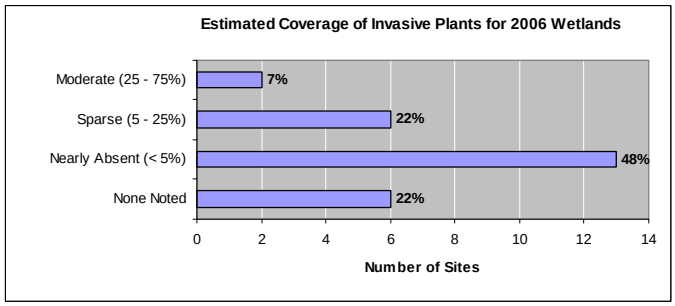
Wetlands assessed in 2006











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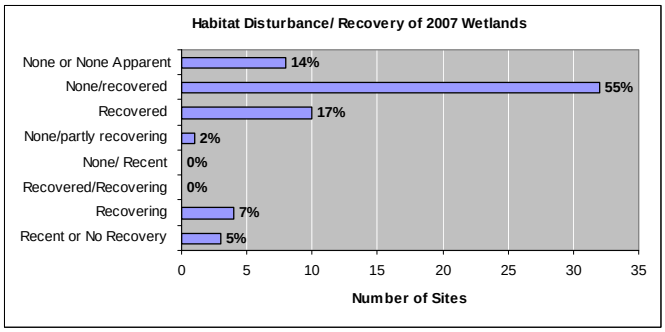

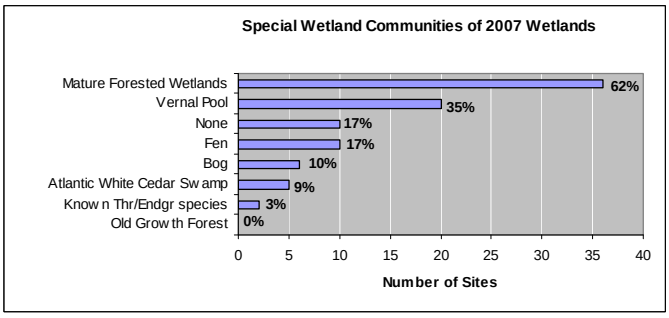

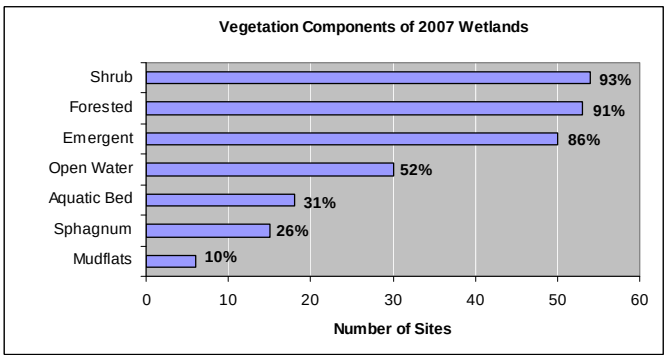

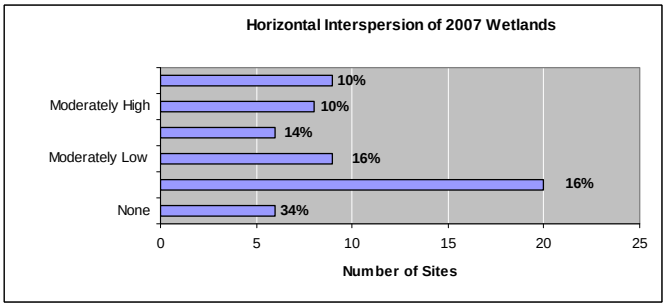

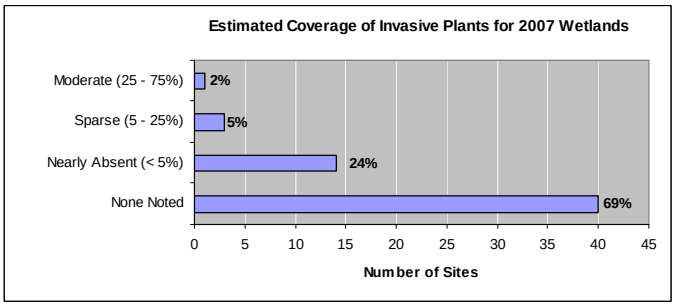

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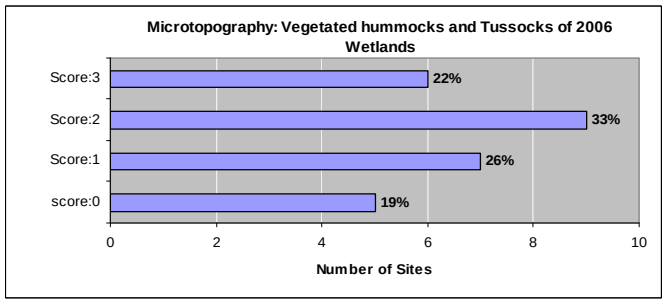

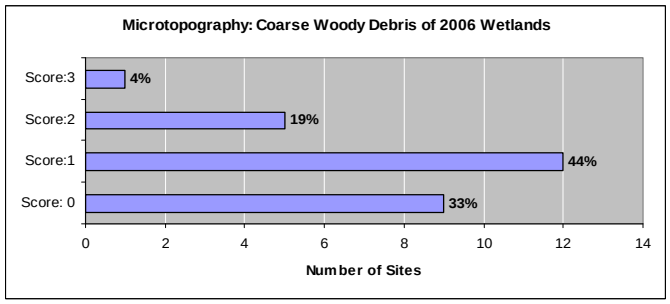

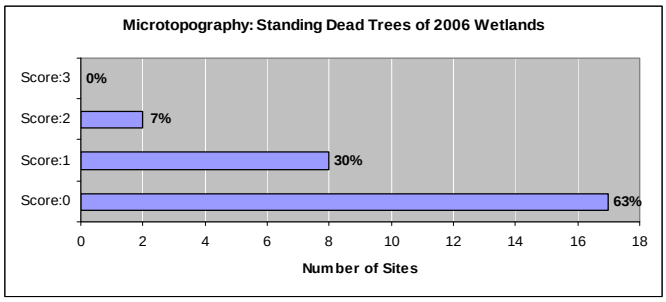

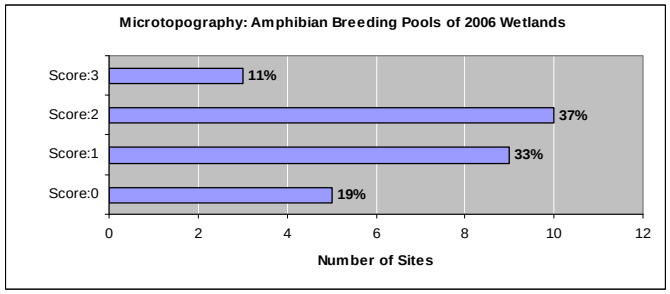

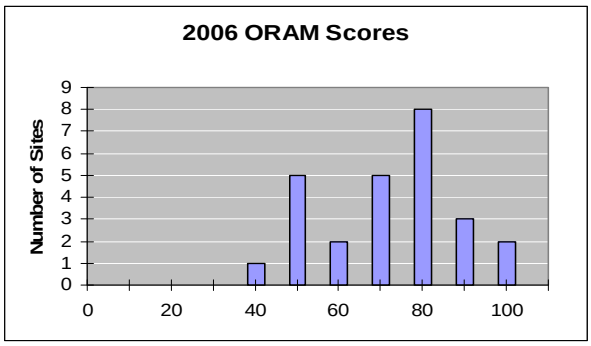

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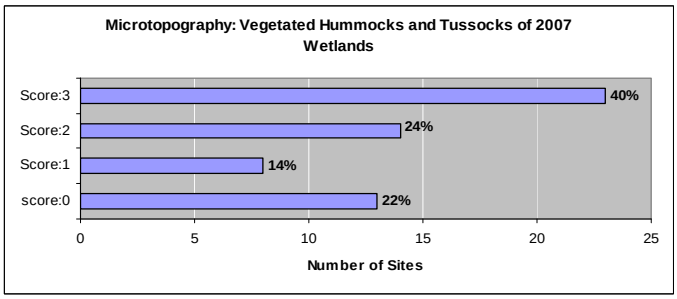

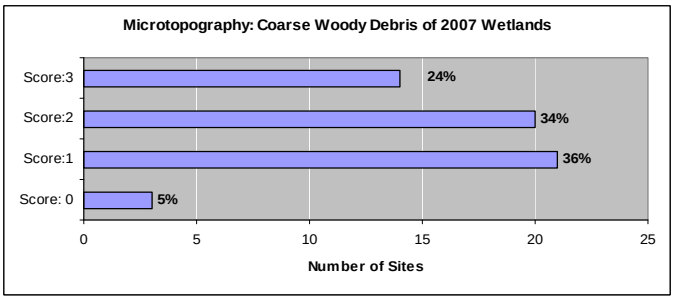

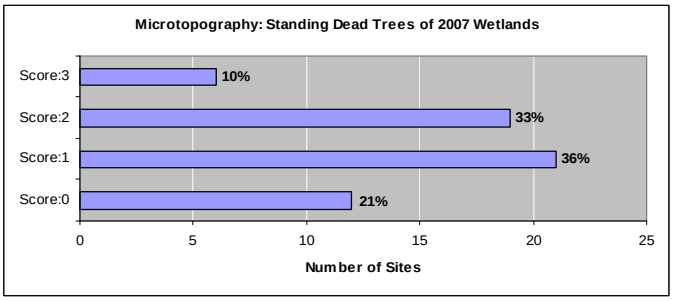

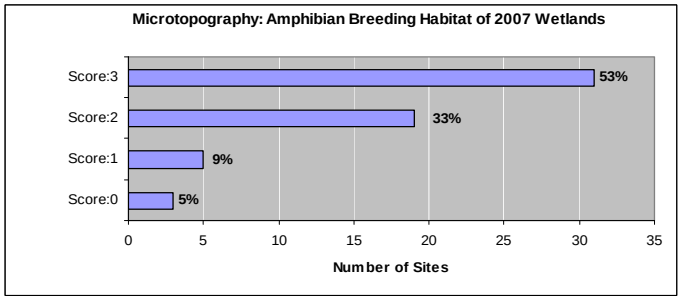

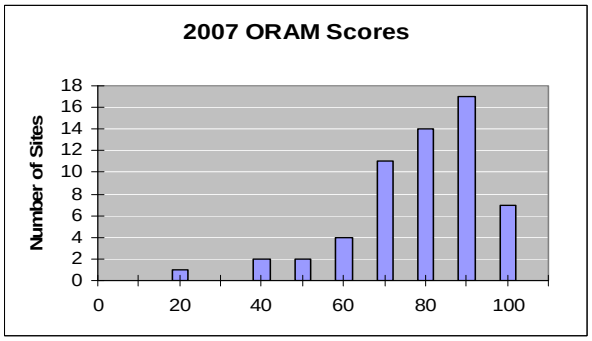

Appendix 7

Proposed *RIRAM v.1* Field Form

Demonstrates:
Revised Cover Sheet
Metrics arranged by metric function
Wetland Characteristics un-scored
DERAP attributes and *Substrate Disturbance* integrated into ORAM *Stressor* metrics
Enhanced *Stressor* scoring capabilities
Revised *Buffer* metrics
Proposed groundwater withdrawal metric

Background Information

Investigator(s):	
Date:	
Affiliation:	
Address:	
Phone Number:	
Email:	
Name of Wetland:	
Site Code:	
Town:	
Property/Easement Owner:	
Access Directions:	
HGM Class(es):	
NWI Class(es):	Dominance Type(s):
RINHP Community Type(s):	
Lat/Long:	
HUC 12 Name:	
HUC 10 Name:	
HUC 8 Name:	
Assessment Unit Size (acres):	
Photos Taken:	

RIRAM v. 1 Scoring Form

Site Number: **Raters:** **Date:**

I. WETLAND CHARACTERISTICS

Stressor Total	_____ +
Condition Total	_____ =
RIRAM Total	

1. Assessment Area

Select one

- ☐ >50 acres
- ☐ 25 to 50 acres
- ☐ 10 to <25 acres
- ☐ 3.0 to <10 acres
- ☐ 0.3 to <3.0 acres
- ☐ 0.1 to <0.3 acres
- ☐ <0.1 acres

2. Hydrologic Characteristics

2a. Sources of groundwater. Select all that apply.

- ☐ Groundwater
- ☐ Precipitation
- ☐ Seasonal/intermittent surface water
- ☐ Perennial surface water

2b. Connectivity. Select all that apply.

- ☐ 100 year flood plain
- ☐ Between stream/lake and human use
- ☐ Part of a wetland or upland complex
- ☐ Part of a riparian or upland corridor

2c. Maximum water depth. Select one.

- ☐ > 0.7m
- ☐ 0.4 to 0.7m
- ☐ <0.4m

2d. Duration of water. Select one or double check.

- ☐ Semi- to permanently flooded
- ☐ Semi- to permanently saturated
- ☐ Seasonally flooded
- ☐ Temporarily flooded
- ☐ Seasonally saturated
- ☐ Regularly flooded (tidal)
- ☐ Irregularly flooded (tidal)

3. Habitat Characteristics

3a. Vegetation structural diversity

Rate all present using 0 to 3 scales at right.

- ☐ Aquatic bed
- ☐ Emergent
- ☐ Shrub
- ☐ Forest
- ☐ Mudflats
- ☐ Open water
- ☐ Sphagnum

3b. Horizontal interspersion

Select one.

- ☐ High
- ☐ Moderately high
- ☐ Moderate
- ☐ Moderately Low
- ☐ Low
- ☐ None

3c. Microtopography

Rate all present using 0 to 3 scale at right.

- ☐ Vegetated hummucks/tussucks
- ☐ Coarse woody debris >15cm
- ☐ Standing dead >25cm dbh
- ☐ Amphibian breeding pools

Vegetation Community Cover Scale	Apply to metric 3a
0	Absent, or comprises <0.1ha **and** <30% contiguous aerial cover
1	Present and either comprises a small part of the wetland's vegetation and is of moderate quality, or comprises a significant part but is of low quality
2	Present and either comprises a significant part of the wetland's vegetation and is of moderate quality, or comprises a small part and is of high quality
3	Present and comprises a significant part or more of the wetland's vegetation and is of high quality

Mudflat and Open Water Cover Scale	Apply to metric 3a
0	Absent, or comprises <0.1ha **and** <30% continuous aerial cover
1	Low 0.1 to 1ha, or <0.1ha **and** comprises >30% continuous aerial cover
2	Moderate 1 to 4ha
3	High 4ha

Microtopography Cover Scale	Apply to metric 3c
0	Absent
1	Present in very small amounts or in moderate amounts of marginal quality
2	Present in moderate amounts, but not of the highest quality, or in smaller amounts of the highest quality
3	Present in moderate or greater amounts and of the highest quality

4. Special Wetlands

Check all that apply.

- ☐ Bog
- ☐ Fen
- ☐ Old growth forest
- ☐ Atlantic white cedar swamp
- ☐ Coastal plain pondshore
- ☐ Interdunal swale
- ☐ Mature forested wetland
- ☐ Vernal pool present
- ☐ Known occurrence of state/federal threatened or endangered species
- ☐ Significant migratory songbird or waterfowl habitat or use
- ☐ Other_____

Site Number: Raters: Date:

II. STRESSOR METRICS

Stressor Total ☐

☐ max 14 pts.

5. Upland buffers and surrounding land use

5a. Estimate % cultural cover within 50m buffer. Select one.

- ☐ <1% (7)
- ☐ 1 to 10% (5)
- ☐ 10-25% (3)
- ☐ 25-75% (1)
- ☐ >75% (0)

5b. Land Use Intensity weighted average within 100m buffer.
Estimate proportion of each class to the nearest tenth and multiply.

- ☐ Very Low (7) × 7 = ☐
- ☐ Low (5) × 5 = ☐
- ☐ Moderately High (3) × 3 = ☐
- ☐ High (1) × 1 = ☐

Sum weighted values for 5b score: ____

5c. Check all significant 100m buffer stressors that apply. Do **not** score.

- ☐ Commercial or industrial development or construction
- ☐ Residential development or construction
- ☐ Land fill or waste disposal
- ☐ Channelized streams or ditches
- ☐ Raised road beds
- ☐ Row crops, turf, or nursery plants
- ☐ Poultry or livestock operations
- ☐ Orchards, hay fields or pasture
- ☐ Piers or docks
- ☐ Golf course
- ☐ Sand and gravel operation

Very Low:	Natural areas
Low:	Recovering natural lands, passive recreation, low trails/dirt roads
Mod High:	Residential, pasture/hay, mowed areas, raised roads to 2-lane
High:	Urban, impervious cover, row crops, turf, paved roads > 2-lane

☐ max 7 pts. min 0 pts.

6. Hydrologic Stressors (within wetland)

Rate all evident disturbances observed on 0 to 3 scale below and sum. **Subtract total from 7.**
Also apply this metric to metric 9a.

- ☐ stormwater inputs
- ☐ other point source
- ☐ stream channelization
- ☐ road bed/railroad track
- ☐ beaver dam removal
- ☐ filling/grading
- ☐ groundwater withdrawal area
- ☐ ditch
- ☐ tile
- ☐ dike
- ☐ weir
- ☐ dredging
- ☐ other_____

☐ **Total**
☐ **7 minus total**

☐ max 7 pts. min 0 pts.

7. Habitat Stressors (within wetland)

Rate all evident disturbances observed on 0 to 3 scale below and sum. **Subtract total from 7.**
Also apply this metric to metric 10a.

- ☐ mowing
- ☐ grazing
- ☐ clear cutting
- ☐ selective cutting
- ☐ woody debris removal
- ☐ toxic pollutants
- ☐ substrate disturbance
- ☐ filling/raised roads
- ☐ Shrub/sapling removal
- ☐ herbaceous or aquatic bed removal
- ☐ sedimentation
- ☐ dredging
- ☐ farming
- ☐ nutrient enrichment
- ☐ other_____

☐ **Total**
☐ **7 minus total**

Rating Scale for metrics 6 and 7 above
0 - Not noted
U - Noted, but unknown effects on hydrology / habitats (I pt.)
1 - Minor effect on hydrology / habitats
2 - Moderate effect on hydrology / habitats
3 - Severe effect on hydrology / habitats

8. Historic Modifications

Check all evident historic disturbances. Do **not** rate these numerically. Only apply them to *Condition* metrics.
Wetlands with **only** historic disturbances should be rated as both *None or none apparent* and *Recovered* when applied to *Condition* metrics.

- ☐ Historic impoundment (>100 years). Apply to metric 9a.
- ☐ Historic draining (>100 years). Apply to metric 9a.
- ☐ Historic clear cutting/farming (>50 years). Apply to metric 10a.

Site Number: Raters: Date:

III. CONDITION METRICS

Condition Total ☐

☐ max 13 pts. min 0 pts.

9. Hydrologic Condition

9a. Modifications to natural hydrologic regime. Score one or double check and average.
Refer to *Stressor Metrics* 6 and 8.

- ☐ None or none apparent (12)
- ☐ Recovered (7)
- ☐ Recovering (3)
- ☐ Recent or no recovery (1)

9b. Conditions evident due to draining. Score the uppermost attribute that applies.

- ☐ Severe root exposure >20cm (-2)
- ☐ Moderate root exposure 10 to 20cm (-1)
- ☐ Slight root exposure 3 to 10cm (0)
- ☐ Soil fissures obvious (0)
- ☐ Uncharacteristic ground cover (0)
- ☐ None noted (1)

☐ max 17 pts.

10. Habitat Condition

10a. Habitat alteration. Score one or double check and average.
Refer to *Stressor Metrics* 7 and 8.

- ☐ None or none apparent (9)
- ☐ Recovered (6)
- ☐ Recovering (3)
- ☐ Recent or no recovery (1)

10b. Habitat development. Select one and assign score.

- ☐ Excellent (7)
- ☐ Very good (6)
- ☐ Good (5)
- ☐ Moderately good (4)
- ☐ Fair (3)
- ☐ Poor to fair (2)
- ☐ Poor (1)

10c. Total coverage of invasive plants. Refer to Appendix 1. Estimate and add or deduct points and score.

- ☐ Extensive >75% cover (-5) ..... Class 4
- ☐ Moderate 25-75% cover (-3) ..... Class 3
- ☐ Sparse 5-25% cover (-1) ..... Class 2
- ☐ Nearly absent <5% cover (0) ..... Class 1
- ☐ None noted (1)

10d. Estimate cover class of each invasive species and list by dominance within site. Do not score.

- ☐ _____
- ☐ _____
- ☐ _____

Appendix 8

Summary of Recommended Modifications to the ORAM for Application in RI

Summary of Recommended Modifications to the ORAM for Application in RI

Draft 2
Tom Kutcher
June, 2008

RHODE ISLAND
NATURAL HISTORY SURVEY
Providing Ecosystem Science and Information

Adaptations
- Metric 5, *Special Wetlands*, is tailored to reflect regional types.
- Submetric 6c, *Coverage of Invasive Species*, is tailored to reflect regional types and enhanced to collect coverage classes of specific dominant species.

Reorganization
- Metrics are reorganized into (1) *Wetland Characteristics*, (2) *Stressors*, and (3) *Condition*.

Enhancements
- In addition to HGM classes, wetlands are characterized by Cowardin et al. and RINHP Natural Community Type(s).
- Metric 2a, *Average Buffer Width*, is substituted with *% Cultural 50-m* metric.
- Metric 2b, *Intensity of Surrounding Land Use*, is substituted with *100-m Weighted Buffe*r metric.
- DERAP stressor attributes are incorporated into ORAM protocols.
- Stressor attributes are scored and metric 4a, *Substrate Disturbance*, is incorporated into this metric.
- A *Historic Alterations* metric is added.
- Soils subsidence and root exposure metric is incorporated into the RAM.

Adaptations

1) Metric 5, *Special Wetlands*, is tailored to reflect regional types

   Benefits:
   - Establishes relevance in the metric for RI application
   - Identifies relevant wetland communities of concern
   - Ensures intended scoring balance of the RAM
   - Directly addresses the following **short-term objective**, *Prioritize wetlands (and adjacent upland habitat) for protection through open space acquisition and other land protection mechanisms*, by identifying the presence of rare, sensitive, or otherwise regionally important habitat types.

   Consequences: none, retains function

   Validation: not assessed but analogous to original

2) ORAM submetric 6c, *Coverage of Invasive Species*, is tailored to reflect regional types and enhanced to collect coverage classes of specific dominant species.

   Benefits:
   - Establishes relevance in the metric for RI application
   - Identifies relevant invasive species incursions

- Ensures intended scoring balance of the RAM
- Enhances RAM utility by identifying explicit species and their effects on wetlands
- Directly addresses the following **short-term objective**, *Monitor location and extent to which invasive species are present and affecting wetland condition*, by identifying the presence and extent of specific invasive plant species.

Consequences: none, retains function

Validation: not assessed but analogous to original

Reorganization

1) ORAM metrics are reorganized into three distinct categories characterizing (1) *Wetland Characteristics*, (2) *Stressors*, and (3) *Condition*.

Benefits:

- Functionality of the RAM is greatly increased
  - Categories facilitate analyses that clarify the relationships between wetland characteristics, stressors to wetlands, and wetland condition
  - Scores can be applied separately to answer numerous questions
  - Scores can be used to prioritize wetlands for preservation or restoration
  - Separate category scores are better predictors of environmental condition, since confounding summations are eliminated
- Revised summation of metric scores retains or improves utility and validity of the original ORAM relevant to RI needs
- Individual metric utility is retained
- Scores do not produce any *value* index for each wetland and thus cannot logically be used to manipulate wetland policy
- Allows the refinement of metrics through inter-category analysis
- Directly addresses the following **short-term objective**, *Prioritize wetlands (and adjacent upland habitat) for protection through open space acquisition and other land protection mechanisms*, by supplying indices of *condition* and wetland characteristic information that can be used to (1) identify wetlands with the highest potential for function and the lowest potential for degradation.
- Addresses the following **short-term objective**, *Monitor and assess impacts to wetlands due to loss and degradation of adjacent upland habitats (buffer zones)*, by supplying (rapidly-assessed) scores that can be used to characterize the severity of wetland degradation for analysis of buffer-loss impacts on various wetland types, i.e. buffer metric (see below) versus wetland *condition* score.
- Addresses the following **long-term objective**, *Develop a database of information necessary to evaluate trends in wetland condition*, by supplying (rapidly-assessed) scores that can be used to characterize wetland condition and stressors, and be applied to trends analysis.
- Addresses the following **long-term objectives**, *(1) Develop a database of information necessary to evaluate trends in wetland* ***condition*** *(2) Evaluate the effectiveness of wetland management and protection programs with respect to wetland* ***condition****, and (3) Identify program and policy changes*

needed to improve overall wetland ***condition*** *statewide*, by generating (rapidly-assessed) scores that can be used to indicate and/or characterize wetland condition, are not confounded by *functional capacity* (value-added) scoring built into ORAM, and can be applied on a wider scale than far-more intensive (e.g. IBI) characterizations.

Consequences:

- Requires a reorganized field form
- Metric 3 and metric 6 scoring caps may be slightly compromised in assessing a total score
- Metrics intended to characterize certain aspects of functional capacity are not scored

Validation:

- Each category produces strong, valid trend data against % developed land cover in the surrounding landscape
- *Stressor* scores are strongly (inversely) correlated (r^2=0.78) with % development in the surrounding 100-m buffer-zone; *condition* scores are less-but-still strongly correlated (r^2=0.60), while *functional capacity* scores are only moderately-weakly correlated (r^2=0.17). This trend is logical since % development directly reflects stressors, indirectly affects condition, and does not necessarily (but may) affect listed functional characteristics.
- The *stressor* scores (logically) strongly predict *condition* scores (r^2=0.56)
- *Functional capacity* scores do not strongly predict *condition* scores, also logical since they are not necessarily interrelated
- In preliminary analyses, *condition* scores are strongly associated with various pilot IBIs indicating amphibian density and richness
- In preliminary analyses, *Stressor* scores are (logically) somewhat less (but still) strongly associated with various pilot IBIs indicating amphibian density and richness

Enhancements

1) In addition to HGM classes, wetlands are characterized by Cowardin et al. classification to dominance type(s) and by the RINHP Natural Community Type(s) according to Enser and Lundgren (2006).

   Benefits:

   - Allows cross-walking between data types (e.g. RIGIS or NWI and RAM data) for data interoperability
   - Allows for analyses based on various classes (e.g. forested versus emergent or riverine versus depressional), which expands the utility of the RAM in addressing all short-term and long-term goals.

   Consequences: none

   Validation: N/A

2) ORAM metric 2a, *Average Buffer Width*, is substituted with *% Cultural 50-m* metric, which estimates cultural cover in the 50-m buffer zone rather than estimating an average buffer width.

   Benefits:

   - More objective measure of adjacent buffer width effects

- Less ambiguity in scoring
- Directly addresses **short-term objective**, *Monitor and assess impacts to wetlands due to loss and degradation of adjacent upland habitats (buffer zones)*, by providing a more precise and objective measure of buffer-width effects.

Consequences: actual buffer width is not directly estimated

Validation:

- Conceptually and numerically analogous to original metric
- Strongly correlated with original metric (r^2=0.70)
- Equally correlated to metric scores rating *condition* as original metric (r^2=0.48 for both)

3) ORAM metric 2b, *Intensity of Surrounding Land Use*, is substituted with *100-m Weighted Buffe*r metric, which estimates the proportions of four classes of land use intensity in the 100-m buffer zone rather than selecting one or two representative classes.

Benefits:

- More objective measure of surrounding land use intensity
- Less ambiguity in scoring
- Much more accurate and precise measure of land use intensity
- Can be used to predict wetland condition in a remotely-sensed environment
- Directly addresses **short-term objective**, *Monitor and assess impacts to wetlands due to loss and degradation of adjacent upland habitats (buffer zones)*, by providing a much more precise, accurate, and objective measure of surrounding land use intensity.

Consequences: none

Validation:

- Conceptually and numerically analogous to original metric
- More strongly correlated with ORAM metrics rating *condition* and *stressors*

4) DERAP stressor attributes are incorporated into ORAM protocols.

Benefits:

- Adds detail to ORAM stressor attributes
- Fills gaps in ORAM characterizations
- Allows the use of a single RAM
- Allows analysis by applying relative value to stressor impacts (see below)
- Directly addresses **long-term objective**, *Identify causes and sources of wetland degradation including cumulative impacts to wetlands*, by identifying specific stressors within wetlands and their 100-m buffer-zones.

Consequences: none

Validation: (see below)

5) Stressor attributes are each rated for intensity and scored on an analogous scale to other metrics characterizing *stressors*. Metric 4a, *Substrate Disturbance*, is incorporated into this metric.

Benefits:

- Clarifies the impact intensity of each specific stressor to each wetland
- Allows analysis of cumulative effects of stressors

- Strengthens the power of the RAM to predict stressor impacts on wetland condition
- Directly addresses **long-term objective**, *Identify causes and sources of wetland degradation including cumulative impacts to wetlands*, by identifying and quantifying specific stressors and their relative effects on wetlands; stressor scores can be summed to reflect cumulative impacts.

Consequences:
- More heavily weights stressor effects in total score
- Increases total score capacity

Validation:
- Improves correlations between metric scores rating *stressors* and *condition*
- Improves coefficient of determination (r^2) values between metrics rating *stressors* and pilot amphibian IBIs
- When combined with *condition* metric scores, improves coefficient of determination values versus various metrics indicating land use intensity

6) A *Historic Alterations* metric is added to the RAM to identify wetlands that have been historically modified either directly (>50ya) or hydrologically (>100ya).

Benefits:
- Standardizes scoring of historically modified wetlands according to ORAM protocols by removing methodological ambiguity
- Lowers the effects of inter-user variability on scores
- Results in more precise data

Consequences: none

Validation: N/A

7) DERAP attribute characterizing soils subsidence and root exposure is incorporated into the RAM

Benefits:
- May indicate effects due to the withdrawal of groundwater
- May directly addresses **short-term objective**, *Develop and implement methods for monitoring impacts to wetlands due to water withdrawals*, by providing a rapidly-assessable indicator of groundwater withdrawal effects.

Consequences: may increase total score capacity

Validation:
- Attempted validations were either negative or inconclusive; however, this metric should be tested on a larger, more controlled sample