RAPID ASSESSMENT OF FRESHWATER WETLAND CONDITION

Year-3 Development of a Rapid Assessment Method for
Freshwater Wetlands in Rhode Island

RIRAM Version 2 Addendum
June 2010

Final Report prepared for

Rhode Island Department of Environmental Management
Office of Water resources

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Acknowledgements

This addendum is in partial fulfillment of the contract agreement between the State of Rhode Island and Providence Plantations Department of Environmental Management (DEM) and the Rhode Island Natural History Survey (RINHS) named *Technical Assistance to Support Monitoring and Assessment of Freshwater Wetlands*. This agreement was funded in part by federal funds provided by a U.S. Environmental Protection Agency (EPA) Clean Water Act Section 104(b)3 Wetland Pilot Demonstration Grant. The project was managed and coordinated at DEM by Sue Kiernan and Carol Murphy. The DEM and the RINHS would like to thank Matt Schweisberg, Peter Holmes, and Jeanne Voorhees, Environmental Protection Agency, Region 1, for their assistance in overseeing this Wetland Pilot Demonstration grant project and for graciously attending meetings, participating in field demonstrations, and reviewing and providing meaningful comments on draft documents.

Thank you to John Mack (former Ohio EPA) who authored the Ohio Rapid Assessment Method, on which the Rhode Island Rapid Assessment Method version 1 (RIRAM v.1) was largely based.

Thank you to Dr. Frank Golet (University of Rhode Island College of the Environment and Life Sciences) for his unlimited advice and valuable assistance in the development of RIRAM v.2.

Thank you to others who provided technical assistance during this project year: Drs. Peter Paton, Graham Forrester, and Art Gold (University of Rhode Island College of the Environment and Life Sciences); Chuck Horbert (DEM wetland supervisor); Dr. Rick McKinney (EPA Atlantic Ecology Division); and Dr. Scott Ruhren (Audubon Society of Rhode Island).

Thank you to Kerry Strout (New England Interstate Water Pollution Control Commission) and Jeanne Voorhees (EPA Region 1) for coordinating the New England Biological Assessment of Wetlands Workgroup (NEBAWWG). This project has benefited from the input and support of all of the NEBAWWG members.

Thank you to all the property owners and their representatives for allowing and arranging our access for field assessments.

Finally, thank you to former and present Rhode Island Natural History Survey staff who participated in this project: Dr. David Gregg, Kira Stillwell, Hillary Siener, and Hope Leeson.

Contents

A-1 Introduction 1
A-1.1.4 RIRAM Version 2 1
A-1.2 Project Objectives 3
A-2 Development and Demonstration of RIRAM v.1 3
A-2.1 Methods 3
A-2.2 Results 3
A-2.2.1 Data Summary 3
A-2.2.2 RIRAM v.2 Development 5
A-2.2.3 RIRAM v.2 Demonstration Analyses 7
A-2.3 Conclusions 14
A-4 Discussion 15
Literature Cited 19

Tables

Table A-1. Basic statistics of RIRAM v.2 index scores from 50 wetlands in the H-P basins..... 5
Table A-2. Spearman rank correlation coefficients of RIRAM v.2 versus RIRAM v.1 indices (*df* =49). 5
Table A-3. Comparisons of RIRAM v.2 metric and index scores generated by two separate observers at 23 wetlands within the H-P basins. 7
Table A-4. Comparisons of RIRAM v.1 and v.2 index scores generated by two separate observers at 23 wetlands within the H-P basins..... 7
Table A-5. Significant Spearman rank correlation coefficients (Rs) of RIRAM v.2 *Response* metric scores versus RIRAM v.2 *Intensity of Surrounding Land Use* scores from 50 H-P sites in 2008 8
Table A-6. Occurrences of invasive plant species observed within 50 study sites in the H-P basins 10
Table A-7.Significant Spearman rank correlation coefficients (Rs) of RIRAM v.2 stress ranks and indices versus invasive plant species cover class scores and species richness at 50 H-P sites in 2008. Higher Stress index indicates less stress. Higher INSP Cover scores indicate less cover of invasive species. Higher Landscape Metrics scores indicate less intense land use. 12
Table A-8. Significant Spearman rank correlation coefficients (Rs) of RIRAM v.2 *Stress* metric ranks and index score versus *Response* index scores at 50 H-P sites in 2008. Higher *Landscape* metrics scores indicate less intense land use. Higher *Stress* index indicates less stress. 13

Figures

Figure A-1. RIRAM v.2 versus RIRAM v.1 index scores generated from 50 sites in the H-P basins. 6
Figure A-2. Absolute values of Spearman rank correlation coefficients (y-axis) between land use cover indices (x-axis) at various surrounding buffer-zone widths and RIRAM v.2 indices (series) of *RIRAM* score, *Response* score, and *Stress* score for 50 assessment units in the H-P basins. 9
Figure A-3. Invasive plant species % cover at 50 H-P basin sites in 2008..... 10
Figure A-4. Invasive plant species % cover at 50 H-P basin sites in 2008 against surrounding land use intensity. 11

A-1 Introduction

This addendum to the report *Rapid Assessment of Freshwater Wetland Condition: Year-3 Development of a Rapid Assessment Method for Freshwater Wetlands in Rhode Island; RIRAM Version 1* (Kutcher 2010) presents an extensive revision of the rapid assessment method RIRAM. The revised version, RIRAM version 2 (v.2), differs from RIRAM v.1 in content, format, and approach, but retains many elements and concepts of the original, including analogous functionality. The changes are expected to increase the utility of the RAM by decreasing subjectivity, refining and clarifying metrics, organizing metrics logically, and generating a set of intuitive indices that better represent wetland stress, response, and condition.

RINHS developed a RIRAM v.2 field datasheet (App. A-1) and applied it concurrently with RIRAM v.1 in Year-3 field assessments. To justify and validate the revision of RIRAM, this addendum will address the goals of the original report (hereafter Report) by replacing RIRAM v.1 data with RIRAM v.2 data in all development and demonstration analyses (Sec. 2 in the Report), and comparing results between the RAM's. Validation efforts detailed in the Report (Sec. 3) did not include RIRAM v.2 (as it was not-yet developed) and will not be directly addressed. To facilitate comparisons, the sections of this addendum are numbered analogously to those in the Report, but include the prefix "A". This addendum is not intended to be a stand-alone document, so some background and introductory text are not included here; however, efforts were made to present important points independent of the Report.

A-1.1.4 RIRAM Version 2

RIRAM v.2 was developed in response to feedback from Federal, State, regional, and academic peer reviewers. Deficiencies and logical inconsistencies of RIRAM v.1 identified by the reviewers include the following:

1. Some of the metrics were too subjective.
2. It was often difficult to discriminate between wetland response to hydrologic alteration versus habitat alteration.
3. It was unclear whether the wetland was being rated on its condition regarding its historic or current type.
4. There was redundancy in stressors because they were not all conceptually analogous.

The RINHS addressed these comments with a sweeping revision of RIRAM. While earlier efforts focused on modest, incremental modifications to the parent RAM, ORAM (Mack 2001), development of RIRAM v.2 included a complete restructuring, the replacement or modification of all metrics, new scoring schemes, and the introduction of new concepts. The modified RAM is intended to guide the user through a logical and consistent process to generate a set of objective, relative conditional indices, based on observable evidence.

Like RIRAM v.1, RIRAM v.2 produces conditional indices by the ranking and summing of stressor intensity and wetland response to stress, which closely follows EPA wetland

monitoring and assessment guidelines (EPA 2006). Three sub-indices evaluating landscape stresses, in-wetland stresses, and wetland response, can be summed to generate a single relative index of overall wetland condition. The index (hereafter *RIRAM* index) is based on 100 possible points; where a score of 100 would indicate pristine condition, and a score approaching zero would indicate complete loss of wetland function. Sub-indices (hereafter identified as specific indices) and metrics can also be used separately for various decision-support efforts.

In the first scored section, Section B, RIRAM v.2 utilizes two metrics ranking surrounding landscape stress by estimating the proportion of land use categories within 50 and 100 meters (App. A-1, B). These metrics are weighted ten points each and are summed to comprise the *Landscape* index. *Landscape* metrics were adopted from RIRAM v.1 and rescored to represent 20% of the *RIRAM* index.

In Section C, RIRAM v.2 utilizes seven metrics ranking in-wetland stress by the intensity and proportionality of effect (App. A-1, C). In-wetland stress (hereafter *Stress*) metrics are categorized by stress type and include the following (listed by metric number):

3) Impoundment
4) Draining or diversion of water from wetland
5) Anthropogenic fluvial inputs
6) Vegetation and detritus removal within wetland
7) Filling and dumping within wetland
8) Excavation, grading, and other substrate disturbances within wetland
9) Invasive species within wetland

Where applicable, each *Stress* metric includes a checklist to document evidence and stressors associated with the stress type. Each *Stress* metric is given equal weight; they are summed, and then subtracted from 50 to generate the *Stress* index score, which comprises 50% of the *RIRAM* index.

In the final scored section, Section D, RIRAM v.2 utilizes a *Response* index to summarize and document impacts to wetlands due to cumulative stresses (App. A-1, D). The index ranks each of six components of wetland integrity along a continuum from *characteristic* to *destroyed*. The components are intended to represent the physical drivers of previously-identified wetland functions and values (e.g. USACOE 1993); they include the following:

- Vegetation structure
- Vegetation composition
- Hydrologic connectivity
- Habitat connectivity
- Microhabitat structure
- Water and soil quality

Rank values are summed to generate a *Response* index score that comprises 30% of the *RIRAM* index. The *Response* index is based upon interpretation of evidence gathered from all previous metrics and requires a strong understanding of wetland processes.

Attributes describing wetland characteristics that are not strictly stressor or response-based are not scored, but are retained from RIRAM v.1 (as modified in the Report) to enhance baseline data and analysis (App A-1, A).

A-1.2 Project Objectives

Refer to the Report for overall objectives of the Year-3 project. The objective of this addendum is to demonstrate the objectivity and utility of RIRAM v.2 in comparison with that of its predecessor, RIRAM v.1. This will be done by running analogous analyses and demonstrations using RIRAM v.2 data in place of RIRAM v.1 data, and discussing the advantages of v.2's approach, structure, and content.

A-2 Development and Demonstration of RIRAM v.1

RIRAM v.2 data, collected concurrently with RIRAM v.1, was applied to all development and demonstration analyses according to the Report.

A-2.1 Methods

RIRAM v.2 assessments were conducted immediately following RIRAM v.1 at each study site by identical methods. Refer to the Report for method details.

A-2.2 Results

A-2.2.1 Data Summary

RIRAM v.2 data are applied here analogously to Section 2.2.1 of the Report. Much of the Summary is identical, since some metrics were effectively unchanged.

RIRAM investigations were conducted on a sample of 50 freshwater wetlands within the H-P basins in 2008; the following statements in this section were derived from the resulting data (see App. A-2 for associated graphs). Total area of assessed wetlands was 445 acres and sites ranged from 0.4 to 53 acres with a mean size of 8.9 acres. The dominant wetland type within the sample (by presence per site) was forested, with shrub swamp, emergent wetlands, riverine and palustrine open water, and aquatic bed comprising the remainder.

The dominant HGM classes were *Depressional* and *Riverine*. The majority (66%) of wetlands were at least partly groundwater fed, while 60% were at least partly surface-water fed. 86% of wetlands were part of a natural complex, 60% were within a riparian corridor, 60% buffered surface-waters from land use, and 60% acted as floodplain buffers. Most wetlands were >0.7m in maximum depth and the majority were seasonally flooded.

Twenty-four percent of the sample wetlands contained mature swamps, mostly dominated by red maple (*Acer rubrum*), and 2% contained Atlantic white cedar swamps. About one third (30%) of all wetlands contained vernal pools, while fens or bogs were component in 6%. Twelve percent of the sample was documented as significant bird habitat and 10% was known to contain threatened or endangered species.

Buffers of the majority of H-P wetlands sampled (76%) were >50% intact, while the remainder (14%) were >50% degraded. Most common stressors within a 100-m buffer zone were raised roads and trails (86% of sites), residential development (72%), commercial/industrial development (40%), and channelized streams and ditches (38%).

The most common in-wetland stress type was filling and dumping (84%), with 82% of wetlands having some fill at or above surrounding upland height. Roads were the primary stressor associated with filling (42% of units). Invasive plant species were present at 82% of the study wetlands, mostly in small numbers (<5% total cover); invasive plant cover was >50% at 10% of the sites. The most common invasive species observed was European buckthorn (*Rhamnus frangula*), followed by Japanese barberry (*Berberis thunbergii*), mostly growing in intermittent streambeds. The invasive vine Oriental bittersweet (*Celastrus orbiculatus*), while not generally found within wetlands, was intertwined with or covering wetland vegetation at 20% of the study sites.

Anthropogenic fluvial inputs were evident at 76% of the study sites, with direct sheet runoff and residential upstream sources being the primary contributors. Water was drained or diverted from 46% of the study sites, primarily by ditching (12%). Thirty-eight percent (38%) of study sites had some excavation, while 32% were at least partly impounded (mainly due to roads—26% of sites). Some vegetation was removed from 24% of sites, primarily from the shrub layer (22%). Mowing and clear cutting were the principle activities responsible.

The greatest interpreted impact to the H-P wetlands was a loss of habitat connectivity, with 78% of all sites assessed as degraded (or worse), while hydrologic connectivity was degraded at 54% of sites. Water or soil quality was assessed as degraded at 38% of the study sites, while vegetation structure and vegetation composition each were degraded at 36% of sites, and microhabitat structure at 24% of sites.

RIRAM v.2 index statistics for the 50 H-P study sites are summarized in Table A-1 and Appendix A-2.

Table A-1. Basic statistics of RIRAM v.2 index scores from 50 wetlands in the H-P basins.

Statistic	RIRAM V.2 Index				
	Landscape	Stress	Total Stress	Response	RIRAM
Valid cases	50	50	50	50	50
Mean	11.5	40.4	51.9	22.3	74.2
Std. Deviation	4.5	5.7	9.0	4.9	13.3
Skew	0.2	0.0	0.3	-0.6	0.1
Minimum	4	28.9	36.3	8	46.4
Maximum	20	50.0	70.0	30	99.8
Range	16	21.1	33.7	22	53.4
5th percentile	4.3	30.2	37.8	13.8	53.4
10th percentile	5.3	33.3	39.6	16.1	55.6
25th percentile	8.5	35.8	46.0	18.0	64.0
Median	10.7	40.8	52.1	23.0	74.8
75th percentile	15.0	46.0	56.9	26.3	82.0
90th percentile	19.3	48.3	67.4	29.0	96.7
95th percentile	20.0	49.9	69.6	29.5	98.7

A-2.2.2 RIRAM v.2 Development

In this section RIRAM v.2 modifications are analyzed for preservation of analogous function with RIRAM v.1 and comparisons of utility and objectivity, where appropriate.

Analogous Function

To assess the extent of analogous function between RIRAM v.2 and RIRAM v.1, correlation analysis was performed on analogous indices. Note that RIRAM v.2 (B) *Landscape* and (C) *Stress* indices were summed (generating *Total Stress*) for analogous correlation with the RIRAM v.1 *Stressor* metric, which incorporates both landscape and in-wetland stresses (Table A-2).

Table A-2. Spearman rank correlation coefficients of RIRAM v.2 versus RIRAM v.1 indices (*df* =49).

Version 1 Index	Version 2 Index	Rs	P
II. Stressors	B.+ C. Total Stress	0.95	<0.01
III. Condition	D. Wetland Response	0.93	<0.01
V.1 Index	V.2 Index	0.96	<0.01
V.1 Index	B.+ C. Total Stress	0.94	<0.01

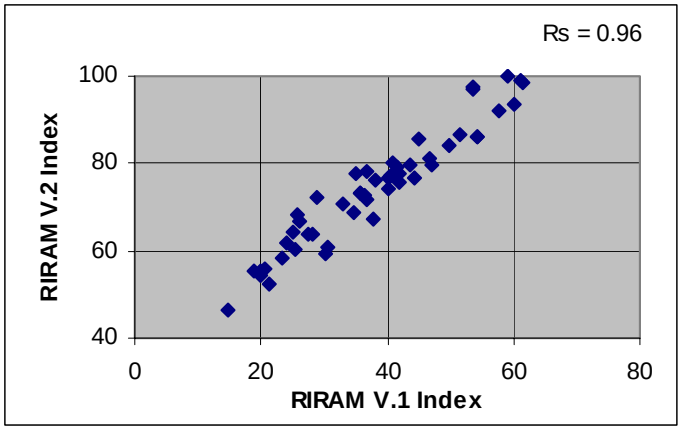


Figure A-1. RIRAM v.2 versus RIRAM v.1 index scores generated from 50 sites in the H-P basins.

All analogous indices were very strongly correlated, indicating similar index function (Table A-2; Fig. A-1). A strong correlation between the *RIRAM* v.1 index and RIRAM v.2 *Total Stress* suggests that evidence-based *Landscape* and *Stress* metrics alone may be sufficient to characterize wetland condition without introducing user biases potentially associated with the interpretation of index D *Response*.

Inter-user Variability

Inter-user variability was analyzed to assess the objectivity of the metrics and indices within RIRAM v.2. Three tests were performed; first, Spearman Rank correlation analysis was applied to determine the relative scoring precision between users; second, a t-test was run to determine whether mean scores were different between users; and third, the percent mean difference (%MD) was calculated to determine the average difference in scores (absolute precision), standardized by the percent of the total possible range of points in the metric. Refer to Table A-3 for comprehensive results listed in order of ascending %MD. Refer to Table A-4 for direct inter-user comparisons between analogous RIRAM v.1 and RIRAM v.2 indices.

Relative precision was similar between all RIRAM v.1 and RIRAM v.2 indices, indicated by very strong inter-user correlations (Rs) for both versions (Table A-4). Paired t-test and %MD values indicate that v.2 *Response* scores may have been statistically different between users by approximately 2.4% or 0.8 points contributing to the *RIRAM* v.2 index; otherwise, RIRAM v.2 outperformed RIRAM v.1 in user-objectivity, according to these two tests. The total *RIRAM* index indicates that RIRAM v.2 retains or improves upon the overall inter-user objectivity of RIRAM v.1 (Table A-4, bottom rows; see also Section 2.2.2 of the Report).

Table A-3. Comparisons of RIRAM v.2 metric and index scores generated by two separate observers at 23 wetlands within the H-P basins.

V2 Metric or Index	Observer 1		Observer 2				
	Mean	SD	Mean	SD	Rs*	P-value**	%MD
6. Vegetation Removal	0.10	0.19	0.07	0.17	0.74	0.23	0.4
8. Excavation and Substrate Disturbance	0.20	0.53	0.29	0.48	0.53	0.32	1.5
1. Degradation of Buffers	4.36	3.26	4.25	2.98	0.97	0.50	1.5
4. Draining or Diversion of Water	0.80	1.43	0.88	1.51	0.73	0.45	1.6
RIRAM V.2 Index	70.49	14.13	70.85	12.98	0.95	0.68	1.6
d. Vegetation Composition	3.64	1.00	3.64	1.00	0.93	1.00	1.8
B. + C. Total Stress	49.12	48.67	10.22	9.04	0.95	0.54	2.0
B. Landscape Index	10.83	5.01	10.81	4.57	0.98	0.94	2.2
D. Response Index	21.36	4.39	22.18	4.28	0.90	0.05	2.4
C. Stress Index	38.29	5.96	37.86	5.54	0.84	0.51	2.5
7. Filling and Dumping	1.97	1.54	2.00	1.54	0.91	0.85	2.8
2. Surrounding Landscape Intensity	6.47	1.95	6.56	1.76	0.92	0.56	3.1
d. Microhabitat Structure	4.00	0.87	4.27	0.98	0.83	0.03	3.6
d. Habitat Connectivity	3.09	1.02	3.00	0.87	0.77	0.54	3.6
9. Invasive Species	3.32	1.64	3.41	1.79	0.89	0.65	4.5
d. Vegetation Structure	3.73	0.83	4.00	0.98	0.75	0.08	4.5
d. Water and Soil Quality	3.59	1.18	3.68	0.89	0.76	0.58	5.5
d. Hydrologic Connectivity	3.32	0.95	3.59	1.05	0.55	0.16	5.5
5. Anthropogenic Fluvial Input	3.18	1.97	3.41	2.06	0.79	0.42	6.8
3. Impoundment	2.14	1.91	2.09	2.04	0.58	0.89	7.1

*Spearman correlation coefficient (P<0.01 for all)
**Paired t-test results
%MD = absolute (mean difference between scores / metric range) x 100

Table A-4. Comparisons of RIRAM v.1 and v.2 index scores generated by two separate observers at 23 wetlands within the H-P basins.

RIRAM Index	Observer 1		Observer 2				
	Mean	SD	Mean	SD	Rs*	P-value**	%MD
V.1 Stressor	14.77	7.16	15.30	5.83	0.92	0.33	3.9
V.2 B. + C. Total Stress	49.12	48.67	10.22	9.04	0.95	0.54	2.0
V.1 Condition	18.97	6.33	19.10	6.29	0.93	0.71	1.9
V.2 D. Response Index	21.36	4.39	22.18	4.28	0.90	0.05	2.4
V.1 RIRAM Index	33.73	12.55	34.40	11.24	0.97	0.33	2.1
V.2 RIRAM Index	70.49	14.13	70.85	12.98	0.95	0.68	1.6

*Spearman correlation coefficient (P<0.01 for all)
**Paired t-test results
%MD = absolute (mean difference between scores / metric range) x 100

A-2.2.3 RIRAM v.2 Demonstration Analyses

Three analyses are provided below to demonstrate the utility of RIRAM v.2 in addressing wetland monitoring objectives identified in the RI Wetland Plan (NEWIPCC and DEM 2006); these are analogous to analyses conducted with RIRAM v.1 data in the Report. Some text from the Report is repeated here for clarity; for example, parts of the invasive plant analysis are identical to those using RIRAM v.1 since the invasive species metric is effectively identical in v.2 (only scoring values differ). The following objectives are addressed:

Short-term objectives

- *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.*

Long-term objective

- *Identify causes and sources of wetland degradation including cumulative impacts to wetlands.*

Effects of Surrounding Land Use on Wetland Condition

The first demonstration analysis addresses the impacts to wetlands due to loss and degradation of surrounding habitats. The structure of RIRAM v.2 allows an analysis of this by generating a land use index representing degradation of adjacent habitats within 100m, and *Response* metric data representing wetland impacts (Table A-5). Correlation coefficient (Rs) values indicate an expected strong relationship between surrounding landscape degradation and loss of habitat connectivity. Land use intensity was also correlated with evident degradation of water/soil quality, vegetation composition—likely due to invasive plant species richness effects (see next section), and microhabitat structure.

Table A-5. Significant Spearman rank correlation coefficients (Rs) of RIRAM v.2 *Response* metric scores versus RIRAM v.2 *Intensity of Surrounding Land Use* scores from 50 H-P sites in 2008

	Surrounding Land Use Metric Score	
Response Submetrics (Impacts)	**Rs**	**P**
Habitat connectivity	0.86	<0.01
Water and soil quality	0.56	<0.01
Vegetation composition	0.40	<0.01
Microhabitat structure	0.30	0.02

To demonstrate how RIRAM v.2 might be further applied, land use intensity within nested buffer zones was compared to RIRAM v.2 indices using Spearman rank correlation. Percent cultural (developed and agricultural) cover was used as a proxy for land use intensity within each of the following zones: 30m, 50m, 100m, and 300m. Percent cultural cover within each buffer-zone was correlated against *Stress*, *Response*, and *RIRAM* v.2 indices to determine the strength of correlation for each pairing and to reveal any trends in effective buffer zone width (Fig. A-2).

Figure A-2 illustrates how the intensity of land use within buffer widths from 30m to 300m is correlated with three indices (excluding *Landscape*) contained within RIRAM v.2. The correlations suggest that surrounding land use intensity is at least partly responsible for wetland stresses and their impacts. RIRAM v.2 data indicate a trend in the effect of buffer width on land use intensity reflecting in-wetland condition, peaking around 100m, while v.1 data were variable (Report Fig. 2). Like RIRAM v.1, v.2 data suggest that land use as far as 300m from a wetland may have an impact on its condition. This method of analysis could be further applied to determine if thresholds of impacts from land use exist, e.g. if correlations grow stronger or weaker as development intensity increases.

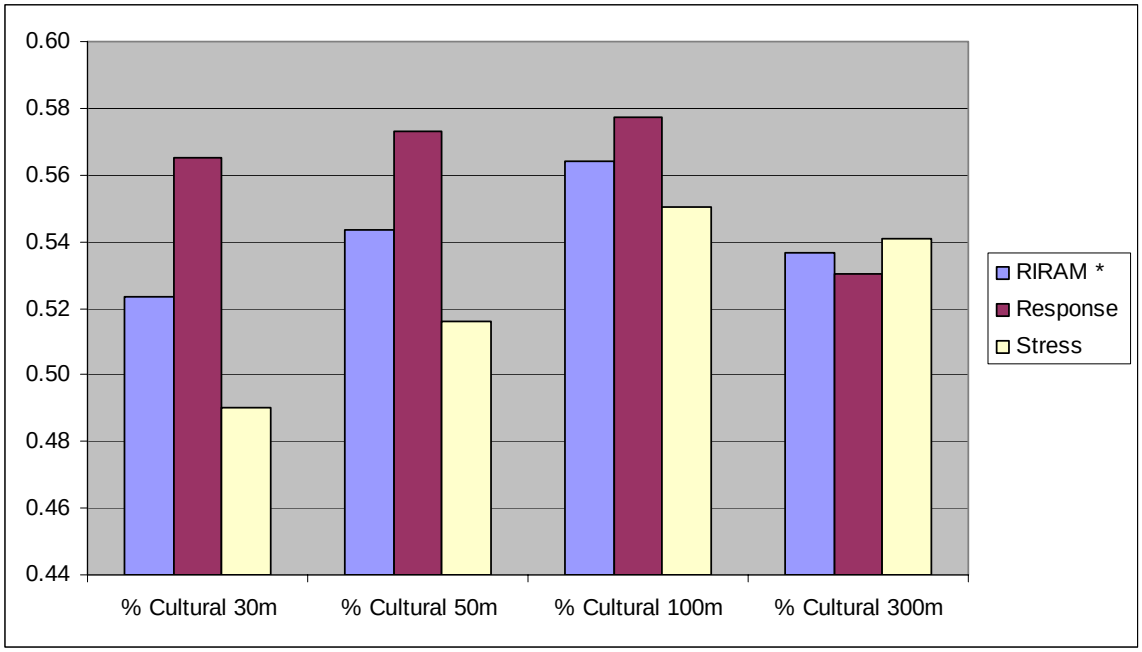


Figure A-2. Absolute values of Spearman rank correlation coefficients (y-axis) between land use cover indices (x-axis) at various surrounding buffer-zone widths and RIRAM v.2 indices (series) of *RIRAM* score, *Response* score, and *Stress* score for 50 assessment units in the H-P basins.
P<0.01 for all. *minus landscape metrics

Relationships between Invasive Plants and Wetland Condition

RIRAM v.2 was applied in the same manner as RIRAM v.1 in the Report. Text, tables and figures presenting identical results were retained (repeated) here for consistency, while those presenting analogous results were revised (i.e. regarding Table A-7).

Another short-term objective for wetland monitoring identified in the RI Wetland Plan is to *monitor the location and extent to which invasive species are present and affecting wetland condition.* To demonstrate how RIRAM v.2 could be applied to address this objective, the 50 H-P assessment units were analyzed by summarizing species, mapping by cover class, and running correlations of RIRAM v.2 indices versus invasive plant species % cover and species richness.

Nineteen invasive plant species were identified within the H-P study sites (Table A-6). Many of these were wetland species, but some were upland (UPL) or upland-preferring (FACU) species that encroached into the wetlands. For example, Oriental bittersweet (*Celastrus orbiculatus*; UPL) was overgrowing wetland flora from the edges of several wetlands, indicating buffer impacts. Barberry (*Berberis thunbergii*) and wild rose (*Rosa multiflora*), both FACU, were present mainly in floodplain wetlands, suggesting hydrologic impacts in some cases.

Table A-6. Occurrences of invasive plant species observed within 50 study sites in the H-P basins

Scientific name	Common name	Percent of sites
Rhamnus frangula	European buckthorn	40
Celastrus orbiculatus	Oriental bittersweet	38
Berberis thunbergii	Japanese barberry	28
Rosa multiflora	Multiflora rose	28
Phragmites australis	Common reed	24
Lonicera morrowii	Morrow's honeysuckle	16
Phalaris arundinacea	Reed canary grass	14
Polygonum cuspidatum	Japanese knotweed	14
Cabomba caroliniana	Fanwort	8
Solanum dulcamara	Climbing nightshade	8
Euonymus alatus	Burning bush	6
Lythrum salicaria	Purple loosestrife	4
Myriophyllum sp.	Water milfoil sp.	4
Elaeagnus umbellata	Autumn olive	2
Ligustrum vulgare	European privet	2
Najas minor	Brittle water nymph	2
Polygonum perfoliatum	Mile-a-minute vine	2
Polygonum sachalinense	Giant knotweed	2
Rorippa naturtium-aquaticum	True watercress	2

Figures A-3 and A-4 demonstrate how RIRAM data could be used to produce mapping products for decision support and outreach. Figure A-3 illustrates the proportions of invasive species intensity among the H-P basin sites. In Figure A-4, invasive plant species location is illustrated in relation to surrounding land use intensity. Color-coding depicts cover of invasive species by cover class, least intense being green and the most intense being red, laid over an analogous depiction of land use intensity generated from RIGIS *Land Use 2003-2004* (RIGIS 2007) geospatial data. Similarity in color coding between the two datasets illustrates the relationship between land use and invasive species incursion.

Figure A-3. Invasive plant species % cover at 50 H-P basin sites in 2008

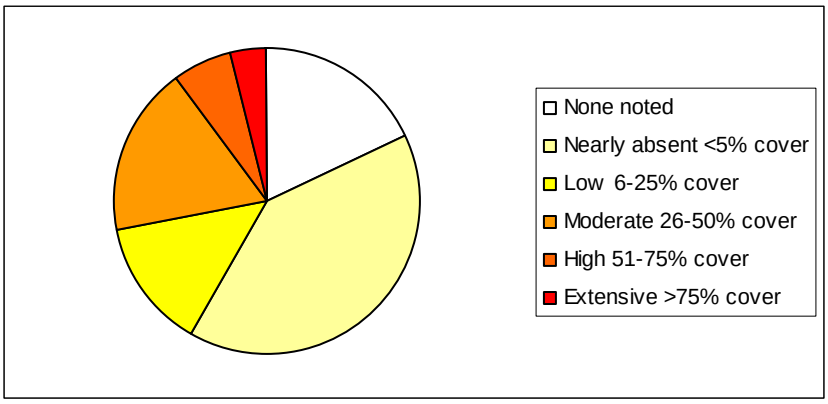
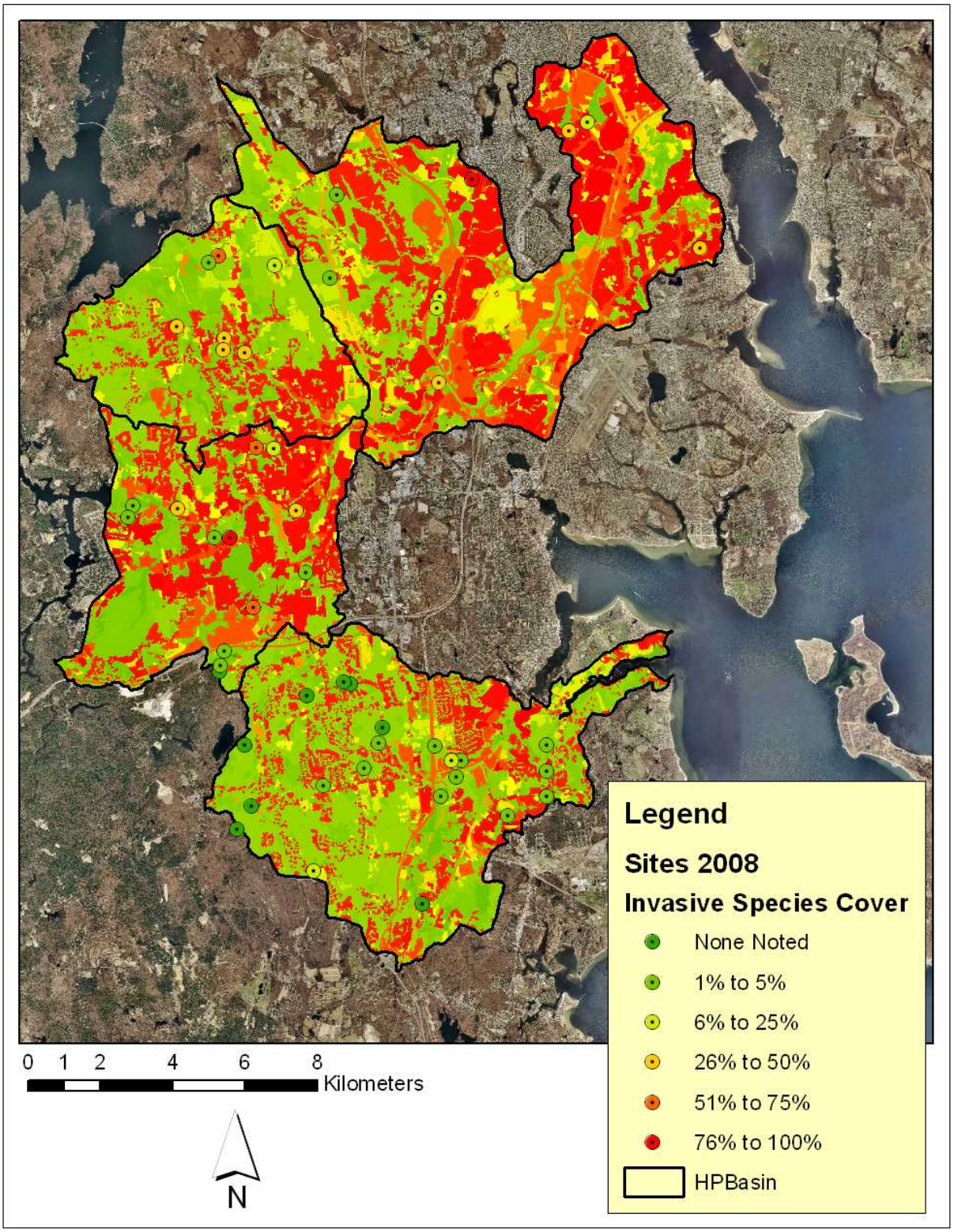


Figure A-4. Invasive plant species % cover at 50 H-P basin sites in 2008 against surrounding land use intensity.



Although numerous factors may affect the establishment of invasive plant species, Figure A-4 shows a general trend toward plant invasions occurring in approximate positive relationship to surrounding land use intensity. Table A-7 clarifies and details relationships between invasive plant species occurrence and various stresses in the H-P basins. As suggested in Figure A-4, Table A-7 suggests that buffer degradation and land use in the surrounding landscape had a moderate-strength effect on invasive plant species cover and richness within the assessment units. The strongest within-wetland stress associated with plant species invasion was from fluvial inputs, with evident nutrient and sediment inputs—largely from sheet runoff and upstream sources (App. A-2)—contributing most. Filling was also associated with invasive plant success; roads were the primary source of fill (App. A-2). These findings concur with other studies that conclude wetland invasion is often facilitated by nutrient enrichment, sedimentation, and filling (e.g. Bertness et al. 2002). The *Stress* index correlations indicate the relative impact of multiple stresses on invasive species occurrence, while *Response* index correlations suggest a strong relationship between invasive plant species intensity and wetland capacity to provide original functions and values (refer to Sec. A-1.1.4).

RIRAM v.2 data indicate that expected human-induced plant invasion processes affect wetlands predictably on a wide scale; they thus might be predictably avoided or mitigated. Applied this way, RIRAM v.2 could be a valuable tool in supporting invasive species prevention and control efforts for the State by providing cause and effect evidence and identifying responsible mechanisms.

Table A-7.Significant Spearman rank correlation coefficients (Rs) of RIRAM v.2 stress ranks and indices versus invasive plant species cover class scores and species richness at 50 H-P sites in 2008. Higher Stress index indicates less stress. Higher INSP Cover scores indicate higher cover of invasive species. Higher Landscape Metrics scores indicate less intense land use.

Metric / Index	**INSP Cover Score**		**INSP Richness**	
	Rs	**P**	**Rs**	**P**
Landscape Stresses Metrics				
2. 100-m Weighted Buffer	-0.38	<0.01	-0.52	<0.01
1. % Cultural Cover 50m	-0.40	<0.01	-0.41	<0.01
Wetland Stresses Metrics				
5. Fluvial Inputs	0.64	<0.01	0.55	<0.01
7. Filling	0.48	<0.01	0.54	<0.01
3. Impoundment	0.28	0.02	0.30	0.02
4. Draining	0.27	0.03	0.30	0.02
Wetland Stresses Submetrics				
5a. Nutrient Inputs	0.65	<0.01	0.43	<0.01
5b. Sediments	0.55	<0.01	0.46	<0.01
5d. Increased Flashiness	0.29	0.02	0.44	<0.01
3a. Increased Water Regime	n/s	n/s	0.28	0.02
3b. Artificial Hydrologic Barrier	0.23	0.05	0.24	0.05
RIRAM v.2 Indices				
B. Landscape Index	-0.39	<0.01	-0.47	<0.01
C. Stress Index*	-0.64	<0.01	-0.67	<0.01
D. Response Index	-0.73	<0.01	-0.65	<0.01
RIRAM Index*	-0.66	<0.01	-0.68	<0.01

*minus invasive species metric; n/s not significant

Effects of Stressors on Wetland Condition

RIRAM v.2 was applied similarly to the analogous section in the Report. The table and text have been revised to reflect RIRAM v.2 data.

Just as anthropogenic stresses may predictably contribute to the establishment of invasive species, they may also individually or cumulatively contribute to the degradation of wetland condition overall. A long-term objective identified in the RI Wetland Plan is to *identify causes and sources of wetland degradation including cumulative impacts to wetlands.* To demonstrate how RIRAM v.2 might address this objective, the 50 H-P assessment units were analyzed by correlation of RIRAM *Stress* metric ranks and indices against the *Response* index, which interprets the relative loss of physical elements that drive wetland functions and values (see Sec. A-1.1.4; App A-1). Results indicate which stress types were most strongly associated with wetland degradation, and whether multiple stresses had cumulative impacts on wetland condition.

Table A-8. Significant Spearman rank correlation coefficients (Rs) of RIRAM v.2 *Stress* metric ranks and index score versus *Response* index scores at 50 H-P sites in 2008. Higher *Landscape* metrics scores indicate less intense land use. Higher *Stress* index indicates less stress.

	D. Response	
Metric / Submetric	**Rs**	**P**
Landscape Metrics		
2. 100-m Weighted Buffer	0.55	<0.01
1. % Cultural Cover 50m	0.55	<0.01
Stress Metrics		
9. Invasive Species Cover	-0.73	<0.01
7. Filling	-0.68	<0.01
5. Fluvial Inputs	-0.54	<0.01
4. Draining	-0.39	<0.01
8. Substrate Disturbance	-0.35	<0.01
3. Impoundment	-0.30	0.02
6. Removal of Vegetation	-0.29	0.02
Stress Submetrics		
5b. Sediments	-0.58	<0.01
5a. Nutrient Inputs	-0.39	<0.01
3b. Artificial Hydrologic Barrier	-0.29	0.02
5c. Toxins / Salt Inputs	-0.23	0.05
Indices		
B. Landscape Index	0.55	<0.01
C. Stress Index	0.86	<0.01
B.+ C. Total Stress	0.85	<0.01

RIRAM v.2 data suggest that invasive plant cover, filling, and fluvial inputs were most closely associated with H-P wetland impacts; roads were the main sources of filling (App. A-2), while evidence of sedimentation was the main contributor to fluvial input stress (Table A-8). Degradation of buffers and surrounding land use were also modestly correlated with *Response* (Table A-8). Strong correlations with *Stress* and *Total Stress* indices indicate the relative strength of cumulative impacts.

RIRAM v.2 data helps clarify the relationships among various anthropogenic stresses and wetland condition and demonstrates the effects of cumulative impacts on wetland condition. These data could be further applied to identify stressor thresholds and quantify the impacts of specific and multiple stressors on various wetland types. When applied in this way, RIRAM data could be valuable in assessing and minimizing wetland impacts during planning, and identifying activities most closely associated with wetland degradation.

A-2.3 Conclusions

The analyses indicate that RIRAM v.2 is an objective RAM capable of providing sound, rapid, conditional data to address State-identified objectives. All indices generated from the RIRAM v.2 data were very strongly correlated with analogous RIRAM v.1 indices (Rs>0.90 for all). This indicates analogous utility in index applications and suggests that validations of RIRAM v.1 (Section 3 in the Report) would apply similarly to RIRAM v.2. The sum of *Landscape* and in-wetland *Stress* indices, generating *Total Stress*, correlated strongly with the *RIRAM* v.1 (total) index, which indicates that the *Response* index may not be a necessary component of RIRAM v.2 (in replacing the *RIRAM* v.1 index) in all applications.

Inter-user analyses indicated that the v.2 revisions retained or improved RIRAM's objectivity and utility in characterizing relative condition. Three measures of inter-user variability representing user relative precision, statistical difference of means, and absolute precision (percent mean difference of scores) indicated a degree of objectivity and reliability in RIRAM v.2 scoring indices that was equal to or better than RIRAM v.1.

Demonstration exercises indicated analogous, enhanced data utility in RIRAM v.2 over v.1. A demonstration analysis on the effects of buffer degradation on wetland condition indicated that land use intensity was correlated with wetland condition to at least 300m. All buffer-zone widths correlated similarly with RIRAM indices, but RIRAM v.2 data suggested a trend toward the 100m buffer-zone determining landscape impacts on wetland condition best; this was not evident with RIRAM v.1 data. RIRAM v.2 *Response* metrics allowed an analysis of impacts associated with surrounding land use degradation, as required by the State objectives; this revealed an expected strong relationship with habitat connectivity and a moderate relationship with anthropogenic fluvial inputs.

The percent cover and species richness of invasive plants was expectedly correlated with several RIRAM v.2 *Stress* metrics and indices. RIRAM v.2 data indicated that fluvial inputs, associated with nutrients from runoff, and filling, mainly from road construction, were most strongly correlated with invasive plant establishment in H-P wetlands; these correlations indicate stressor contributions to invasive species establishment and success. Correlations with the *Stress* index (incorporating all significant and non-significant *Stress* metric scores) indicate how collective stresses facilitate invasive species success. Moderate and strong correlations with the *Response* index demonstrate invasive species' relatively strong influence on overall wetland condition in the H-P study area.

Finally, the data indicated that anthropogenic stresses within or surrounding a wetland predictably degrade wetland condition (Table A-8). The data suggested that filling (primarily road construction and other development) and fluvial inputs (mainly sediments and nutrients) were among the highest contributors to wetland degradation within the study area. A much stronger correlation between the *Stress* index (summing all significant and non-significant *Stress* metric scores) and the *Response* index demonstrates the cumulative effect of collective stresses on wetland condition.

These analyses demonstrate how RIRAM v.2 could be applied to address objectives identified by the RI Wetland Plan. RIRAM v.2 data collected over a longer term could be further used to identify trends relating to condition and stressors, such as stressor-response thresholds, synergistic stressor impacts, and impacts specific to particular wetland types or regions. It could also be used to identify reference sites and establish gradients in the development or analysis of physical and biological conditional indicators. And important to the project goals, these analyses indicate (through expected correlations) proper function of RIRAM v.2 in providing applicable (numeric), relative indices of wetland stress, response (impact), and overall condition.

A-4 Discussion

RIRAM v.2 was developed to produce an objective, repeatable, evidence-based RAM capable of providing sound conditional data to address State-identified objectives. Analyses in this addendum provide evidence that RIRAM v.2 is analogous to RIRAM v.1, and equally or more objective and repeatable (Section A-2.2.2). Demonstration analyses showed that v.2 can also be applied similarly to v.1 data. However, several changes made to RIRAM v.2 make it more useful, sound, and defensible for a variety of applications.

Systematic Format

RIRAM v.2 is organized in a manner that requires the user to systematically compile evidence to support the scoring of subsequent sections. First, in section A, the user is required to identify the assessment unit's current wetland type, setting, and physical characteristics, which familiarizes him or her with the study unit. Next, in section B (App A-1), the user is required to observe and asses surrounding landscape and buffer stressors. In addition to directly generating landscape metric scores, this provides context and information for assessing in-wetland stresses assessed in the next section. For example, aerial photography will often provide evidence of impoundment (e.g. widening of wetland upstream of some linear structure), ditching, or fill (e.g. unnaturally straight wetland edge) and alert the user to look for signs of (e.g.) anthropogenic fluvial inputs. Next, in section C, the user documents the evidence, intensity, and proportionality of each in-wetland (and adjacent) stress type and identifies primary and secondary stressors associated with each. Finally, in section D, the user is required to apply the landscape and in-wetland information, gained through completing sections A, B, and C, to interpreting the cumulative stress impacts to six elements that control wetland functions and values. By this point, the user is making an informed interpretation, based on documented evidence; thus subjectivity is reduced.

Binning of Stresses by Type

RIRAM v.2 (section C. *Stress*, App. A-1) seeks to identify all stresses acting on wetlands and bins them into categories by stress type. Within each bin, stresses are broken into components that characterize the stress and are rated for intensity and proportionality of effect, as applies to each type. Stressors (actuators of stress) are nested beneath each type. This allows the data to capture the effect of stressors by the type(s) of stress each produces, which is not captured in version 1. Nesting clarifies the actual effects of stress by removing vagueness and redundancy and allowing an investigator to "dig" through data layers to reveal the mechanisms of a relationship. Also nested by stress type is evidence of each stress, which adds a degree of defensibility to the data that is lacking in RIRAM v.1.

Evidence-based Metrics

Every metric in RIRAM v.2 requires that the user base his or her assessment on observed evidence; this lends defensibility and confidence to the data. Interpretation, when utilized, is based on evidence from prior evidence-based metrics. RIRAM v.2 metrics document a string of evidence that can be summarized as follows: evidence of stress is identified and documented; responsible stressors are identified and documented; stress intensity is estimated and documented; proportion of stress impact is estimated and documented; cumulative impacts to wetland elements are estimated and documented; wetland elements control wetland functions and values (not incorporated). The string of evidence falls short of identifying gains and losses of original wetland functions and values, which would confound project objectives. RIRAM v.2 retains "blindness" to wetland type by avoiding metrics that score wetland functions and values, since they may be inherent to wetland type and thus bias the characterization of condition (Kutcher 2010).

Incorporation of Proportionality

Proportionality of stress impacts is incorporated into *Landscape* and most *Stress* metrics. Efficient stressor-based RAM's have been developed that rate wetlands using coarse stressor ranks based on presence, proportion, or overall intensity (e.g. Penn State Stressor Checklist; Brooks et al. 2002). RIRAM v.2 quantifies each stress by its intensity and the proportion of the unit it affects, separately. This lends precision to each metric and to the RAM indices without adding considerable effort. Often, selecting a specific intensity (based on evidence) and a proportion (based on observation or aerial photography) takes less time and effort than deciding on a single coarse rank that may loosely incorporate both (and document neither). The result is less arbitrary—thus more repeatable—and more precise; furthermore, useful baseline data is generated.

Addressing RIRAM v.1 Ambiguities

RIRAM v.2 addresses ambiguities inherent in RIRAM v.1. Version 1 utilized response metrics from ORAM (Mack 2002) that were vague in their handling of historical wetland modifications. At the crux of the matter, many wetlands can adapt to a change in water or disturbance regime and become a different type of wetland containing a new set of functions and values; or a wetland remnant (e.g. partly filled) may function as a healthy smaller wetland. These issues require the RAM to specify what iteration of the wetland is being assessed (historic or current); this was not clarified in previous versions. RIRAM

v.2 addresses these issues by requiring certain rules to be followed. First, the user must identify and document the current wetland type (based on Cowardin et al. 1979) and size. The user must then assess each stress type *independently*, based on evidence of its *specific* effects. Each stress is considered "current conditions" when evaluating all other stress metrics. So, for example, a partly filled wetland would lose points under metric 7 *Filling*…, but the remnant wetland would be assessed as the complete unit for all other metrics. Wetland *Response* is then rated according to its current size and (identified) type.

Another ambiguity inherent in RIRAM v.1 was the determination of wetland response from hydrologic versus direct habitat alterations. Vague wetland-response metrics utilized by version 1 required the user to consider whether the assessment unit had recovered from hydrologic alterations and from direct habitat alterations, separately. This forced the user to try to determine which source was the cause of any evident wetland impacts, which was often difficult. RIRAM v.2 requires the user to determine impacts to wetland elements considering all stresses: landscape, hydrologic, and direct. This allows unqualified documentation of cumulative impacts, and associated effective stresses can be determined through data analysis (see Section A-2).

Section D. Response to cumulative stress

Some concern has been raised regarding the incorporation of *Response* metrics (Section D, App. A-1) into RIRAM v.2, which require the user to interpret the intensity of stress impacts to six physical and conceptual elements that control wetland functions and values. *Response* differs in concept from the stressor-based approach employed throughout the rest of RIRAM v.2, which relies on direct evidence and estimation of intensity and proportionality. It is mainly the interpretation, or the application of best professional judgment, in *Response* that raises the concern.

Correlation analysis indicated that *Response* may not be necessary to generate a RIRAM v.2 index that strongly correlates with RIRAM v.1 (see Section 2.2.2; Table A-2); but *Response* may be important to the functionality of RIRAM v.2. All analyses conducted in this addendum demonstrate the utility of retaining *Response* as a dependent variable representing cumulative impacts. This directly serves State monitoring objectives, which is critical to the intended utility of RIRAM. And, *Response* generates useful baseline information on cumulative impacts.

Response also contributes to the precision of RIRAM v.2 in reflecting overall condition. Both stress and response determine ecological condition, just as disease and symptom determine human health; the former applies strain to the system, while the latter is the degree to which the system manifests that strain. The rating of stresses alone may be deficient in representing overall condition because it is based on the assumption that wetlands respond predictably to stress, when in fact, different wetland types may respond to various stresses differently; e.g. two wetlands may respond differently to the same stress at the same level of intensity. *Response* compensates for variations in wetland resiliency to stress by lowering RIRAM scores of sensitive wetlands in relation to wetlands more resistant to stress impacts.

Response can also help the user validate and quality-control determinations made in the identification or rating of stresses. To interpret impacts to wetland elements, which is the objective of *Response*, the user must review and summarize stresses to reconcile relationships between stress and response. Reconciliation validates the user's determinations by documenting cause-response evidence, which is stronger than either alone. Any apparent inconsistencies will alert the user to revisit determinations and reapply a strict evidence-based approach.

Further RIRAM Refinements

Further work is needed to refine and validate RIRAM v.2. Before application in Year-4, v.2 will be vetted through a peer review process according to the QAPP. RIRAM has already been tested at the annual meeting of the New England Biological Assessment Wetland Working Group (NEBAWWG) and by State and Federal peers. In addition, RINHS gained considerable insight to the functionality of RIRAM v.2 in Year-3 field applications. All reviewers indicated a preference for RIRAM v.2 approach and content over version 1. However, some suggestions have been made that will be addressed before application in Year 4.

First, the cover page *Background Information* and Section A. *Wetland Characteristics* (Section I of App. A-1) need to be refined and updated to improve their utility for the State, while minimizing redundancies and the time and effort involved in their application. This may include adding checklists for HGM and NWI classes, simplifying basin identification, removing *Assessment Area*, and assigning new depth categories to *Maximum water depth*.

Issues will also be addressed in Sections B. *Landscape* and C. *Stress* (App. A-1). Redundancies will be removed from the *Associated Stressors* sections where necessary; this is especially apparent in identification of fluvial input stressors, where roads and sheet runoff may be redundant with residential development. Text boxes named *Hydroperiods* will be renamed *Water Regimes* for accuracy. It has been suggested that categories in *Proportion of unit affected* boxes may be too fine; this will be considered. More specifically, stress sub-metric C.3b *Impoundment, artificial barrier*… will be updated to four categories and will be additive; while 7 *Filling*… and 8 *Excavation*… metric intensities will be reassigned slightly.

Finally, Section D. *Response* will need to be assessed for whether it is a necessary component of RIRAM. Justifications provided in the above section may need to be considered by peer reviewers.

Validation of RIRAM v.2

Very strong correlations between RIRAM v.1 and v.2 indices suggest that validations performed on RIRAM v.1 data in the Report would apply similarly to v.2 data. However, direct validation of RIRAM v.2 against quantitative physical or biological condition data will provide stronger evidence regarding the validity of the RAM and may add to the body of evidence necessary for confidence in its applications. Efforts will be made to identify and procure validation opportunities for future RAM development.

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Appendix A-1

RIRAM v.2 Datasheet

B. Stressors within the Surrounding Landscape. Sum metrics 1 and 2 (Max = 20, Min = 0)

1) Degradation of Buffers

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

- ☐ <5% (10)
- ☐ 6 to 25% (7)
- ☐ 26-50% (4)
- ☐ 51-75% (1)
- ☐ >75% (0)

Associated Stressors: Check all that apply

- ☐ Commercial or industrial development
- ☐ Sewered residential development
- ☐ Unsewered residential development
- ☐ Construction
- ☐ Landfill or waste disposal
- ☐ Channelized streams or ditches
- ☐ Raised road beds or trails
- ☐ Row crops, turf, or nursery plants
- ☐ Poultry or livestock operations
- ☐ Orchards, hay fields or pasture
- ☐ Piers or docks
- ☐ Golf course
- ☐ Sand and gravel operation
- ☐ Other _____

2) Intensity of Surrounding Land Use

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

Proportion		Score	Weighted Value
_____	Very Low	× 10 =	_____
_____	Low	× 7 =	_____
_____	Moderately High	× 4 =	_____
_____	High	× 1 =	_____

Sum weighted values for score: _____

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, new construction, row crops, turf crops, paved roads > 2-lane

Sum of Metrics 1 and 2 = ☐ B. Landscape Stressors Score

C. Stresses affecting assessment unit. Sum metrics 3 to 9 and subtract from 50. (Max = 50, Min = 0)

3) Impoundment.

Sum a and b (Max = 7)

a. Increase in depth or hydroperiod. Select one and multiply by the proportion of the unit affected to the nearest tenth.

- ☐ None (0)
- ☐ Wetland was *created* by impoundment (1)
- ☐ Changes velocity only (1)
- ☐ Less than one water regime (1)
- ☐ One water regime (3)
- ☐ Two or more water regimes (5)
- ☐ To deepwater (7)

Evidence: check all that apply

- ☐ Physical barrier across flow downstream of wetland
- ☐ Deepening of wetland upstream of barrier
- ☐ Widening of wetland upstream of barrier
- ☐ Abrupt and unnatural edge downstream of wetland
- ☐ Dam or perched culvert downstream of wetland
- ☐ Dead or dying vegetation

Proportion of unit affected (circle one)
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1.0

Associated Stressors:
Rank as primary (P) or secondary (S)

- __ Road
- __ Railway
- __ Weir / Dam
- __ Raised Trail
- __ Other _____

b. Artificial barrier to movement of resources through water. Select one.

- ☐ None (0)
- ☐ Barrier to upstream movement at low water (1)
- ☐ Barrier to upstream and downstream movement at low water (2)
- ☐ Barrier to upstream or downstream movement above low water (3)

Hydroperiods

Temporarily Saturated …… Temporarily Flooded
Seasonally Saturated …….. Seasonally Flooded
Semipermanently Saturated …… Semipermanently Flooded
Permanently Saturated …… Permanently Flooded

4) Draining or Diversion of water from wetland.

Decrease in depth or hydroperiod. Select one and multiply by the proportion of the unit affected to the nearest tenth (Max = 8).

- ☐ None (0)
- ☐ Changes velocity only (2)
- ☐ Less than one water regime (2)
- ☐ One water regime (5)
- ☐ Two or more water regimes or to upland (8)

Hydroperiods

Temporarily Saturated ……Temporarily Flooded
Seasonally Saturated …….. Seasonally Flooded
Semipermanently Saturated ……Semipermanently Flooded
Permanently Saturated ……Permanently Flooded

Proportion of unit affected (circle one)
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1.0

Evidence: check all that apply

- ☐ Drainage ditches or tiles evident
- ☐ Culvert or dam upstream of wetland
- ☐ Other impoundment upstream of wetland
- ☐ Severe root exposure
- ☐ Moderate root exposure
- ☐ Soil fissures
- ☐ Uncharacteristically dry groundcover
- ☐ Dead or dying vegetation

Associated Stressors:
Rank as primary (P) or secondary (S)

__ Road
__ Railway
__ Dike
__ Raised Trail
__ Drainage ditch
__ Tile Drain
__ Major well withdrawals
__ Surface water pumps
__ Other _____

5) Anthropogenic fluvial inputs.

Circle the strength of evidence for each and sum (Max = 7).

a. Nutrients	b. Sediments	c. Toxins / salts	d. Increased flashiness
☐ None (0)	☐ None (0)	☐ None (0)	☐ None (0)
☐ Slight (1)	☐ Slight (1)	☐ Slight (1)	☐ Slight (1)
☐ Moderate (2)	☐ Moderate (2)	☐ Moderate (2)	☐ Moderate (2)
☐ Strong (3)	☐ Strong (3)	☐ Strong (3)	☐ Strong (3)

Evidence: check all that apply

- ☐ Excessive algae or floating vegetation
- ☐ Excessive submerged rooted vascular vegetation
- ☐ Excessive emergent vegetation
- ☐ Obvious discharges or plumes
- ☐ Chemical smell
- ☐ Strangely tinted water
- ☐ Stark lack of life
- ☐ Root exposure or bank erosion due to scouring
- ☐ Runoff sources evident

Associated Stressors:
Rank as primary (P) or secondary (S)

__ Storm water inputs
__ Sheet runoff
__ Residential upstream
__ Agriculture upstream
__ Golf course upstream
__ Other _____

6) Vegetation and detritus removal within wetland. Rate extent and multiply by the estimated proportion affected for each layer (Max = 7).

Layers affected	Extent	Proportion	
☐ Aquatic Bed (1)	× _____	× _____	= _____
☐ Detritus (1)	× _____	× _____	= _____
☐ Emergent (1)	× _____	× _____	= _____
☐ Shrub (1)	× _____	× _____	= _____
☐ Canopy (1)	× _____	× _____	= _____
		Sum =	_____

Extent of removal

- None (0)
- Partial or recovering (1)
- Complete (2)

Proportion of unit affected
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1.0

Evidence: check all that apply

- ☐ Cut stems
- ☐ Immature vegetation strata
- ☐ Missing vegetation strata
- ☐ Mowed areas
- ☐ Browsing or grazing

Associated Stressors:
Rank as primary (P) or secondary (S)

__ Mowing
__ Grazing/browsing
__ Clear cutting
__ Selective cutting
__ Development
__ Woody debris removal
__ Shrub removal
__ Aquatic bed removal
__ Farming
__ Other _____

7) Filling and dumping within wetland. Select one and multiply by the proportion of the unit affected to the nearest tenth (Max = 7).

Depth of fill
- ☐ None (0)
- ☐ Changes soil quality or aesthetics only (2)
- ☐ Changes water regime or affects vegetation (5)
- ☐ Changes area to upland (7)
- ☐ Fill is above surrounding upland grade (10)

Proportion of unit (or perimeter) affected (circle one)
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1.0

Evidence: check all that apply
- ☐ Direct evidence of fill
- ☐ Unnaturally abrupt change in ground level
- ☐ Abrupt change in soil texture or content
- ☐ Unnaturally straight or abrupt wetland edge
- ☐ Unnatural items on or within the sediments

Associated Stressors:
Rank as primary (P) or secondary (S)
__ Road __ Raised Trail
__ Railway __ Trash
__ Residential development
__ Commercial development
__ Fill
__ Other _____

8) Excavation, grading, and other substrate disturbances within wetland. Select one and multiply by the proportion of the unit affected to the nearest tenth (Max = 7).

Intensity of disturbance
- ☐ None (0)
- ☐ Wetland unit was *created* by excavation (1)
- ☐ Soil structure or quality disturbed only (3)
- ☐ Causes changes to water regime or vegetation (5)
- ☐ Excavated to deep water (7)

Proportion of unit (or perimeter) affected (circle one)
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1.0

Evidence: check all that apply
- ☐ Unnaturally abrupt lowering in ground level
- ☐ Loss of vegetation
- ☐ Unnaturally straight and abrupt wetland edge
- ☐ Direct evidence of disturbance

Associated Stressors:
Rank as primary (P) or secondary (S)
__ Vehicle disturbance __ Dredging
__ Grading __ Channelization
__ Footpaths __ Ditching
__ Excavation
__ Other _____

9) Invasive species within wetland.

9a. Select one class for total coverage. (Max = 7).
- ☐ Extensive >75% cover (7) …… Class 5
- ☐ High 51-75% cover (5) …… Class 4
- ☐ Moderate 26-50% cover (4) ……Class 3
- ☐ Low 6-25% cover (3) …… Class 2
- ☐ Nearly absent <5% cover (2) ……Class 1
- ☐ None noted (0)

9b. List and select a cover class for each invasive plant species noted.

Cover Class	Species
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Sum of C2 to C9 Scores = ☐ **50 Minus Sum =** ☐ **C. Wetland Stresses Score**

D. Overall Wetland Unit Response to Cumulative Stress. Circle one score for each component and sum (Max = 30). Refer to Sections C and D. Consider current wetland types.

	Characteristic	Degraded			Destroyed
Vegetation Structure……...	5	4	3	2	0
Vegetation Composition…….	5	4	3	2	0
Hydrologic Connectivity……	5	4	3	2	0
Habitat Connectivity……...	5	4	3	2	0
Microhabitat Structure……	5	4	3	2	0
Water and Soil Quality……	5	4	3	2	0

SUM = [ ] **D. Cumulative Response Score**

B. Landscape Stressors Score (max 20) _____ **+**

C. Wetland Stresses Score (max 50) _____ **+**

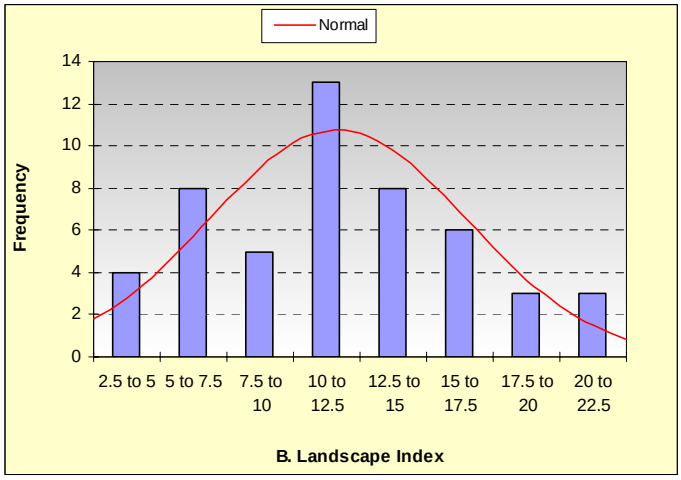
D. Cumulative Response Score (max 30) _____ **=**

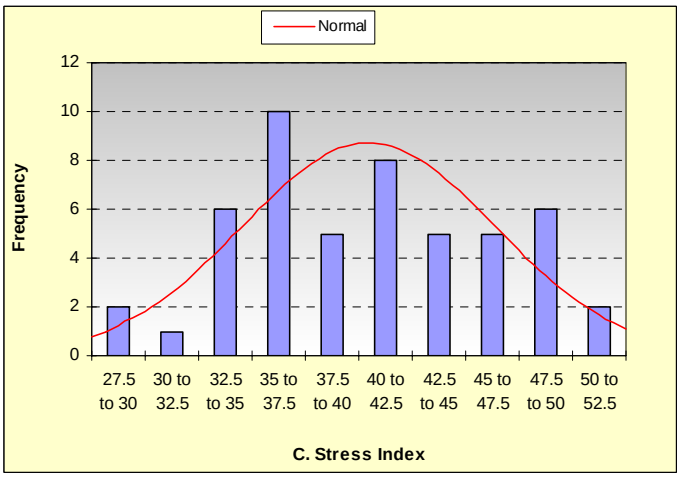
RIRAM V. 2 Condition Index [ ]

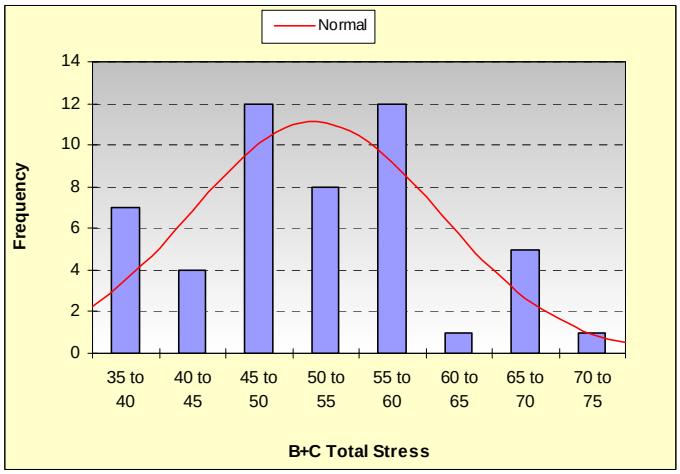
Appendix A-2

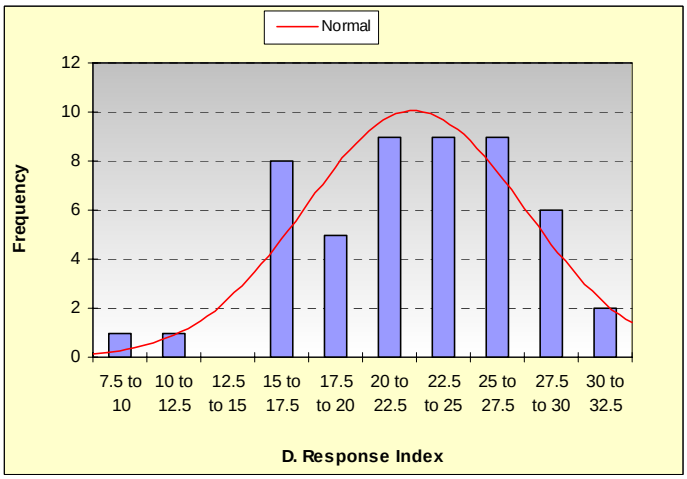
Summary of RIRAM v.2 Index and Selected Metric Data Collected in Year 3 (2008) at 50 Wetland Assessment Units located in the Hunt and Pawtuxet River Basins

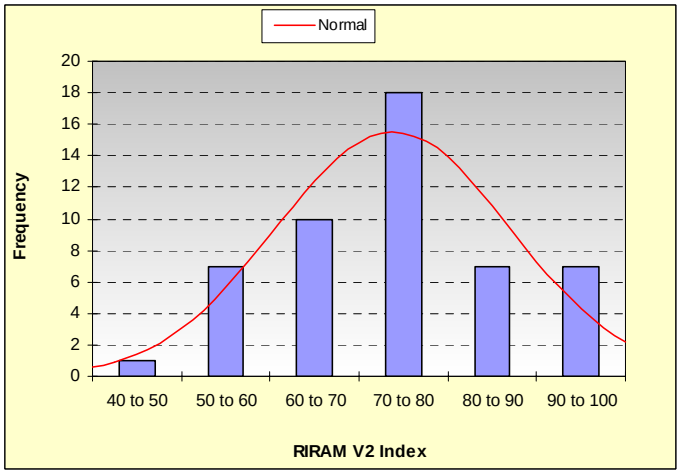
RIRAM v.2 Indices



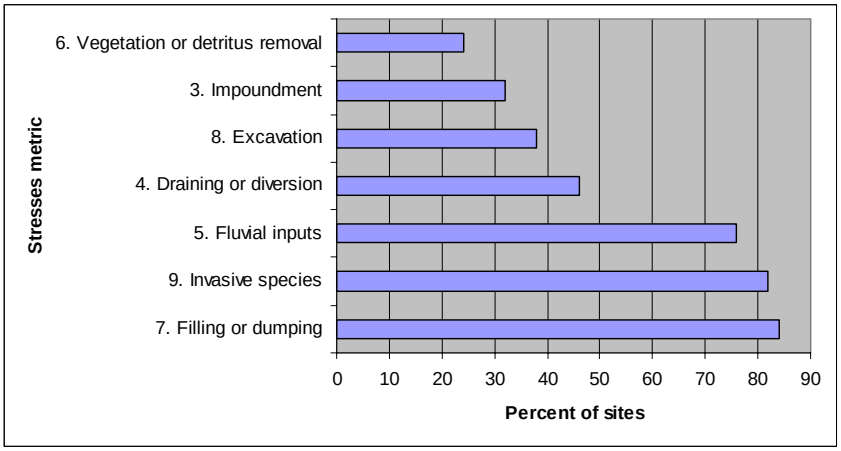




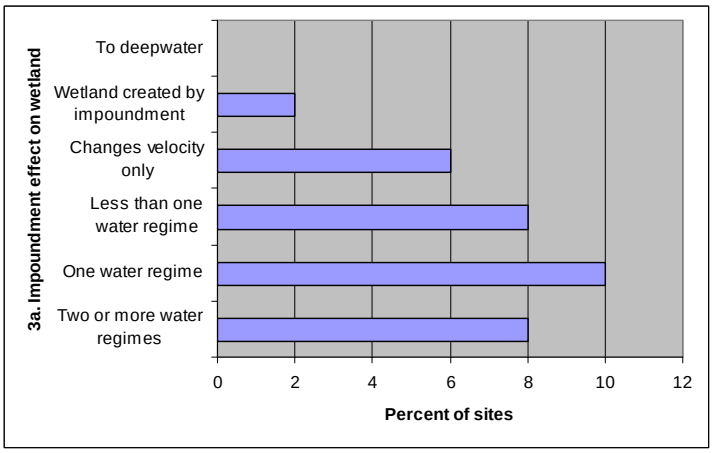


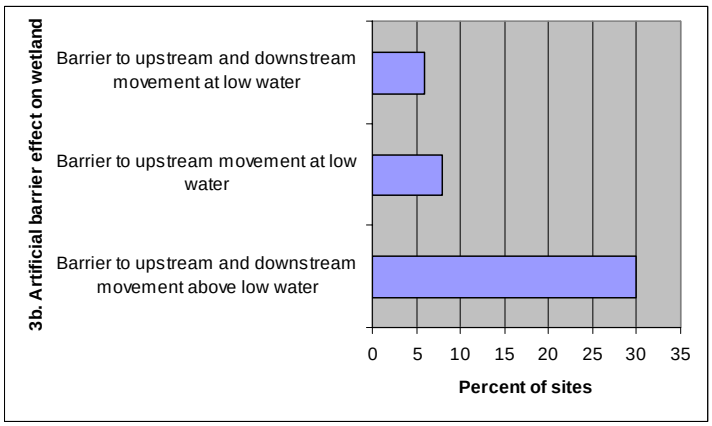


Presence of stress in H-P wetlands by type

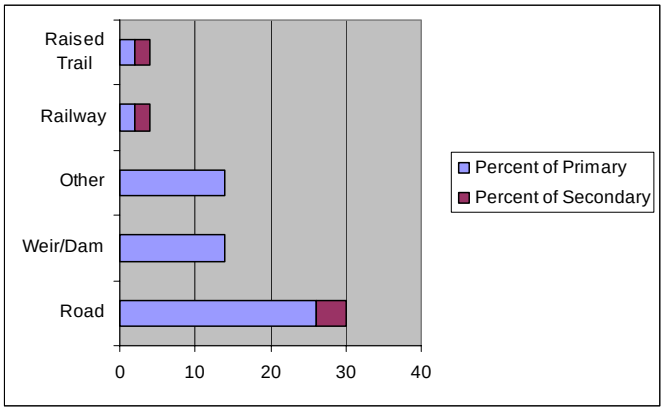


Metric 3. Impoundment

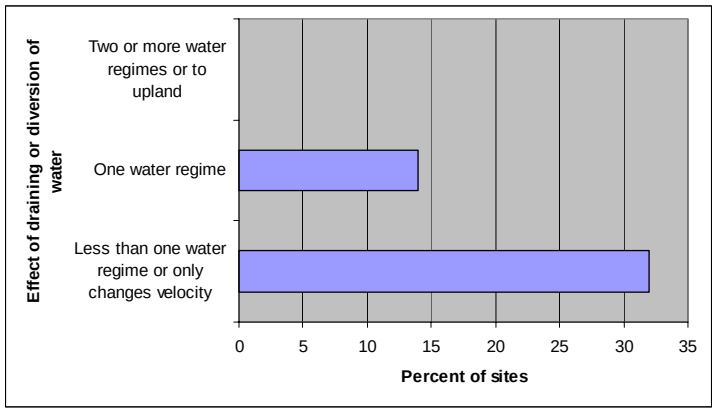




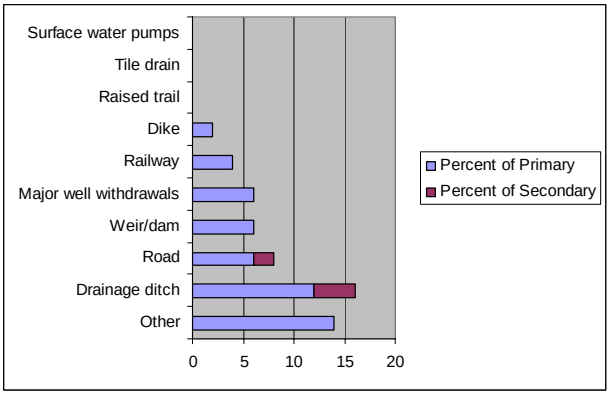
Metric 3. Associated Stressors



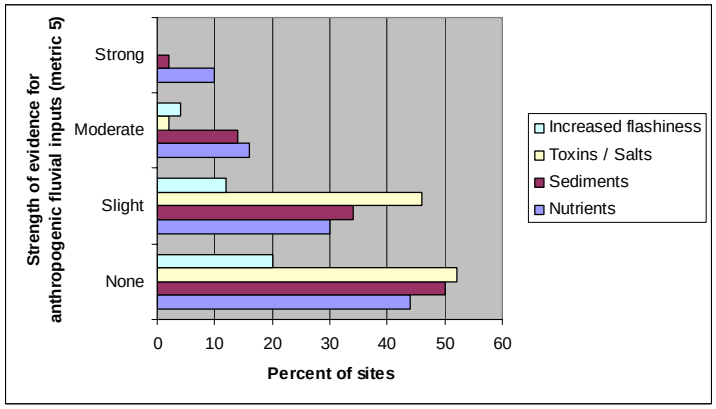
Metric 4. Draining and Diversion of water from wetland



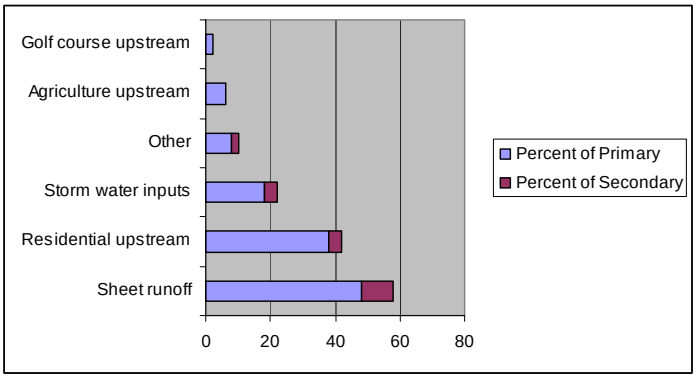
Metric 4. Associated Stressors



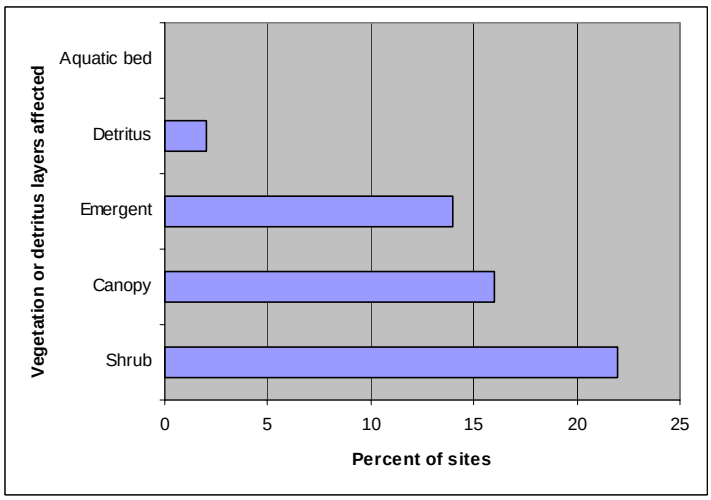
Metric 5. Anthropogenic fluvial inputs



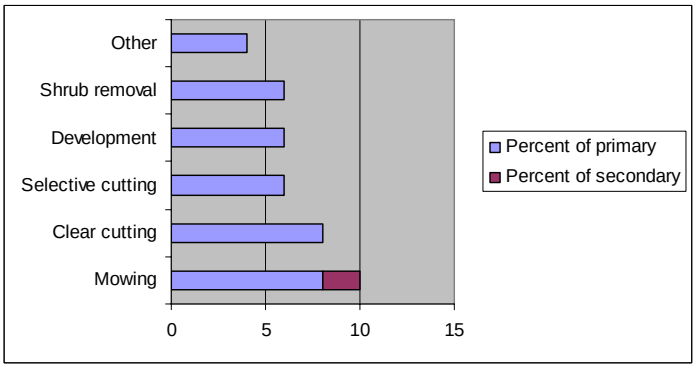
Metric 5. Associated Stressors



Metric 6. Vegetation and detritus removal from within wetland

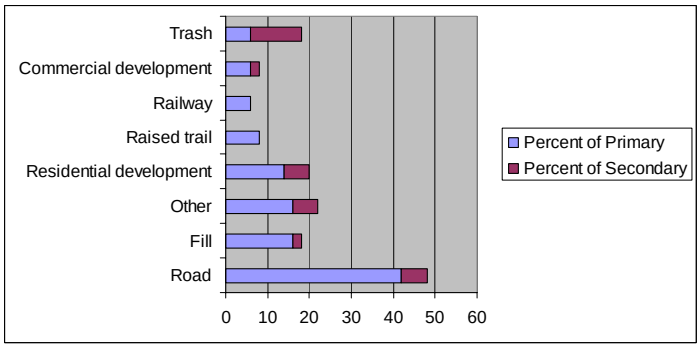


Metric 6. Associated Stressors

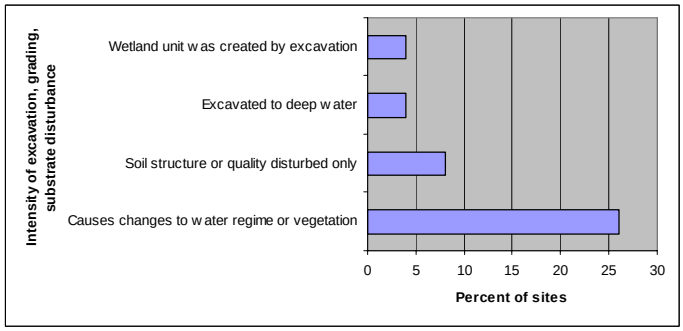


Metric 7. Filling and dumping within wetland

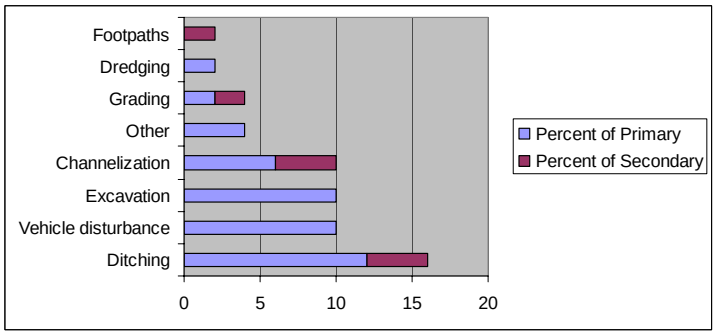
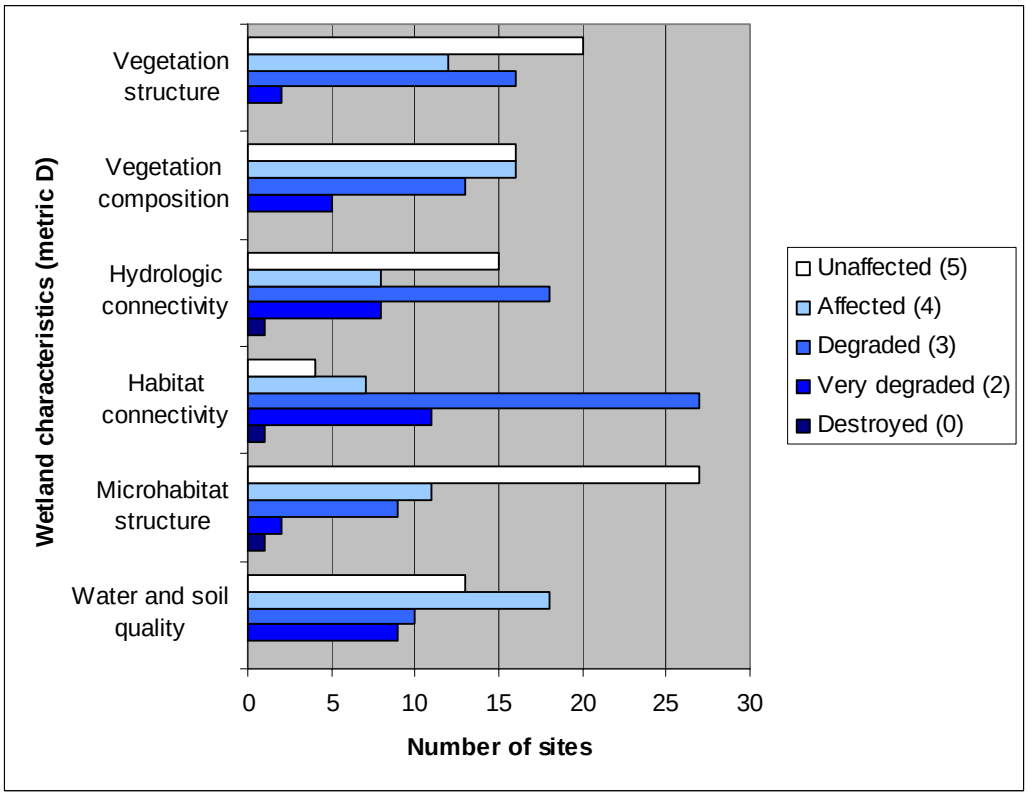
Metric 7. Associated Stressors



Metric 8. Excavation, grading, and other substrate disturbances



Metric 8. Associated Stressors



Index D. Overall wetland response to cumulative stress