Applying the Rhode Island Rapid Assessment Method to Identify Reference Conditions in Rhode Island Freshwater Wetlands

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Abstract
The U.S. Environmental Protection Agency (U.S. EPA 2002) has developed recommendations regarding the identification of wetland reference conditions for states to apply in reference-based assessment, such as bio-assessment. More recently, NatureServe has recommended an approach to identify wetland reference conditions for a national wetlands assessment effort currently underway. Both sources offer recommendations on wetland classification and on criteria for establishing reference sites. Recommendations were analyzed here for applicability in State efforts. Classification recommendations were modified to be more effective for use in Rhode Island. Specifically, this report recommends that Rhode Island classify wetlands by Cowardin (1979), modified HGM (Brinson 1993), and Enser and Lundgren (1996) classifications to facilitate flexibility in the grouping of wetlands to address various objectives.

EPA and NatureServe both recommend the use of an independent measure of wetland condition to identify a reference gradient and reference-standard units. EPA recommends that a reference gradient be established using an index that incorporates the evaluation of multiple prevailing disturbances to wetlands and the surrounding landscape. NatureServe similarly recommends a measure based on landscape and rapid assessment information and further assert that the data meet the following criteria: contain classification information, expressly measure relative wetland condition, contain georeferencing information and other metadata, are capable of characterizing a full gradient of reference conditions, and have been tested to produce sound data.

The Rhode Island Rapid Assessment Method (RIRAM) was developed to characterize, and assess the condition of freshwater wetlands in Rhode Island. It employs metrics evaluating multiple landscape and in-wetland stresses, as well as observed wetland integrity, to produce relative indices of wetland condition. In addition, it documents detailed classification and geospatial information. Because RIRAM was specifically designed to set wetland units on a relative scale of condition (i.e. along a condition gradient), RIRAM data fully meet the EPA and NatureServe criteria. RIRAM is therefore recommended for identifying reference conditions for freshwater wetlands in the State. Specific recommendations for its application are offered.

Introduction

Identification of reference conditions has become an important process in the assessment of ecological integrity, especially in the development and application of biological assessment (bio-assessment) techniques (U.S. EPA 2002a; Stoddard et al. 2006; Herlihy et al. 2008). In recent decades, methods have been developed to infer the relative ecological integrity of surface waters and other ecological resources through comparisons of their biological assemblages with those of predetermined reference sites (i.e. sites possessing reference conditions); this has been referred to as *reference-based* assessment. In this context, reference condition has been described as representing relative *naturalness*, which implies a lack of human disturbances (Stoddard et al. 2006). Reference sites can be identified as a *reference standard*: a set of sites reflecting minimally-disturbed (MDC) or least-disturbed condition (LDC), or as a *reference gradient*: the full gradient of conditions representative of a given population of interest (Stoddard et al. 2006; Faber-Langendoen et al. 2009). While establishing minimally disturbed sites allows the identification of reference-standard metric parameters, establishing a gradient allows the identification of thresholds or correlations that are necessary for the proper development of bioindicators (U.S. EPA 2002a).

In order to identify the biological (or physical) parameters that will represent reference conditions in reference-based analysis, a set of reference sites must be identified *a priori* based upon an independent measure of condition. Applying independent criteria is critical to avoiding circularity in analysis, and is often accomplished through a sifting and ranking process based upon measures of land use intensity, stressor intensity, existing physical or chemical data, or simply by applying best professional judgment (Stoddard et al. 2006; U.S. EPA 2002a). U.S. EPA (2002a) has outlined methods to establish an independent gradient of human disturbance based on multiple rapidly assessed metrics for application in reference-based monitoring.

More recently, NatureServe has further developed and refined EPA's methods as part of a recent national wetland monitoring effort (Faber-Langendoen et al. 2009). NatureServe recommends an ecoregion classification, a wetland habitat classification protocol, and an approach to identifying reference gradients and reference standards. NatureServe recommended that ecoregions be classified according to existing Wadeable Streams Assessment (WSA) Ecoregions (U.S. EPA 2010). Since the entire State of Rhode Island falls within a single one of these ecoregions, the recommendation is not applicable to this effort. Wetland classification and the identification of a freshwater wetland reference gradient are the foci of this report.

The Rhode Island Rapid Assessment Method (RIRAM) was developed to classify, characterize, and assess the condition of freshwater wetlands in Rhode Island. It employs metrics evaluating multiple landscape and in-wetland stresses and the observed integrity of wetland functional characteristics, based on observed evidence, to produce relative indices of wetland condition (App. 1). RIRAM was designed to serve as a central component in a three-tier monitoring and assessment program utilizing landscape, rapid, and intensive assessment methodologies to address previously-identified State objectives. A key consideration in RIRAM development was maximizing its utility in generating a gradient of relative wetland condition that could be used in exploratory analysis and in identifying reference conditions for further program development.

Wetland Habitat Classification

Classification Context

Wetland classification serves many functions in the gathering, analysis, and interpretation of monitoring and assessment data. The goal of classification is to group wetlands by categories that serve identified and potential objectives. Objectives may consider vegetation type, hydrology, setting, habitat structure, vulnerability, rarity or commonness, habitat value, functionality, or a host of other interests. In specific regard to establishing reference conditions, wetland classification is often applied to categorize wetlands according to reference-based monitoring needs. It is often necessary to identify a specific subset of wetlands to develop and apply reference-based bio-assessment methods, since many flora and fauna assemblages are dependent on wetland type. Wetland type must therefore be categorized or standardized to isolate bio-indicator variability due to condition alone; this can be accomplished by applying classification data to identify the appropriate subset or subsets (i.e. type) for which reference conditions are sought.

No known classification can categorize wetlands *a priori*, based on all of the meaningful groupings for which reference conditions may be sought. A useful approach may then be to collect classification information along with monitoring data across all wetland types. Then, when reference conditions for a wetland grouping of concern are sought after, a sample can be queried from the classification data and reference conditions can be generated from that sample. This necessitates that the classification protocol utilized be as comprehensive and as ecologically and functionally meaningful as possible. Collecting rigorous classification information for all sites allows the identification of reference conditions for numerous groupings of interest, broadening reference applications toward the development, validation, and analysis of wetland condition monitoring protocols and data.

Classification Schemes

Two general kinds of classifications are widely applied in wetlands. The first is a *structural* classification that determines habitat units based on a fixed and often hierarchical set of physical or biological characteristics, such as hydrology, vegetation, substrate, and landscape setting. This format promotes comprehensiveness and analytical utility. For wetlands, the two most widely-applied classifications of this kind are the Hydrogeomorphic (HGM) classification schemes (Brinson 1993) and the Cowardin et al. (1979).

The HGM classification classifies wetlands by broad categories of hydrogeomorphology to characterize a wetland by the general shape, position, and hydrology of the wetland basin; it does not focus on the vegetation communities within. HGM categories may include depressional, riverine, flat, slope, and fringing wetland types, among others, depending on which of many subsequent applications of the scheme is employed. A single HGM class may include a single or multiple vegetation communities or habitat types and thus is usually supplemented with higher-resolution classification data when habitat characterization is required.

The Cowardin classification categorizes wetland habitat units primarily by vegetation or substrate structure, represented by the level *Class* (i.e. forested (FO), scrub-shrub (SS), emergent (EM), aquatic bed (AB), unconsolidated bottom (UB), etc.), along with broader and finer, pre-determined classification levels. The classification is designed to describe any wetland or deepwater habitat type likely encountered in the United States. To achieve comprehensiveness, a habitat type is

identified by stringing together fixed classification components. While Cowardin can be applied almost universally, it does not group wetlands by some commonly-recognized wetland types that may represent resources of concern (such as fens). A single wetland type (of interest) may contain a mix of *Classes* and, conversely, multiple wetland types may fall under the same *Class*. For example, a *fen* may be classified as (Palustrine) SS or EM, or both, while a *shallow marsh* may also be classified as (P) EM. Herein lies a limitation of the structural classification; units of ecological importance or human interest cannot always be clearly identified in a strict hierarchy.

The second kind of classification utilizes an *organized descriptive list* of commonly-applied naming conventions (such as *dwarf shrub bog*) and definitions that may insinuate habitat function or include groupings and discriminations not easily captured in structural classifications. In Rhode Island, Enser and Lundgren (2006) have developed a descriptive classification of *natural community* types that utilizes Cowardin *System* and *Subsystem* levels (for organization) and classifies wetlands by descriptive types and subtypes. Similar types are utilized by the DEM Wetlands Program (DEM 2009b). For example, *Swamp*, *Marsh*, *Bog*, *Shrub Wetland*, *Pond*, *Stream*, *Intermittent Stream*, and *Flood Plain Wetland* are State regulatory classifications that are also described by Enser and Lundgren (along with various subtypes). However, Enser and Lundgren do not define the terms precisely the same way as DEM, nor do they consistently group wetlands according to the DEM types; for example, DEM *Swamps* are distributed across three Enser and Lundgren groupings: *Open* (mineral soil) *Wetlands*, *Forested Mineral Soil Wetlands*, and *Forested Peatlands*. Herein lie the limitations of the organized descriptive list; there may be a lack of term consistency and data cannot be consistently grouped or split for analysis.

Classification Scheme Recommendation

U.S. EPA (2002b) recommended that wetlands be classified according to hydrogeomorphic and vegetation classification categories. Recently, NatureServe (i.e. Faber-Langendoen et al. 2009) more specifically recommended that wetlands be classified by a combination of the Cowardin et al. (1979) classification and the National Vegetation Classification (NVC; FGDC 2009). According to NatureServe recommendations, the Cowardin level *Class* would be utilized to identify vegetation classes, while NVC would be utilized to add descriptive nomenclature as well as detail at the state level. Certain classification levels within NVC use descriptive text to group wetlands by common type, while other levels are analogous to Cowardin *Class*. Recommending a combination of the two schemes was a compromise between the commonly-applied Cowardin scheme and the descriptive, but lesser-known NVC scheme.

Initially, the combined Cowardin/NVC classification method would seem appropriate for the classification of wetlands in applications such as the Rhode Island Wetland Monitoring and Assessment Year-4 study (Kutcher 2011). For example, *Atlantic white cedar swamp* habitats can be definitively described by the Cowardin et al. (1979) classification (SYSTEM: Palustrine, CLASS: Forested, SUBCLASS: Needle-leaved Evergreen; DOMINANCE TYPE: *Chamaecyparis thyoides*), while bogs and fens cannot (SYSTEM: Palustrine, CLASS: varies, SUBCLASS: varies; DOMINANCE TYPE: varies). NVC contains several cedar swamp and bog-and-fen descriptive categories under L3 *Formation*, L4 *Group*, and L5 *Macrogroup* levels; however, the complex NVC classification framework makes it difficult to determine whether there is a single level that consistently documents descriptive wetland types at the level of detail desired.

Rhode Island employs the Cowardin classification in wetland mapping, inventory, and enforcement efforts, thus wetland professionals are accustomed to the method. In contrast, RI does not formally apply the NVC, which is highly detailed and requires considerable up-front familiarization to employ. It cannot, then, be expected that RI will quickly adopt the NVC method. The Enser and Lundgren descriptive classification provides all of the ecological detail of the NVC, without redundant regional iterations that are built into the various NVC hierarchical categories for each habitat type. Additionally, the Enser and Lundgren document is familiar to State ecologists and was used to inform the NVC habitat list; thus the two should be easily crosswalked. Hydrogeomorphic (HGM) setting is commonly applied in the delimitation of wetland assessment units and may be an important factor in the variability of wetland condition (e.g. Wardrop et al. 2007).

Accordingly, Rhode Island may be best served by classifying monitoring-and-assessment wetlands by the (1) Cowardin, (2) Enser and Lundgren, and (3) HGM classifications. Enser and Lundgren could be crosswalked to NVC, as necessary, to support national monitoring efforts. The RIRAM v.2 field form (App.1) incorporates these three classifications in checklist format to facilitate the collection of these data during RIRAM assessments.

Establishing Reference Conditions

U.S. EPA (2002a) has outlined methods to establish a gradient of human disturbance for application in developing indices of biological integrity (IBIs). EPA recommends that the gradient be established using an independent index that incorporates multiple prevailing disturbances to wetlands and the surrounding landscape. Specifically, the index should ideally include metrics evaluating the condition and impacts of: surrounding land use, buffers, habitat continuity, impoundments, fluvial inputs, extraction of water, vegetation removal, microtopography, steepening of banks, soil disturbances, ditching, deposition, vegetation complexity, and pollution.

NatureServe (Faber-Langendoen et al. 2009) similarly suggests an assessment approach that utilizes landscape and field assessment criteria to determine relative ecological integrity. The approach would employ a landscape stressor model and/or use existing rapid assessment data. According to NatureServe, the ideal rapid assessment data would contain wetland classification information, be the result of a field assessment for wetland condition, contain georeferencing information, and contain appropriate metadata for QA/QC purposes. The data generated would need to be capable of characterizing a gradient of condition and identifying wetlands of highest ecological integrity. And the assessment method would need to be tested to determine its efficacy in providing sound, reliable data that can be correlated with stress gradients (Faber-Langendoen et al. 2009).

RIRAM evaluates virtually all of the EPA-recommended metrics. And, because it was specifically designed to set wetland units on a relative scale of condition (i.e. along a condition gradient), RIRAM meets all of the NatureServe criteria for establishing reference condition via rapid assessment (App. 1). RIRAM was specifically designed to be a central component of a three-level monitoring program and was intended to be utilized in the inter-validation and development of landscape, bio-assessment, and other assessment data. RIRAM uses a combination of landscape, buffer, and in-wetland assessment based on the intensity of multiple physical stresses and observed wetland integrity to generate a numeric index of wetland condition. The data can be applied to characterize a gradient of wetland condition across or within wetland types; and reference-standard wetlands can be established by identifying the highest-scoring (LDC) set of wetlands in any sample of interest (Kutcher 2009, 2010a and b, and 2011). RIRAM data have consistently correlated with

independent measures of landscape degradation, and has been shown to correlate with intensive biological and physical indicators of wetland condition (Kutcher 2010a; Kutcher unpublished data). Further, RIRAM data include wetland classification information, contain georeferencing information, and contain detailed metadata. RINHS and DEM have been collecting RIRAM pilot data since 2007; these data have initiated a statewide wetland monitoring and assessment dataset.

Applying RIRAM to Identify Reference Conditions

Establishing a reference gradient requires the identification of a defined sample of interest. A sample may be determined by area, such as all wetlands within a given basin, by wetland type (classification groupings), such as discussed in this report, or by both, i.e. a given type within a given area. A typical RIRAM reference gradient can be coarsely verified by studying a correlation scatterplot of RIRAM indices versus surrounding land use intensity (Fig 1).

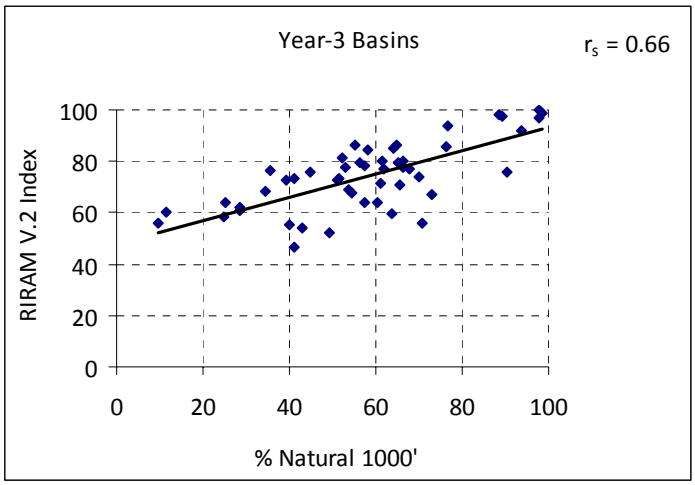

Figure 1: RIRAM Index score distributions in relation to the percent cover of natural lands within a 1000' buffer zone. Source: Kutcher 2010b.

This scatterplot illustrates how RIRAM data generates a gradient that correlates with a reliable (albeit course) measure of wetland condition. The RIRAM gradient can be applied to the development or validation of other assessment methods, such as landscape models and indicators of biological integrity (IBIs). RIRAM has been successfully applied in this capacity (e.g. Kutcher 2009, 2010a and b, 2011, and unpublished data).

For this sample (Fig.1) MDC or LDC reference-standard sites could be represented at the top of the RIRAM Index gradient. Reference-standard sites can be selected by setting a fixed index value or percentile threshold, or on the basis of natural breaks in the data. Setting a fixed index or percentile is straightforward and commonly applied (e.g. Herlihy et al. 2008). The reference-standard cut-off values selected may depend on the number of reference sites needed and the distribution of the sample. For example, if the desired number of reference sites cannot be identified by selecting sites above the 90th percentile, the range of acceptable sites may need to be expanded to include lower-scoring units, such as all sites above the 75th percentile. However, setting a value or percentile too low may compromise the reference-standard's representation of naturalness.

When appropriate, natural breaks in the data may be applied to identify sites that are "set apart" from the rest of the distribution (i.e. are above an observable threshold of degradation); these can be identified by simply studying sorted bar graphs at the upper ends of the data for a given sample (e.g. Fig. 2). For example, among Year-3 sites, natural breaks occur at 97, 92, and 84 (Fig. 2).

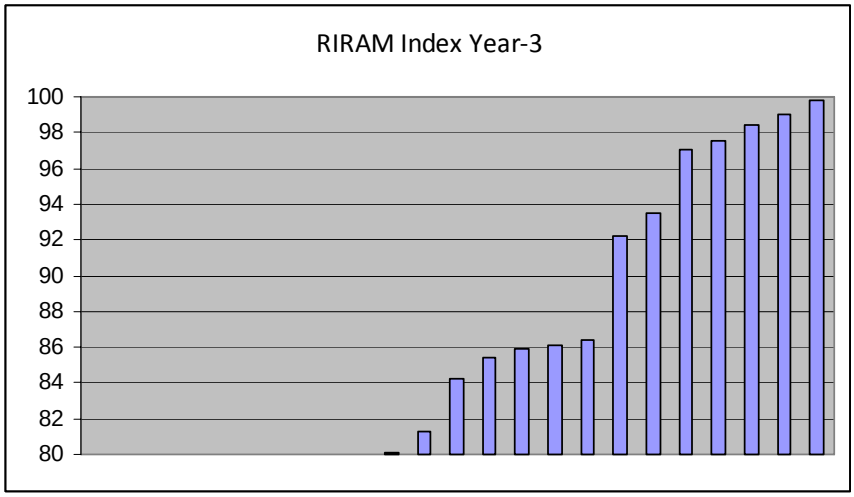

Figure 2: The upper portions of sorted RIRAM Index score distributions from RI Year-3 assessment efforts (Kutcher 2010b).

As an independent stipulation, assessment units that have been intentionally or unintentionally manmade (by excavation, impoundment, or otherwise) could be disqualified from, or included in, reference-*standard* consideration, depending on the study objective. EPA has suggested that sites representing reference-standard conditions should possess a high degree of relative *naturalness* (Stoddard et al. 2006). Under that same principle, RIRAM rates the condition of an assessment unit relative to an unstressed, natural wetland of the same identified type. But by design, RIRAM may rank certain manmade features highly; this is common to abandoned historic stream impoundments, where the only remaining evident stresses are the impoundments, and otherwise the resulting wetlands are unstressed and un-degraded. But because manmade wetlands are not likely to possess the same physical and biological characteristics of a natural wetland that has developed over multiple centuries, they may not always be appropriate for representing reference standards. Disqualification of manmade sites may not apply to certain applications, particularly those utilizing the LDC reference concept. Manmade wetlands should generally be included in reference *gradients* to ensure that the sample represents the entire population of interest.

Finally, to best represent any wetland type or area of interest for statewide implementation, the largest possible sample, or a combined sample from a number of similar studies, should be applied to represent reference gradients and identify reference-standard sites. This will generally improve the sample's representation of the entire population of the type or area. The sample should be selected from RIRAM studies that utilize assessment units based on either HGM class or on vegetation type, but they should not be mixed, since the two methods may produce incompatible index score distributions (Kutcher 2011). If a conditional *gradient* is going to be employed, either an entire sample of interest should be used, or a sub-sample should be generated by selecting sites randomly along a sorted list of RIRAM Index scores (including reference-standard sites); reference *standard* sites should be selected as described above, from the entire sample.

In studies collecting new data, reference conditions can be established using a two-step process. Collection of new data may be necessary when the subject of interest requires selection of specific sites that have not previously been monitored. The process would involve (1) the coarse establishment of a preliminary gradient based on remote analysis of surrounding land use intensity, followed by (2) the establishment of a final reference gradient and reference-standard sites, based on independent rapid assessment data. To apply this two-step process, study sites can be initially

selected along a gradient of surrounding land use intensity based on percent cultural land cover, road density and intensity, percent impervious cover, a landscape model, or other metrics. RIRAM data can then be collected at the study sites prior to, or concurrent with, the biological or physical assessment data for which reference conditions are being established. RIRAM Index scores can then be applied as an independent measure to establish the final reference gradient and identify the final reference-standard sites (as described above). Reference parameters for the biological or physical assessment data can be identified using these final reference conditions.

Summary of Reference Site Identification Recommendations

In Summary, this report recommends the following protocols to identify reference sites for freshwater wetland condition in Rhode Island.

1. Collect extensive classification and spatial data for all assessment units. Due to the complexities of how we perceive the natural world, all useful wetland groupings of interest cannot conceivably be determined *a priori* or effectively represented by any single, existing classification scheme. By collecting comprehensive classification and spatial data for every assessment unit, various known and yet-determined groupings of interest can be queried from the data, as required by a given project. Accordingly, wetland monitoring data collected in RI should include, at minimum, the following classification information for each assessment unit:
    a. Cowardin (1979) *Class*, *Dominance Type*, and *Water Regime*, according to the RIRAM v.2 Field Form checklist
    b. Modified Brinson (1993) Hydrogeomorphic (HGM) class, according to the RIRAM v.2 Field Form checklist
    c. Enser and Lundgren (2006) natural community types, according to the RIRAM v.2 Field Form checklist
    d. Geospatial coordinates based on the approximate centroid of the assessment unit and recorded in longitude and latitude or Rhode Island state plane feet, NAD 83.
2. Use RIRAM v.2 data to establish reference gradients and identify reference-standard sites for freshwater wetlands. RIRAM was specifically designed to be a central component of a three-level monitoring program and was intended to be utilized in the inter-validation and development of landscape, bio-assessment, and other assessment data. Accordingly, RIRAM fully meets the requirements of an independent measure to identify reference conditions for wetlands, as recommended by EPA (2002a; Stoddard et al. 2006) and NatureServe (Faber-Langendoen et al. 2009). RIRAM has been shown to generate a meaningful numeric index of relative wetland condition based upon the evaluation of landscape and in-wetland stresses, and wetland integrity (Kutcher 2009, 2010a and b, and 2011). Thus, it can be applied to produce a reference gradient and identify reference-standard sites based on MDC or LDC (Stoddard et al. 2006), for a given sample of interest.
3. For any given effort, consistently delimit RIRAM assessment units by basin, habitat structure, or natural community type. Data collected from units delimited in these different ways may not always be compatible for certain comparisons. This occurs because wetlands delimited by habitat structure or natural community type may be buffered by surrounding wetland, thus score higher than the wetland basin that contains it.
4. Collect RIRAM data across all wetland types, ideally using a probabilistic sampling design. Groupings of interest may be determined by location, wetland type, or some combinations of the two. Collection of a probabilistic sample in a consistent manner (as in 3 above) allows

sub-samples to be queried as necessary to address various topics of interest (i.e. monitoring and assessment objectives).

5. Utilize a two-step process to identify reference conditions for new data. First, identify study sites along a gradient of surrounding land use intensity using remote measures of land use. Next, apply RIRAM to the study sites to establish a final reference gradient and identify reference-standard sites. Use the RIRAM-established reference conditions to identify reference parameters for the study metrics (e.g. biological thresholds or models).

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