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Watershed Approach to Wetland Mitigation: A Conceptual Framework for Juneau, Alaska

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EXECUTIVE SUMMARY

There continues to be a need for improved standards for wetland compensatory mitigation, to ensure that wetland acres, conditions and functions are not lost through unavoidable impacts to existing wetlands and other aquatic resources. Federal regulations are improving compensatory mitigation planning by emphasizing a watershed based approach. Efforts are being made to demonstrate how such a watershed approach to compensatory mitigation might work. The City and Borough of Juneau, Alaska wanted to upgrade their mitigation plan, and through funding from the U.S. Environmental Protection Agency (EPA), we developed a proposed conceptual three (3) part watershed-based framework for Juneau, Alaska, relying on several key methods.

We first explain three key methods that are used in the framework– wetland classification, the watershed profile, and the wetland Ecological Integrity Assessment (EIA) method (which can be expanded to include functional assessments). We then develop the three (3) part framework as follows:

Part I. Watershed Information and Watershed Priority Criteria. The framework depends on compiling existing watershed information on wetlands and other aquatic resources within the watershed where impacts and mitigation plans are proposed (in this case, the Lynn Canal, a 5th level 8 digit U.S. Geological Survey (USGS) Hydrologic Unit Code (HUC), hereafter referred to as the "Juneau Watershed".) For almost all states, the basic information is readily available using (a) wetland inventory maps, including information on basic wetland types (using the Cowardin et al. and U.S. National Vegetation Classifications (NVC) in combination with the Hydrogeomorphic Classification (HGM)), (b) wetland condition or ecological integrity assessments (using a nationally available Landscape Condition Model (LCM)) followed by on-site evaluations and wetland functions, using the National Wetland Inventory (NWI+) approach, and other available sources of information. We then assemble information to establish three sets of ratings: we create a watershed profile, based on wetland type abundance and conditions, we assess the wetland types by their complexity and difficulty of restoration, and we provide the tools to assess the ecological integrity (condition) of each wetland site. Steps of Part 1 are:

1. Watershed Profile Rating: create a watershed wetland profile showing abundance and condition based on Landscape Condition Model.
2. Wetland Type Rating: identify the wetland type, which establishes its complexity and conservation status (rarity)
3. Ecological Integrity Rating: conduct an EIA and rate the ecological integrity of the wetland/water resource
4. Watershed Priority: Combine the three ratings above to determine the priority of the wetland within the watershed.

Part 2. Impact Site Assessment. Having gathered the watershed information; the mitigation framework first addresses the impacted site in three steps:

1. Wetland Type Rating: identify the wetland type, which establishes its complexity and conservation status (rarity)
2. Ecological Integrity Rating: conduct an EIA and rate the ecological integrity and proposed functions of the impact area
3. Watershed Priority: Combine these two ratings with the watershed Profile rating from Part 1 to determine the priority of the impacted site.

Part 3. Mitigation Site Assessment. The mitigation site is assessed using the same watershed information but we must compare the proposed mitigation to the impacted site and determine the most appropriate mitigation action taking into consideration the following criteria:

Criteria 1. Watershed Priority Rating of the mitigated site (based on watershed profile, wetland type and the current EIA score)
Criteria 2. Compare Impact site and Mitigation site Watershed Priorities
Criteria 3. Assess factors to determine In-kind vs. Out-of-Kind
Criteria 4. Assess factors to determine Type of Mitigation

The mitigation framework we propose requires some basic information on the watershed, prior to addressing characteristics of both the impacted and the mitigated sites. We have attempted to insure that the information required is readily accessible for most, if not all, parts of the country. The watershed profile we develop is a first approximation of the kinds of information needed on wetland types and values within a watershed. It provides the basic level of information that can guide a watershed based mitigation framework.

In addition we propose new compensatory ratios based on watershed priority to discourage impact on the highly valued wetlands and to encourage compensatory mitigation (through preservation, enhancement, establishment/creation, and restoration) of high priority wetlands.

With this framework, a next step can be to develop a watershed plan where the goal is to gather additional information and make informed decisions, and create catalogs of potential restoration and conservation areas to support decisions regarding compensatory mitigation of wetlands and aquatic resources.

INTRODUCTION

Wetlands and aquatic resources comprise a diverse set of habitats, from forested wetlands/bogs and fens to riverine wetlands and salt marshes. Reductions in the cumulative historical wetland acreage and functions has led to a national goal of "no net loss." Under the Clean Water Act Section 404, for development activities that could adversely impact jurisdictional wetlands and other aquatic resources, a first step is to avoid adverse wetland impacts, to minimize unavoidable adverse impacts, and then to provide compensatory mitigation. Under the federal regulations for Compensatory Mitigation for Losses of Aquatic Resources (COE and EPA 2008) compensatory mitigation can be carried out through restoration, enhancement, establishment/creation, or preservation of wetlands and other aquatic resources using a watershed approach. There are three mechanisms for providing compensatory mitigation: permittee-responsible compensatory mitigation, mitigation banks and in-lieu fee mitigation. But compensatory mitigation planning in a watershed context has its challenges. In this report we develop a framework to address some of those challenges in the context of the Juneau watershed in Southeast Alaska.

To ensure "no net loss" of wetlands, a systematic inventory of wetlands is needed. But the quality of information on wetlands across the 50 states is variable. And, in the large state of Alaska, wetland inventories are a considerable challenge. Wetlands cover approximately 170 million acres of Alaska (about 43 percent), which is more than the existing acreage of wetlands in the rest of the United States (ELI 2007). In Southeast Alaska, which receives the greatest annual precipitation in the state (Figure 1), wetlands are a large component of the landscape, approximately >29% of the land area, according to the National Wetland Inventory (NWI) database (CBJ 2005). This value is likely to be higher, as some wetland habitats are excluded from NWI such as herbaceous intertidal and sub-tidal zones of estuaries and near-shore coastal waters and wetlands that fall below detection at the 1:60,000 scale (ADNR 2005).

Previously, the City and Borough of Juneau addressed the needs of wetland mitigation by completing a wetland inventory map and a Juneau Wetlands Management Plan (CBJ 2008). The plan also ranks each parcel of wetland from highest value wetlands least suitable for development to the lower value wetlands that are more suitable for development. Similarly, the Anchorage Wetland Management Plan (MOA 1996) provides wetland designations from highest and moderate to high value wetlands requiring Corps Individual permit, to lowest value wetlands which can be covered by City General Permits. Both of these municipal valuations of wetlands within their jurisdiction are based on the number and type of wetland functions and values as well as public input as to the perceived value of a wetland for open space, recreation or wildlife viewing.

However, while individual wetland valuation is important and useful, there is a need for a larger, watershed-scale perspective of wetlands and their priority. For example, in Southeast Alaska, buildable land is for the most part limited to relatively flat areas of land adjacent to the coast and thus impacts to wetland and water resources are higher on coastal wetlands relative to other types of wetlands found within this watershed. For these reasons, information on wetlands and potential impacts to them are best addressed in a watershed context. The 2008 Federal Rule on wetland and water resources compensatory mitigation (COE and EPA 2008) states a watershed approach is necessary for more effective wetland compensation, and that site-by-site mitigation has had a cumulatively unhelpful, to even detrimental, effect in maintaining wetland functions and values for the watershed.

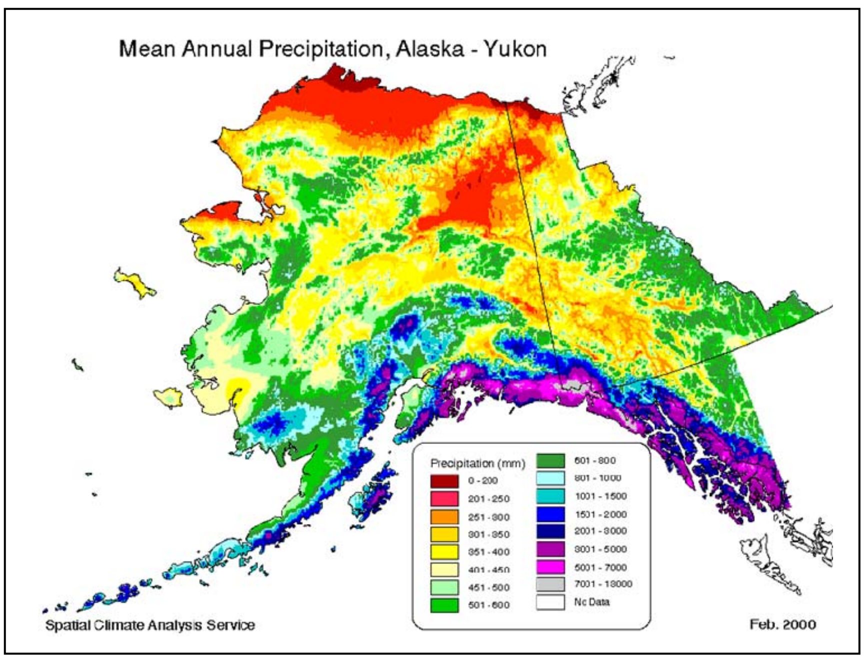

Figure 1. Mean annual precipitation for Alaska and the Yukon as of Feb. 2000. http://coolweather.net/staterainfall/alaska.htm Data source: National Climatic Data Center, Asheville, NC

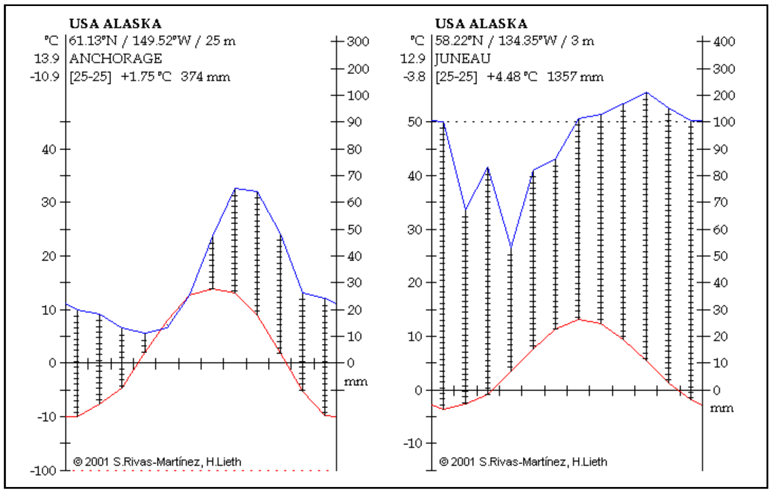

Figure 2. Comparison of total precipitation between Anchorage on the left and Juneau on the right. Blue line and right axis are precipitation in mm (Rivas-Martinez 2001), the red line and left axis are mean monthly temperatures in degrees Celsius.

Here, we develop a Wetland Mitigation Framework to complement existing management plans mentioned above, the Juneau Comprehensive plan (CBJ 2008). This framework is more inclusive than those plans, as it includes all types of wetlands, estuarine or freshwater, riparian and floodplain areas both in and outside municipal boundaries. The framework can help place the multiple municipal plans into a watershed context.

In the framework presented here, wetlands are valued by their complexity and structure (vegetation, hydrology and soil) and their overall watershed abundance. The area for this pilot framework is Lynn Canal, a 5th level 8 digit USGS HUC 19010301 (**Figure 3**.). Throughout this document we refer to this area as the “Juneau watershed.”

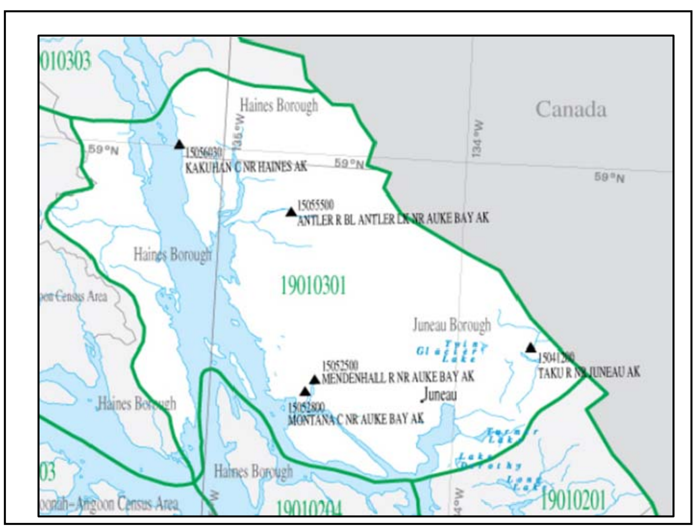

Figure 3. The Juneau Watershed, USGS HUC 19010301.

1 METHODS FOR THE WATERSHED-BASED MITIGATION FRAMEWORK

EPA engaged NatureServe to look into the application of our 35+ years of conservation resource inventory, mapping and data standards to wetland compensatory mitigation. As a conservation organization, we focus primarily on inventory and status of elements of biodiversity (species and ecosystems), but also support applications that address conservation planning and management of those elements. NatureServe and the network of Natural Heritage Programs and Conservation Data Centers throughout the western hemisphere have established standards and protocols for ranking the rarity of elements, and assessing their condition. This translates into standardized data that shows what a wetland should look like when it has good ecological condition (or ecological integrity), and a process by which we compare and prioritize elements of biodiversity for conservation planning. We applied these same methods to develop a profile or inventory of wetlands and their condition for the Juneau watershed. Specifically, we:

1) characterize wetland types using a variety of wetland classifications;

2) provide a watershed wetland profile that summarizes abundance and condition of wetlands by type, based on a remote-sensing driven landscape condition model,

3) summarize field tests of wetland condition using the Ecological Integrity Assessments (EIA) method from individual wetlands located within the Juneau pilot watershed.

We then present a framework for how this information can be used in a watershed approach to inform compensatory mitigation for wetlands and aquatic resources.

1.1 *Wetland Classification*

One main tool we use in the framework is that of wetland classification, including the U.S. National Vegetation Classification (NVC) (FDGC 2008) and the Ecological Systems Classification for the United States (Comer et al. 2003). NatureServe's EIA methods have been developed for broad wetland types (equivalent to the NVC formation level), such as "Salt Marsh," "Floodplain & Swamp Forest," etc[1]. We also combine the use of the NVC with the National Wetland Inventory (NWI) classification (Cowardin et al. 1979). These wetland classifications are helpful for a variety of reasons, including guiding the selection of wetland indicators of condition, the approaches to restoration, and the assessment of conservation status (degree of rarity or at-risk).

The success of developing indicators of wetland ecological integrity depends on understanding the structure, composition, and processes that govern the wide variety of ecosystem types (we use the term "ecosystem" in a generic sense to refer to both ecological communities and systems). Ecological classifications can be helpful tools in categorizing this variety. They help ecologists to better cope with natural variability within and among types so that differences between occurrences with good integrity and poor integrity can be more clearly recognized.

If we know the type of wetland, we also know something of its complexity; that is, its natural range of variability in structure, composition, and processes. This information can be used to determine the

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[1] Other programs, including the Colorado and Washington Natural Heritage Programs, (e.g. Decker 2005, Rocchio 2006, and Rocchio 2010) have developed EIA methods at the scale of ecological systems (roughly comparable to the NVC Group level). Some Heritage programs around the US have developed EIA specifications for individual or groups of plant associations (or natural communities), the lowest unit within the NVC.

relative difficulty of restoration. It can also establish "ecological equivalency;" that is, it can provide guidance on how an impacted salt marsh can be restored to a comparable salt marsh.

We may also be able to determine the global, national and state endangered (or at-risk) status, because some wetlands types are rarer, declining more rapidly or more greatly threatened than others. NatureServe and the Network of Natural Heritage Programs currently maintain a comprehensive set of status ranks for all wetland types, at the association scale, and are working to provide them at ecological system and higher scales (Master et al. 2009, Faber-Langendoen et al. 2009). Global ranks (G1 - G5) are available on NatureServe Explorer (http://www.natureserve.org/explorer/). State level ranks (S1 – S5) are available for Alaskan wetland types (http://aknhp.uaa.alaska.edu).

1.2 *Landscape Condition Model and Watershed Profile – remote sensing assessment*

We assembled map data layers (Juneau Watershed Boundary = HUC 19010301 "Lynn Canal"), Alaska National Wetlands Inventory (NWI) map, National Land Cover Database (NLCD 2001), Landfire Existing Vegetation Type (EVT) Map (based on NatureServe Ecological Systems (Landfire 2008), Urban Areas (ERSI 2010), Juneau parcel map , Roads (ERSI 2010), USGS hydro-lines of rivers, ponds and lakes, Alaska Natural Heritage Program locations of G1 and G2 or S1 and S2 species and ecosystems, and conservation priority sites identified by The Nature Conservancy Alaska Program.

We develop a profile of wetlands and their condition for the entire watershed by overlaying the NWI wetland map (USFWS 2006) with a Landscape Condition Model (Comer and Hak 2009). The Landscape Condition Model provides a single integrated index of the stressors surrounding a wetland. It is a by-pixel calculation of the degree of impact based on the type and distance from human activities such as mines, roads, towns, industrial areas. High impact activities such as a divided highway with heavy traffic are weighted more heavily than lower impacted activity such as a single lane dirt road. A distance decay function extends the impact outward from the point of stress to adjacent areas, based on the relative strength of the stressor. For example, the distance decay function weight for agricultural hay fields is 0.9 (rapid decay) and the decay function weight for a divided highway with heavy traffic is 0.1 (slow, extensive decay (for details see Comer and Hak 2009). We ran the Landscape Condition Model across the entire watershed to show the range of conditions, from high levels of stressors (e.g., urban areas, roads, mines) to low levels of stressors (e.g., natural, unfragmented land cover, low impact land uses).

An intersection of NWI wetland layer with the Landscape Condition Layer provides an estimate of the condition of each wetland polygon (**Figure 4**). The Juneau watershed is a largely intact watershed, with impacts of human activity largely concentrated in the south central coastal region around the populated areas. The resulting Juneau watershed profile of wetlands indicates that tidal salt marshes (estuarine wetlands) and riverine wetlands (riparian areas and their stream channels) are the least abundant and most heavily impacted type of wetland and forested/scrub wetlands are the most abundant, showing the least impact (**Figure 5**).

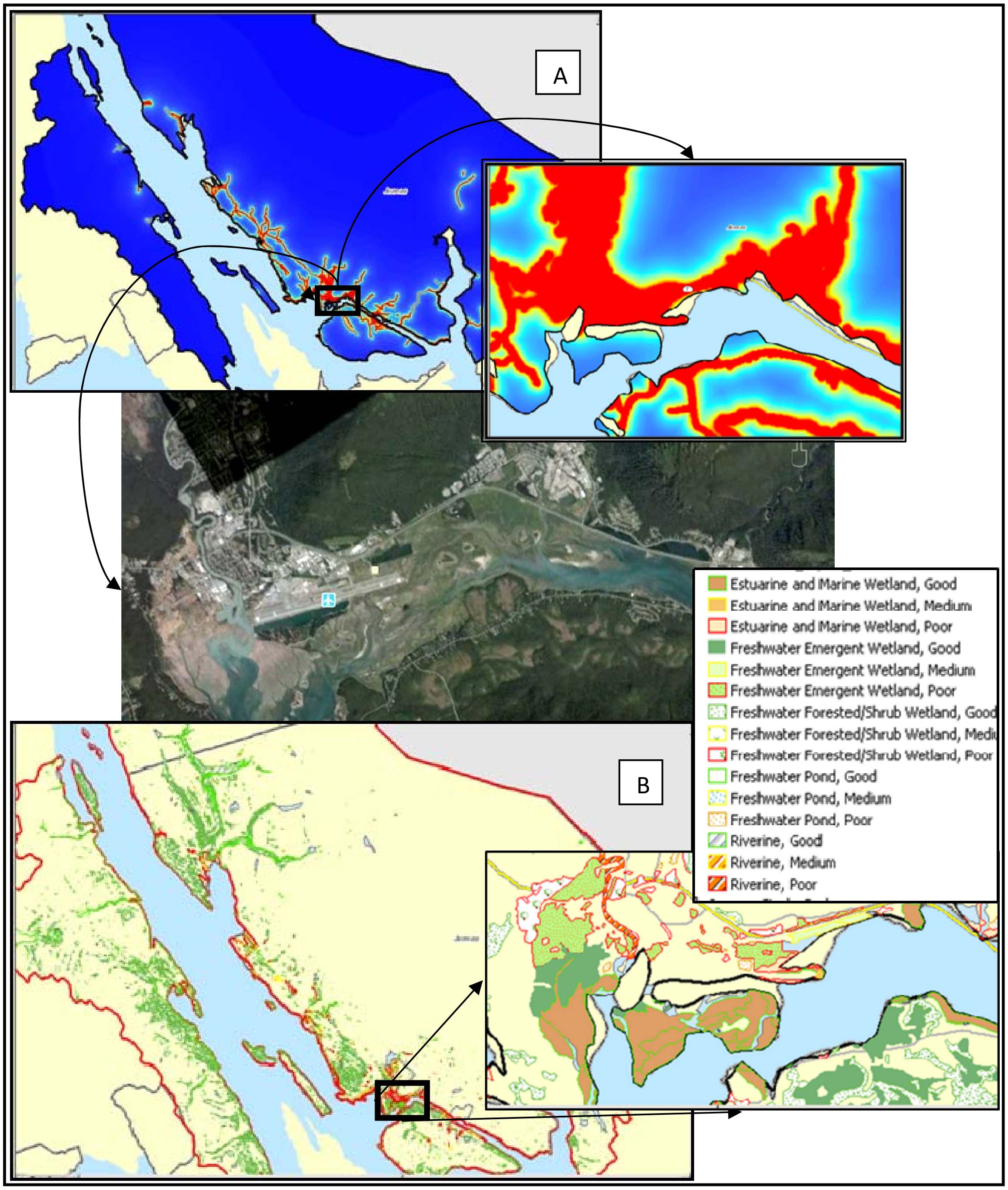

Figure 4. Juneau, AK pilot study NWI wetlands and Landscape Condition Model. **A**. Landscape Condition Model. Red = highest impact, blue= lowest or no impact from human activities. Inset: Zoom-in near the Juneau Airport and north Douglas Island areas, and a satellite Image of the same area. **B**. NWI wetland polygons clipped to Juneau watershed. Inset: Zoom-in of NWI wetlands overlain by the Condition Model (see legend inset where each polygon is labeled by NWI name and Landscape Condition category) near the Juneau Airport and north Douglas Island areas.

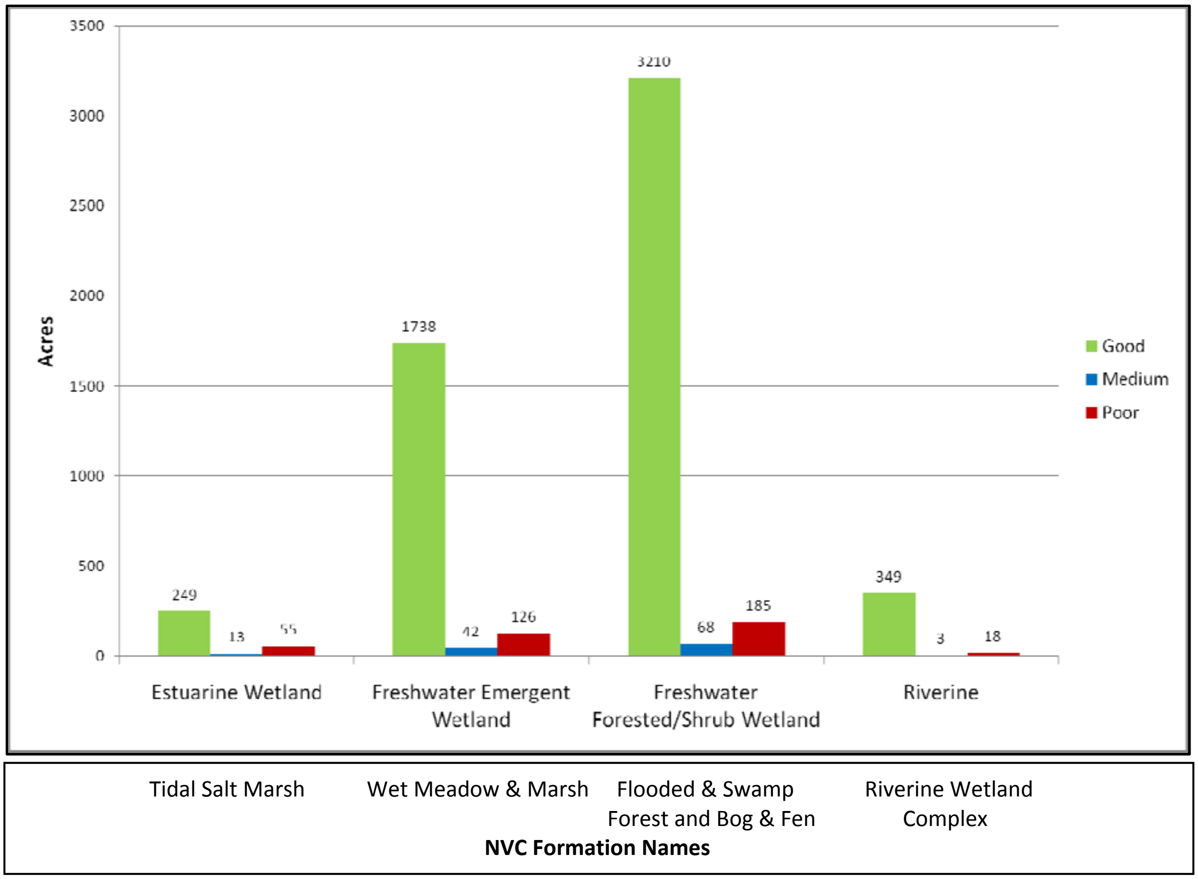

Figure 5. Juneau Watershed Wetland Profile: Abundance of NWI Type and Status. NWI Mapped wetlands were overlain against the Landscape Condition Model, indicating the amount of surrounding human impacts, categorized into three levels of condition: good (low impacts), medium (medium impacts) and poor (high impacts). We cross walked NWI names to NVC Formations as follows: Tidal Salt Marsh (Estuarine), Wet Meadow & Marsh (Freshwater Emergent), Flooded & Swamp Forest and Bog & Fen (Freshwater Forested/Scrub), and Riverine Wetland Complex (Riverine). Forested/Shrub wetlands include both forested wetlands and scrub bogs and fens. NWI does not distinguish peatlands from other wetlands. We rely in field verification data to identify peatlands in SE AK.

1.3 *Ecological Integrity Assessment Method – field assessment*

A critical part of a watershed based mitigation framework is the evaluation of wetland condition on individual wetland polygons. The Landscape Condition Model presented above provides both an overall characterization of the condition of the watershed and a preliminary assessment of the condition of individual wetland polygons based on remote sensing, but a more systematic and field-based method is needed to characterize condition. For that, we applied the Ecological Integrity Assessment (EIA) method.

We assessed on-site wetland condition using the Ecological Integrity Assessment (EIA) method (Faber-Langendoen et al. 2008a,2008b). The EIA method provides standardized indicators and metrics for any type of wetland (Faber-Langendoen 2010, NatureServe 2010). Field tests of the EIA method on wetlands has been conducted in six of the lower 48 states (MI, IN, CO, WY, MT, NM, e.g., Faber-Langendoen et al. 2011, Muldavin et al. 2011). We welcomed the opportunity to see if this same method can be applied to Southeast Alaska wetlands. See Appendix I for an overview of the EIA method.

As explained above, we first developed a profile of wetlands and their condition for the entire watershed by overlaying NWI maps (USFWS 2006) with a Landscape Condition Model. The resulting profile made it possible to choose wetlands that had a variety of impact levels. We used the results of the landscape condition model to determine where a variety of wetland types with good to poor levels of landscape condition could be found within the Juneau watershed. We selected a range of sites on which to test the EIA method. We collected data on a number of primary ecological factors at each wetland: (1) Landscape Context (buffer and landscape), (2) Condition (vegetation, hydrology, and soils), and (3) Size. Each factor has metrics that can be collected at three levels of intensity: Level-1 is remote sensing in-office GIS based assessment, Level-2 is a rapid field visit, and Level-3 encompasses detailed field data collection. Here we focus on the Level 2 and level 3 assessment methods, and rely on the Landscape Condition Model (see above) for our Level 1 assessment.

1.3.1 EIA Field Level-2 Metrics

Field crews keyed the predominant vegetation of the assessment area for each wetland to an Alaska state plant association and a NatureServe Ecological System, which is linked to the NVC Formation level information (see **Table 1**). EIA Level-2 metrics collects data to both characterize the wetland and assess ecological factors with a relatively rapid field visit. Data collected include condition assessment of vegetation, soil, and hydrology. The EIA method accommodates different wetland types, by varying some metrics, as needed by wetland type. For example, vegetation structure will have different ratings by wetland type, with woody wetlands having metrics for tree density and size, whereas herbaceous wetlands evaluate the structure of the dominant herb layer. Another example is for hydrology, where the EIA method provides separate ratings for tidal vs non-tidal hydrologic metrics. Crews also fill out a stressors checklist that details impact use extent and intensity within and surrounding the wetland. Example EIA Level-2 and Level-3 field forms are available in Appendix II.

Specific metrics include:

1. LANDSCAPE CONTEXT

Primarily measured using remote sensing imagery, but field checked where possible (difficult with large wetlands) —

- ✓ Landscape-
    - Landscape Connectivity
    - Land Use Index

- ✓ Buffer-

- Percent of Assessment Area with Buffer
  - Buffer Width
  - Buffer Condition

2. SIZE

- ✓ Absolute Size
- ✓ Relative Size

3. CONDITION

- ✓ Vegetation-
  - Vegetation Structure (metrics vary by woody vs herbaceous types)
  - Organic matter accumulation
  - Cover of native plant increasers
  - Relative Cover of Native Plant Species
  - Cover of Exotic Invasive Plant Species
  - Vegetation Regeneration
  - Vegetation Composition
- ✓ Hydrology –
  - Tidal vs. Non-Tidal (different metrics are provided for the assessment of tidal hydrology)
  - Water Source
  - Hydroperiod
  - Hydrologic Connectivity
- ✓ Soil/ Substrate Condition
  - Soil Disturbance
  - Water quality effects of soil disturbance
  - Patch Type Diversity (Surface Features)

4. STRESSORS

- ✓ Stressors Checklist-- presence, intensity and scope of
  - Development Activities --agriculture, buildings, roads, utility lines
  - Recreation Activities-- passive and active such as off-road vehicle use
  - Vegetation Management Activities -- presence and abundance of non-native species, management activities such as mowing or cutting, pesticide use, etc.

1.3.2. Level-3 Metrics

In addition to Level-2, we conducted Level-3 metrics assessments, which involve a detailed vegetation plot (**Figure 6**) species composition data collection and soils pit analysis and observations. Metrics include:

- ✓ Vegetation Species composition (% cover each species)
- ✓ Stem count
- ✓ Standing snags
- ✓ Fallen Log count
- ✓ Soil Pits (soil texture, color, presence of wetland indicators)

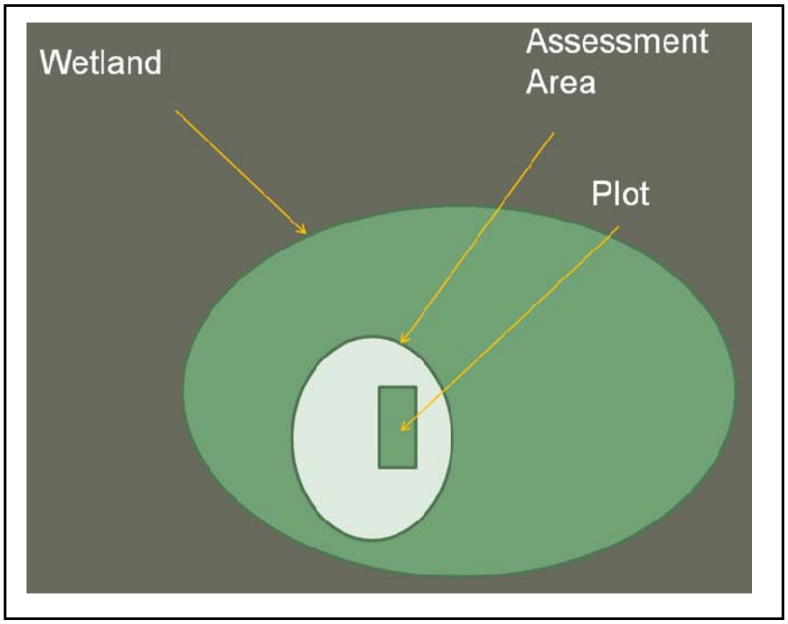

Figure 6. When wetlands are large (> 5 acres), the field assessment area is a portion of the wetland. Detailed Level-3 plot data is collected from a representative location within the assessment area.

Level-3 metrics are important when the identification of the wetland type need verification or when there is a need to quantify the amount of species abundance (for invasive species for example) or when documentation of the presence of endangered or threatened species is required.

1.3.3. EIA Database and Scorecard

A standardized database is also available for data entry and automatic scoring. The data base forms are in the same format as the field forms, making data entry relatively straightforward. The database summarizes the individual metric scores and calculates the final overall site EIA score. These are reported as a scorecard or rating (A – D) for each wetland (**Figure 7**). The EIA score uses a continuous numerical scale from 1 to 5, which is translated into report-card style ratings, from "A"(High or Excellent, >4.4), to "B" (High or Good, 3.1 – 4.4), "C" (Medium or Fair, 1.9 – 3.0) and finally, those with significant degradation would be ranked "D" (Low or Poor, <1.9). Detailed definitions for each level are provided in Appendix I. All data collected at the 12 sites was entered into the EIA database. Scorecards are built into the database, which automatically sums and averages the assessment scores for the three main factors of Landscape Context, Size and Condition. Each factor is rated for its condition and status relative to what is expected for the wetland type in minimally disturbed condition, also called "reference standard condition." The EIA score can accommodate different intensity levels and will calculate a score based on just Level-1 metrics, Level-1 and Level-2 metrics, or it will calculate the score based on all three levels.

1.3.4. EIA Results

Site: DOUGLAS ISLAND - PEAT BOG **Wetland Type (MG):**

RANK FACTOR	MAJOR ECOLOGICAL ATTRIBUTE/ Metric	AssignedRating	Score (Points)	Weight	Weighted Score	Calculated Rank/ Rating	Manual Rank
EIA RANK			4.5			A	
LANDSCAPE			3.8	0.25	0.9	B	
	LANDSCAPE CONTEXT		3.8	1.00	3.8	B	
1a	Landscape Connectivity			1.00			
	Core Landscape (L1)			1.00			
	Supporting Landscape (L1)			0.50			
1b	Land Use			1.00			
	Core Landscape (L1)			1.00			
	Supporting Landscape (L1)			0.50			
1c	Buffer Index		3.8	1.00	3.8	B	
	% Contiguous Buffer (L1)			1.00			
	Buffer Length (L1)			1.00			
	Buffer Condition (L2)	B	3.75	1.00	3.8		
	Summed Weights and Scores			1.0	3.8		
SIZE			4.2	0.15	0.6	B	
	SIZE		4.2	1.00	4.2	B	
5a	Absolute Size	B	3.75	1.00	3.8		
5b	Relative Size	A	5.00	0.50	2.5		
	Summed Weights and Scores			1.5	6.3		
CONDITION			5.0	0.60	3.0	A	
	VEGETATION		5.0	1.00	5.0	A	
2a	Vegetation Structure	A	5.00	1.00	5.0		
2b	Organic Matter Accumulation	A	5.00	0.50	2.5		
2c	Increaser Cover	A	5.00	1.00	5.0		
2d	Native Cover	A	5.00	1.00	5.0		
2e	Invasives Cover	A	5.00	1.00	5.0		
2f	Vegetation Regeneration	A	5.00	1.00	5.0		
2g	Vegetation Composition	A	5.00	1.00	5.0		
	Summed Weights and Scores			6.5	32.5		
	HYDROLOGY		5.0	1.00	5.0	A	
3a	Water Source	A	5.00	1.00	5.0		
3b	Hydroperiod	A	5.00	1.00	5.0		
3c	Hydrologic Connectivity	A	5.00	1.00	5.0		
	Summed Weights and Scores			3.0	15.0		
	SOILS		4.9	0.50	2.4	A	
4a	Soil Surface Condition (Disturbance)	A	5.00	1.00	5.0		
4b	Water Quality	A	5.00	1.00	5.0		
4c	Physical Patch Types (Patch Diversity)	AB	4.38	0.50	2.2		
	Summed Weights and Scores			2.5	12.2		

Figure 7. Example score card from the EIA database that summarizes all of the metrics into a single site score. In this example Condition score is 5.0 (A), Size score 4.2 (B), Landscape context score 3.8 (B). The overall EIA score is 4.5 (A).

The field crews worked with local City and Borough of Juneau Planners, the information generated by the NWI x Landscape condition assessment and their own experience to locate a selection of wetland sites that covered a variety of wetland types (salt marsh, riparian forests, peatland bogs) and varying degrees of impact. We wanted to see if the EIA method was sensitive to the differences in wetland type as well as pick up the increased stressors with increased levels of impact. NatureServe provided the in-office GIS layers to assess the landscape context metrics for each of the 12 wetlands visited. The landscape context metrics use an over-lay of land use type and percent continuous natural landscape surrounding the wetland in three concentric areas surrounding the wetland: 1000 ha supporting area, a 100 ha core area, and within a 100 m buffer area (**Figure 8**). In addition, the wetland absolute size can be determined from the imagery, and the percent of continuous buffer around the wetland perimeter (**Figure 9.**).

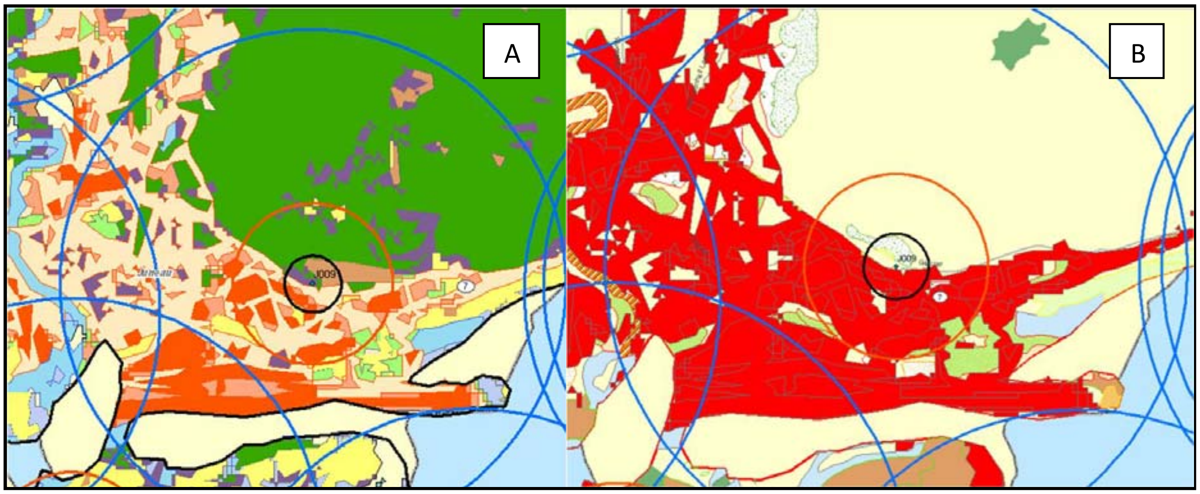

Figure 8. Level-1 EIA method using NLCD Land use categories. **A**) Land Use (red =high density urban, pink = medium density urban, pale green= open space, dark green = natural vegetation) and **B**) natural (open space and natural vegetative cover) vs non-natural (all urban, etc) cover in 1000 ha (blue circle), 100 h (red circle) and 100 m (black circle) surrounding a wetland in Juneau AK.

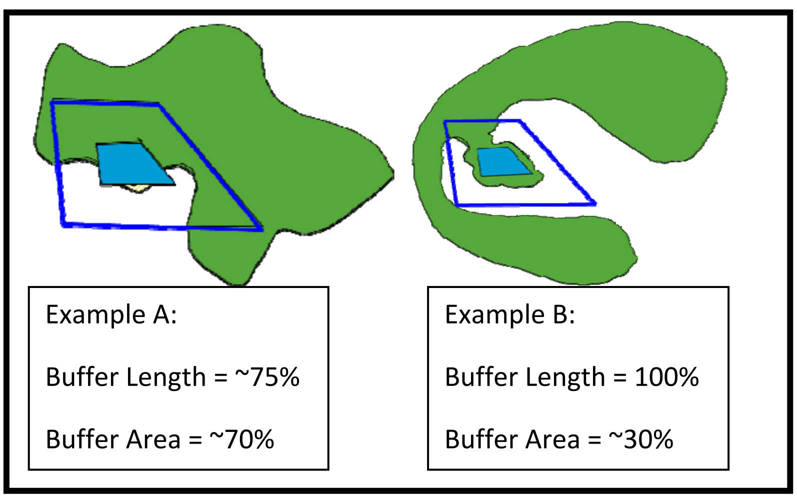

Figure 9. Two metrics measured for buffer of a wetland: 1) the length (in percent) of a continuous line at least 5 m wide and 2) the percent natural cover within the 100 m buffer area. Example A has a discontinuous buffer, with 70% natural cover within the buffer area. Example B has a continuous buffer with only 30% natural land cover within the 100 m buffer area. Blue is the wetland, green is natural vegetation cover, and white is urban or other human footprint land cover type.

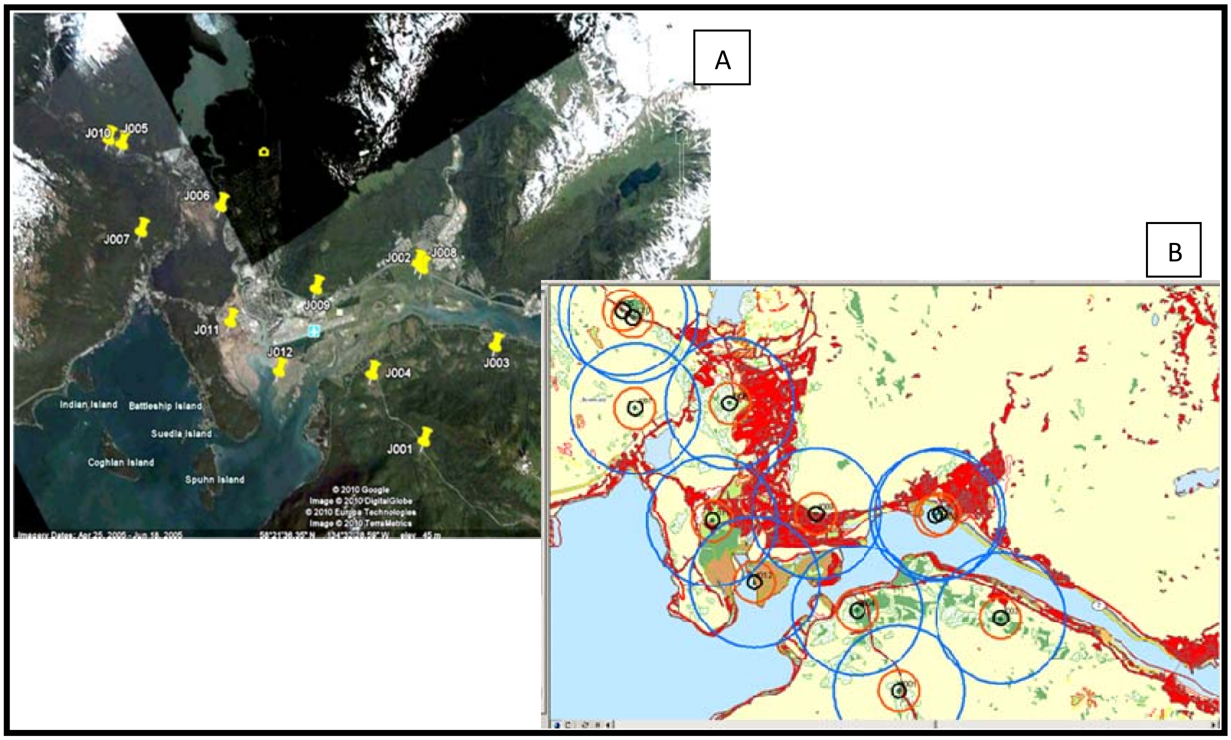

Figure 10. Location of the 12 assessment sites in the Juneau watershed. A. Satellite image, the pale blue square is located on the Juneau airport runway; B. NWI map with NLCD Land use categories (as shown in Figure 8b) with the three buffer areas (1000 ha supporting landscape area, 100 ha core landscape area, and 100 m buffer area) around each assessment wetland.

AKNHP field crews then collected information on all the on-site condition metrics using the standard EIA field forms (Appendix II).

AKNHP field crews successfully applied NatureServe's EIA method and field forms to the major wetland types found in Southeast Alaska. Having the database design correspond directly to the field forms made for relatively straightforward data entry. The combination of metrics under landscape context, size and condition factors provided a good assessment of the condition of the wetlands. The EIA score supported the original Level-1 landscape condition model scores (Table 1).The EIA method can be applied to any type of wetland including estuarine salt marshes or wooded bogs, and can be applied at any level of identification, at the broad NWI type (Forested scrub, Freshwater Marsh, Salt Marsh) or NVC Formation (Bog and Fen, Salt Marsh, Flooded & Swamp Forest) or with finer levels of identification such as NatureServe Ecological System or even the Plant Association. The method also picked up on the nuances of having excellent on-site condition but having impacts in the surrounding landscape and vice versa, thus integrating influences from the surrounding parts of the watershed. In this way, the EIA method could support evaluating sites for compensatory mitigation using a watersed approach, which is consistent with the 2008 final rule on Compensatory Mitigation for Losses of Aquatic Resources (COE and EPA 2008).

Table 1. Juneau Wetland Ecological Integrity Assessment Results. This table compares the GIS Landscape Condition Model (LCM) (Good, Medium, Poor) with the Ecological Integrity Assessment (Level-1-GIS metrics, and field-based Level-2 and 3 metrics) final summed scores. A finer scale of identification was possible in the field (NVC Formation and Ecological System) that informs more details about wetland type and function than the NWI categories. J002 and J008 polygons of a tidal estuary were not identified on the NWI map.

Map Level Identification				**Site Level Identification**			**EIA**	
ID	**Site Name**	**LCM**	**NWI Name**	**NVC Formation**	**NatureServe Ecological System**	**HGM**	**Score**	**Rank**
J001	Douglas Island	Good	Freshwater Emergent Marsh	Temperate & Boreal Bog & Fen	Alaskan Pacific Maritime Shore Pine Bog and Poor Fen	Organic Soil Flats	4.8	A
J003	Douglas Island	Good	Forested Scrub	Salt Marsh	Alaskan Pacific Maritime Poorly Drained Conifer Woodland	Slope	4.8	A
J004	N. Douglas Island	Good	Freshwater Emergent Marsh	Temperate Flooded & Swamp Forest	Alaskan Pacific Maritime Shore Pine Bog and Poor Fen	Organic Soil Flats	4.6	A
J006	Mendenhall Valley	Good	Forested Scrub	Temperate & Boreal Freshwater Wet Meadow & Marsh	Alaskan Pacific Maritime Shrub and Herbaceous Floodplain Wetland	Organic Soil Flats	4.8	A
J007	UAS Student Housing	Good	Forested Scrub	Temperate & Boreal Bog & Fen	Alaskan Pacific Maritime Shore Pine Bog and Poor Fen	Organic Soil Flats	4.6	A
J009	Glacier Highway	Good	Forested Scrub	Temperate & Boreal Bog & Fen	Alaskan Pacific Maritime Poorly Drained Conifer Woodland	Mineral Soil Flat	3.3	B
J012	Airport Dike	Good	Estuarine Marsh	Salt Marsh	Temperate Pacific Tidal Salt and Brackish Marsh	Estuarine Fringe	4.8	A
J005	Upper Montana Creek	Medium	Freshwater Emergent Marsh	Temperate & Boreal Bog & Fen	Alaskan Pacific Maritime Fen and Wet Meadow	Organic Soil Flats, slope	4.4	A
J002	Mendenhall State Game Refuge	n/a	n/a	Salt Marsh	Temperate Pacific Tidal Salt and Brackish Marsh	Estuarine Fringe	3.9	B
J008	Mendenhall State Game Refuge	n/a	n/a	Temperate & Boreal Bog & Fen	Temperate Pacific Tidal Salt and Brackish Marsh	Estuarine Fringe	4.2	B
J010	Upper Montana Creek	Poor	Freshwater Emergent Marsh	Temperate Flooded & Swamp Forest	Alaskan Pacific Maritime Shore Pine Bog and Poor Fen	Organic Soil Flats	3	C
J011	Sherwood Lane	Poor	Freshwater Emergent Marsh	Temperate & Boreal Freshwater Wet Meadow & Marsh	Alaskan Pacific Maritime Coastal Meadow and Slough-Levee	Mineral Soil Flat	3.2	B

With these methods and tools in hand, we are ready to introduce the mitigation framework.

2 FRAMEWORK FOR WETLAND MITIGATION IN SOUTHEAST ALASKA

We propose a three (3)-part framework for wetland mitigation: Part 1- Basic Watershed Information, Part 2- Impact Site Assessment and Part 3- Mitigation Site Assessment. We demonstrate its use in the Juneau Watershed of Southeast Alaska.

2.1 *Framework Overview*

Part 1. Watershed Information

The basic watershed information starts with the defined watershed area and information on the wetlands and landscapes in the watershed. It provides information for the watershed profile, wetland types, and the ecological integrity of wetlands across the watershed. This profile establishes the watershed priority of any given impacted wetland relative to that of any proposed mitigation site. Each step is explained in further detail in proceeding sections.

Step 1—Watershed Profile Rating: from the watershed wetland profile
Step 2—Wetland Type Rating: based on the type of wetland, which establishes its complexity ranking (explained below) and conservation status (rarity).
Step 3—Ecological Integrity Assessment: The ecological integrity assessment functions of the proposed impact area,
Step 4—Watershed Priority **–** the priority of any given wetland site within a watershed, based on the combination of watershed context rating, wetland type rating, andx EIA rating.

Part 2. Impact Site Assessment

On-site evaluation is used to confirm the (potential) impacted wetland type (and thereby also its complexity) and its current EIA score. Together, these establish the watershed priority rating of the potential impact site. The wetland integrity or condition can be assessed using ecological integrity methods as the primary condition tool, supplemented by functional assessments (such as Wetland Functional HGM Assessments or NWI+) and classification of wetland types (NWI and NVC). The combination of wetland type and integrity ratings will capture the majority of ecological functions and values of the impacted wetland, and this information will lead to more effective and more appropriate mitigation.

Part 3. Mitigation Site Assessment

The choice of an appropriate mitigation site is important for determining the success of the mitigation and the degree of compensation for the loss incurred at the impacted site. The mitigation site should help protect or restore the health and condition of aquatic resources within the watershed. Four criteria are needed to assess where the most appropriate and successful mitigation site may be:

Criteria 1-Watershed Priority: Establish the proposed mitigation site's watershed priority rating.
Criteria 2- Impact/Mitigation Priority Comparison: Understand the debt load relative to the potential credit.

Criteria 3- In/Out-of-Kind, On/Off-Site: A consideration of on-site parameters vs. available off site locations and watershed needs.
Criteria 4- Type of Mitigation: The location and wetland condition of the mitigation site should inform best course of action: Preservation, Enhancement, Restoration, or Establishment/Creation.

2.2 *Framework Part 1-WATERSHED INFORMATION*

Wetland Types.

The following wetland types were identified in the Juneau watershed:

NVC FORMATIONS – NVC formation level types (Cowardin crosswalk in parentheses) from NWI maps

- Wet Meadow & Marsh (Palustrine Emergent, Palustrine Scrub-Shrub)
- Tidal Salt Marsh (Estuarine Emergent, Estuarine Scrub-Shrub)
- Floodplain & Swamp Forest (Palustrine Forested)
- Bog & Fen (Palustrine Forested/Palustrine Scrub-Shrub)

HGM TYPES—some types are identified at the watershed scale, others are only identified from field visits:

- Riverine (from NWI Maps)
- Lacustrine (field)
- Depressional (field)
- Organic Flats (field)
- Tidal (field)
- Slope (field)

Any given wetland site can be attributed by these two major wetland classification types. E.g., NVC Forested Swamp – HGM Lacustrine.

Watershed Layers.

- The watershed is the Juneau Watershed, or HUC 19010301 “Lynn Canal” ,
- NWI National Wetlands Inventory (Alaska) (USFSW 2006)
- NLCD National Land Cover Database (NLCD 2001)
- Landfire Existing Vegetation Type (EVT) Map (based on NatureServe Ecological Systems (Landfire 2008)
- Urban Areas (ERSI 2010)
- Juneau parcel map , Roads (ERSI 2010)
- USGS hydro-lines of rivers, ponds and lakes
- Alaska Natural Heritage Program locations of G1, G2, S1 and S2 species and ecosystems
- Conservation priority sites identified by The Nature Conservancy Alaska Program.
- Landscape Condition Model (Comer and Hak 2009).

Step 1-Watershed Profile Rating

The watershed profile is based on an inventory of the abundance, condition, diversity and status of wetlands within a watershed and has been proposed and implemented in several studies (Bedford 1996, Van Lonkhuyzen et al. 2004, Johnson 2005, Johnston et al. 2009, Godwin et al. 2002). A watershed profile of wetlands allows us to see how impact or mitigation to a single wetland could affect both the immediate site and watershed-scale wetland functions (Stein et al. 2010). Historic maps are important in highly altered landscapes, as some wetland types that were once common may be entirely absent from today's landscape (Johnson 2005, Stein et al. 2010). Wetland profiles can provide answers to questions such as:

- What are the current wetland types in the watershed?
- What was their historic and current distribution and abundance? (Although a valid question in general, it depends on availability of historic information and degree of alteration over time. For SE Alaska, where impacts at the watershed scale are relatively low and land use history is relatively recent, this is less of a priority).
- What is the status of their current ecological condition relative to historic conditions? For relatively pristine watersheds like the Juneau area, we can assume the cumulative historic loss is not greater than the current human footprint.

Current abundance can be measured by compiling existing wetland maps, especially those of the National Wetland Inventory (NWI). NWI maps include a wetland type classification (Cowardin et al. 1979), and more recently include an NWI+ applications, which describes the hydrologic functions of the watershed and site scales (USFWS 2010), and should be supplemented by other nationally standardized classifications, particularly the U.S. National Vegetation Classification (NVC), a federal vegetation classification standard (FGDC 2008) and NatureServe's Ecological Systems (NatureServe 2010), which can be used to characterize ecosystems for any watershed in the United States. For the Juneau pilot study we used NWI – linked to the NVC formation level during field surveys (**Figure 4** and **Figure 5**).

Current condition can be measured using remote-sensing based Landscape Condition Model (Comer and Hak 2009) or using the Ecological Integrity Assessment (EIA) Method Level-1 metrics (Faber-Langendoen 2008a) (**Figure 4**, **Figure 8**, respectively).

A watershed profile should also include other layers of information, such as wetlands identified in the Juneau Wetlands Management Plan (CBJ 1997), biodiversity features including the location of threatened and endangered species, productive salmon fishery stream reaches, protected areas, and Development Features, such as future urban growth areas, recreational sites, educational sites. However, we did not include these layers as part of our pilot study.

We summarize the wetland's watershed priorities within the Juneau watershed based on the watershed profile (**Figure 5**). These are as follows (listed by NVC type (names simplified) and NWI equivalent):

Higher priority–

Tidal Salt Marsh (Estuarine Wetland) – Least abundant, most negatively impacted (17% are in poor condition),
Riverine Wetlands Complex (Riverine) – Also least abundant, less negatively impacted (5% in poor condition)

Medium priority –

Wet Meadow & Marsh (Freshwater Emergent Wetland)-- Slightly more abundant, moderately impacted (7% are in poor condition), even though more easily restored than Forested/Scrub-Shrub wetlands, they are ranked higher because there are so much fewer of them.

Lower priority –

Flooded & Swamp Forest- (Freshwater Forested/Scrub-Shrub Wetland) -Most abundant, least impacted (only 5% are in poor condition). However acreage is an over estimation of the lowest priority of wetlands as NWI does not distinguish peatlands from other woody wetlands.

Watershed Wetland Profile Rating (for Juneau, Alaska) — based on available map data abundance and Landscape Condition Model, relative abundance and status of wetlands throughout the watershed (Summed by NWI categories)

Tidal Salt Marsh— High (low abundance, high threat)

Riverine—High (low abundance, moderate threat)

Wet Meadow & Marsh – Medium (Low abundance, low threat)

Flooded & Swamp Forest –Low (very abundant, low threat)

Bog & Fen – n/a (NWI map does not distinguish)

The Juneau pilot study results indicate that tidal salt water marshes are the most threatened type of wetland (see also **Figure 5**, page 8).

Step 2-Wetland Type Complexity Rating

Each wetland can be given a quantitative complexity rating based on the type of wetland, as designated by NWI or NVC classifications. If we know the type of wetland, we know something of its complexity; that is, its natural range of variability in structure, composition, and processes. Based on reference condition information and restoration literature we can compare the effort required to restore such a wetland. Many factors affect our ability to restore wetlands and not all wetlands are equally restorable. Thus we can rank wetlands relative to each other based on their 'ease' of restoration, or said another way, based on their complexity. For example, emergent freshwater wetlands, such as bulrush or cattail marshes and wet meadows, are relatively less complex as they generally have one layer of herbaceous vegetation and therefore are more easily restored or created than forested/scrub wetlands. However our ability to re-create or restore even these wetland types rarely replaces the full complexity of natural undamaged wetland soils and biotic components (Campbell et al. 2002, Bruland and Richardson 2006, Hossler and Bouchard 2010, Hoeltje and Cole 2007, Hartzell et al. 2007). Peatlands (bogs and fens) are among the most difficult type of wetland to restore (Bruland and Richardson 2006, Schrautzer et al.

2007). They may take hundreds if not thousands of years to develop, and woody growth within bogs and fens is very slow.

Relative complexity ranks can represent the difficulties expressed in the wetland restoration and creation literature. Studies consistently show created and restored wetlands aged from 2 to 20 years old have lower or different hydrologic functions, less soil organic matter, lower biomass accumulation, lower vegetation structure and significant differences in biotic assemblages of plants, macro-invertebrates and vertebrates than natural wetlands across different types of HGM classes (Campbell et al. 2002, Bruland and Richardson 2006, Hossler and Bouchard 2010, Hoeltje and Cole 2007, Hartzell et al. 2007). Lewis (2011) summarizes several decades of restoration attempts of various types of wetlands worldwide and ranks them based on the likelihood of successful restoration, based primarily on the ease of replicated hydrology. **Figure 11** represents this hierarchy of the success rate declining top to bottom. Interestingly this order closely matches our wetland complexity rating.

Probability of Restoration Success

. . . High

- Estuarine Marshes
- Coastal Marshes
- Mangrove Forests
- Freshwater Marshes
- Freshwater Forests
- Groundwater Seepage Slope Wetlands
- Seagrass Meadows

. . . Low (from Lewis 2011)

Figure 11. General hierarchy of wetland based on probability of successful restoration or creation (from Lewis 2011).

Complexity rating based on wetland type proposed here are an attempt to illustrate the *relative* difference among wetland categories.

Wet Meadow & Marsh – herbaceous or low shrub, generally a single layer of vegetative complexity, least difficult to restore/create both in level of effort and time to reach expected maximum benefit.

Tidal Salt Marsh – herbaceous, generally a single layer of vegetative complexity, least difficult to restore/create, however these wetlands are constrained by location and tidal hydrologic requirements.

Floodplain & Swamp Forest—scrub or forested, generally complex with multiple vegetation layers, restoration /creation takes greater amounts of time and effort to reach full benefits.

Bog & Fen— Organic soils take hundreds to thousands of years to develop, and can be among the most difficult type of wetland to restore or create. Many can be restored through a return of hydrologic flow to sites or the placement of vegetation plugs in damaged areas. However to reach full complexity of vegetation structure and composition, peatlands generally take more time and resources for successful restoration than other types of wetlands.

Relative Wetland Complexity Rating--a way to quantify and compare different wetland types based on the vegetative, soil and hydrologic complexity. Based on broad NWI and NVC Formation categories:

Wet Meadow & Marsh – Low

Tidal Salt Marsh— Moderate

Flooded & Swamp Forest/Bog & Fen –High

Step 3- Ecological Integrity Rating

The wetland can be assessed and assigned an Ecological Integrity Assessment (EIA) score. A wetland with good to high ecological integrity is providing functions characteristic for the type of wetland. A wetland with a poor ecological integrity provides fewer functions or lesser amounts of those functions. EIA uses three major factors of **Landscape context** around the wetland, including the immediate buffer, the **Size** of the entire wetland polygon and **Condition,** including vegetation, hydrology and soil status. In addition there is a stressor check list for observed human activity within the wetlands such as recreation, utility lines, roads, etc, rated for scope (extent) and intensity (degree) of impact. EIA can be conducted at three levels in intensity, Level-1- remote GIS based, Level-2- rapid field visit and Level-3- Intensive field sampling. Regardless of the level used, the EIA method provides a rating or score of the level of integrity. The method uses a continuous numerical scale from 1 to 5, which is translated into report-card style ratings, from “A” (High or Excellent), to “B” (Good), “C” (Medium or Fair) and finally, those with significant degradation would be ranked “D” (Low or Poor). Detailed definitions for each level are provided in Appendix I.

Step 4- Wetland Prioritization based on Watershed Information

What does it mean to prioritize wetlands? Why do we need to? If we are to follow the 2008 Federal Rule on Compensatory Mitigation for Losses of Aquatic Resources, that the “ultimate goal of the watershed approach is to maintain and improve the quality and quantity of aquatic resources within watersheds through strategic selection of compensatory mitigation sites” (§ 230.93c, COE and EPA 2008) we have to be able to say which wetlands have a higher priority for mitigation[2] (and at the same time which wetlands have a higher penalty for impact). If we do not prioritize wetlands, then we cannot know if cumulatively we are maintaining or improving the aquatic resources within the watershed. We cannot take the risk of conducting another watershed profile years later only to discover that we did not maintain the diversity and proportionality of wetlands (and consequentially the diversity and

[2] In and around Juneau, Alaska, the primary means of compensatory mitigation to date has been preservation, as the ratio of undeveloped and pristine wetlands outweighs the needs for wetland restoration or enhancement. However, because of development impacts to wetlands and other aquatic resources on the landscape, restoration, enhancement, and establishment/creation opportunities may be available. This frame work encompasses the process to evaluate all compensatory mitigation possibilities.

proportionality of their functions) in the watershed. Prioritization is part of the guidance on how to mitigate for loss. From a conservation point of view, we suggest to protect the rare and highest priority wetlands and to give them higher mitigation "cost" for impacts.

From an economic perspective, debit to credit ratios reflect quantity to quality tradeoff. Where two assets involved in a trade are of equal value they can be fairly traded on a one-for-one basis. The mitigation ratio is intended to balance gains and losses because the functions and services of created or restored wetlands are usually expected to be less than a natural wetland (King and Price 2004). The notion that "all wetlands are valuable" reflects the resistance to classify one wetland as having any more or less value than another. However, within the context of watersheds, historical land use impacts, and wetland functions, we can develop appropriate measures of wetland value relevant to mitigation. The prevailing compensation ratios are inconsistent with asset-based trading; that is, the assumptions that mitigation gain is always equal to the amount of impacted loss. Prioritization gives guidance to district engineers and to the public that not all wetlands will "cost" the same in terms of the amount of mitigation required.

Watershed Priority Rating

With quantified watershed profile rating, wetland type rating and the EIA score, we combine these three scores to achieve the Watershed Priority. That is, Watershed Profile Rating x Complexity Rating x EIA Score (expressed as a percentage) = Watershed Priority.

- ✓ Watershed Profile Rating—based on results of Juneau Watershed Wetland Profile:
  - Tidal Salt Marsh – High-- least abundant/most damaged
  - Wet Meadow & Marsh – Moderate--less common
  - Flooded & Swamp Forest / Bog & Fen – Low --very abundant
- ✓ Complexity Rating (based on wetland NWI and/or NVC type)
  - High (Woody, peat soils)
  - Moderate (Herbaceous/Scrub, tidal)
  - Low (Herbaceous)
- ✓ Ecological Integrity Rating (based on wetland EIA method)
  - High (A,B)
  - Moderate (C)
  - Low (D)

Table 2. Example Scoring of wetland prioritization based on watershed profile, wetland type and EIA score. Note that the watershed rating is assessed based on the watershed profile of each type, the complexity rating is assessed based on the wetland type, whereas the EIA rating varies depending on on-site, size and landscape context characteristics. The Watershed Priority is based on the ratings for Watershed Rating, Complexity, and EIA score expressed as a percentage. The resulting values (details available in Appendix III) were generalized into Low, Moderate and High categories.

Field delineated Wetland Type (NWI and/or NVC)	Wetland Ratings			Watershed Priority
	Watershed Profile Rating (Juneau)	Wetland Type Complexity Rating	Wetland EIA Rating	
Tidal Salt Marsh	High	Moderate	Low	Moderate
			Moderate	High
			High	High
Wet Meadow & Marsh	Moderate	Low	Low	Low
			Moderate	Moderate
			High	Moderate
Flooded or Swamp Forest/Scrub	Low	High	Low	Moderate
			Moderate	Moderate
			High	High
Bog & Fen	n/a[1]	High	Low	Moderate
			Moderate	High
			High	High

[1]Fens and Bogs were not mapped separately by NWI.

2.3 *Framework Part 2-IMPACT SITE ASSESSMENT*

Identify the type of wetland, its current EIA score, and the watershed profile rating for that wetland to determine the Watershed priority of the potential impact site (Section 2.2 and Table 2). If the impact site is a high priority wetland, can it be avoided?

The debt incurred is a function of the direct loss of wetland acres, and the indirect loss in ecological integrity, weighted by the overall watershed priority within that watershed (Table 2 above). A wetland with good to high ecological integrity is providing functions characteristic for the type of wetland. A wetland with poor ecological integrity provides fewer functions or lesser amounts of those functions. For an impacted wetland, the amount of loss can be measured by the number of acres impacted multiplied by their ecological integrity assessment rating. For complete wetland destruction, the debit equals the number of destroyed acres times the overall prioritization rating (Table 2). For partial loss, we can measure (or anticipate) the reduction in the wetland ecological integrity after impact. Some impacts may include acres of wetland that are completely destroyed plus a reduction in the ecological integrity of the surrounding or adjacent acres of the same wetland. The ecological integrity assessment rating then serves as measure of the amount of debit, on a per acre basis, of wetland loss and decline.

Debit = [direct impact in acres x watershed priority) + (indirect impact in acres x watershed priority) (note that to establish watershed priority rating, the ecological integrity is assessed for both acres directly and indirectly impacted.

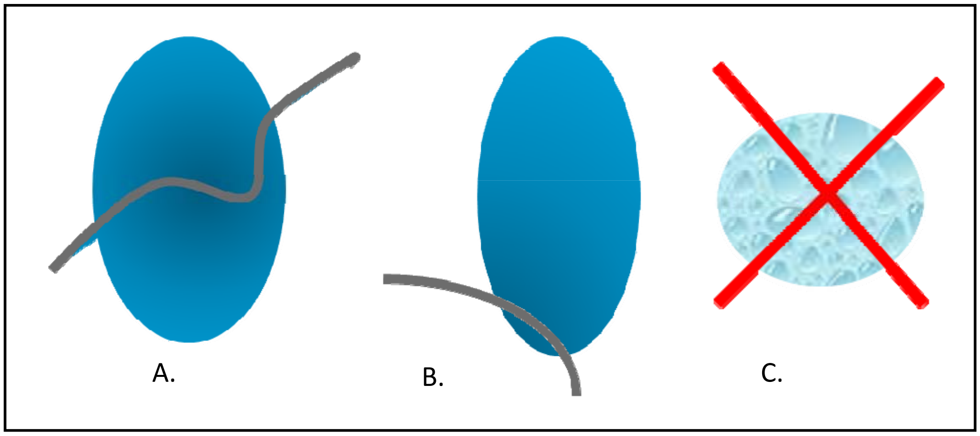

Figure 12. Schematic of different debit calculation scenarios.
Debit Calculation includes direct acres of impact from a new road. A) the debt includes the direct loss of acres by developing the new road plus the loss in wetland integrity because of altered hydrology, among others, along the road x watershed priority. B) there are less acres loss and the impact on the rest of the wetland may be less than in scenario A. C) the entire wetland is lost, and the debit is equal to the number of acres X watershed priority.

2.4 ***Framework Part 3-MITIGATION SITE ASSESSMENT***

To choose a mitigation site, four critical areas of information are needed:

Criteria 1. Watershed Priority Rating
Criteria 2. Comparison with Impact to Mitigated Watershed priorities.
Criteria 3. In/Out-of-kind, On/Off-Site
Criteria 4. Type of Mitigation

Criteria 1-Mitigation Site Watershed Priority

Is the proposed mitigation site consistent with watershed profiles? As with the impact site, the watershed profile (see section 1.2 and Table 2) characterizes the diversity and condition of wetlands which in turn influence the landscape function. Choosing higher watershed priority wetland for mitigation is one way of increasing the mitigation value for the watershed. Mitigation of lower priority wetlands may result in increased area required for compensation. Mitigation locations that are not currently part of the watershed profile may be considered high risk (e.g., a proposal to establish/create a wetland where no known historical wetland occurred).

Criteria 2-Comparison of Impact to Mitigation Wetland Watershed Priority

High priority wetlands as identified by the watershed profile are fully functioning and providing many landscape and local scale ecosystem services. Impact to high priority wetland carries a higher debt load than a lower priority wetland. This expresses the wetland value relative to the watershed context and the amount of compensatory mitigation required. In addition, the more closely the mitigation can match the type of impact wetland, and meet physical site criteria for successful outcome, the more efficient the ratio can be. The Debit-Credit ratio incorporates the watershed priority and the degree of risk associated with mitigation plans (**Table 3**).

Criteria 3-In/Out-of Kind, On/Off-Site

Determine whether in-kind mitigation or out-of-kind mitigation may be used. In-kind mitigation can more closely replace lost types, conditions, functions and values; where in-kind is not chosen, out-of-kind mitigation needs to be a type and location that best benefits the watershed as outlined by the watershed priority. Information needed to make this determination include:

- ✓ Watershed profile rating
- ✓ Wetland type complexity rating
- ✓ Condition rating (EIA)
- ✓ Watershed Hydrologic Position

By choosing in-kind mitigation we may be able to compensate more fully for those losses. However this is not always the most viable option. If a similar wetland cannot be used, then the mitigation site should be chosen to improve the watershed. Wetlands differ in their complexity and in the suite of ecological integrity and biodiversity values and ecosystem services they provide. For out-of-kind compensation, the watershed profile and the watershed priority will guide mitigation type and location that will most benefit the watershed as a whole. It is important that the mitigation site be scrutinized for providing hydric soils, adequate hydrology to support the targeted type of wetland, adequate buffer and the best landscape context possible, the current status of which can be ascertained from the EIA method. For example if the mitigation site is targeted for protection, but is surrounded by urban interface, it may not be the best site for Protection as the mitigation action.

The location of the mitigation site is critical to the success of the mitigation. In order to compensate for the loss of functions and values of the impacted wetland, on-site mitigation has the advantage of being located in the same watershed position (same distance from headwater) and may be the best choice. On-site mitigation may be appropriate where mitigation has a high likelihood of success in replacing the functions loss at the impact site and such mitigation is consistent with watershed profile priorities. On-site may also pose high risk mitigation or have little mitigation opportunity because the site no longer has adequate buffer, landscape context or hydrology. The watershed profile illustrates off-site mitigation locations that fit broader watershed needs. Off-Site mitigation may involve in-kind or out-of kind mitigation. Off-site mitigation may be more appropriate for urban-area impacts, but may direct mitigation to other urban sites in need of restoration. An assessment of the character of the impact site and the watershed profile are the most important sources of information to guide on-site/off-site and In-kind/out-of-kind decisions.

Watershed Hydrologic Position

The mitigated wetland should have a similar priority to that of the impacted site, based on watershed profile rating, wetland type rating, and ecological integrity assessment / functions rating. The latter may include being in a similar position in the watershed as represented by the distance of the wetland from the head or to the terminus of the watershed. With layers such as National Hydrologic Data (NHD) and digital elevation models (DEM) we can represent the hydrologic positioning and proportion of NWI wetland polygons, and this can be added to the wetland profile by identifying headwater riverine, main stem riverine, etc. (but this was not done as part of the Juneau pilot study). Mitigation has the potential to reconfigure the kinds and spatial distribution of wetland ecosystems over large geographic areas (Bedford 1996). To preserve the diversity, spatial distribution and watershed-level hydrologic functions of wetlands, inventory needs to include each wetland's position within the watershed. Part of wetland function is driven by the relative position in the watershed, its watershed hydrologic function.

Wetlands in the upper reaches of watersheds play important roles in watershed hydrologic function which include regulating water quantity and quality, protection from sedimentation, timing of downstream flows, and other functions. Upper watershed wetlands also contribute to groundwater flows that can influence wetland functions in the lower watershed. Headwater wetlands and wetlands located downstream of agricultural areas contributes more ecological services to water quality than wetlands located lower in the watershed (Bedford and Godwin 2003). Riparian areas and wetlands adjacent to rivers and streams provide flood water retention and fish and wildlife habitat. Upper stream reaches play a role in providing nutrient pulses to fish habitat in lower reaches. Wetland functions along rivers can be further linked to riverine functions, as summarized using the river continuum concept, which predicts the functions of each river segment from headwaters to the lower reaches (Vannote et al. 1980). Aquatic macro-invertebrate species composition changes with stream-reach position: upper reaches have greater proportion of coarse-debris detritivores, while lower reaches have specialists in processing smaller types of litter and nutrient sources (Vannote et al. 1980). Wetlands along coast lines have important functions for shoreline protection and marine fisheries productivity (Maltby 2006). Choice in mitigation location should be designed to match or mimic the impacted wetland watershed position in order to maintain watershed-level hydrologic functions.

Criteria 4-Type of Mitigation

An existing wetland Ecological Integrity Assessment score can inform the type of mitigation action required for the mitigation site. *Preservation* may be the most appropriate action where wetlands are in very good to pristine condition (e.g. EIA score of 4.5-5, or a FACWet Score of 0.85-1.0) (Johnson et al. 2011). *Enhancement* may be the best action when a single threat can be abated (such as removal of a ditch) (as expressed by an EIA score of 3.5-4.5, or FACWet score of 0.65-<0.85). *Restoration* may be needed for wetlands with several problems, such as weed infestations, drainage problems or other degradations that can be reversed (e.g. EIA score of 2.0-3.5, or a FACWet score of .50-0.65). *Establishment/Creation* will be required where a wetland is very heavily damaged or non-existent but the site was known to contain a wetland in the past (historic) (e.g. EIA score <2.0, FACWet score of <5.0). For any mitigation action, physical site criteria must be met to ensure the low risk of failure and the highest success for meeting performance standards. Physical site criteria include watershed position, landscape position, and hydrologic source.

Any mitigation action should result in an increase in ecological integrity rating (which may include increased acreage) of priority wetlands (through restoration, enhancement, preservation or establishment/creation), which together contributes to the amount of "credit." With an increase in ecological integrity, we gain more functions or higher amounts of those functions for a given type of wetland. Sites that best support the type of mitigation action proposed are more likely to meet performance standards over time. Credit can be calculated for the mitigated site by starting with the overall watershed priority score for the wetland (from Table 2 above, based on the wetland type, the watershed profile rating, and the current level of ecological integrity prior to mitigation efforts), and re-calculating the credit by the amount of acres and expected improvement in the EIA rating (Faber-Langendoen et al. 2008).

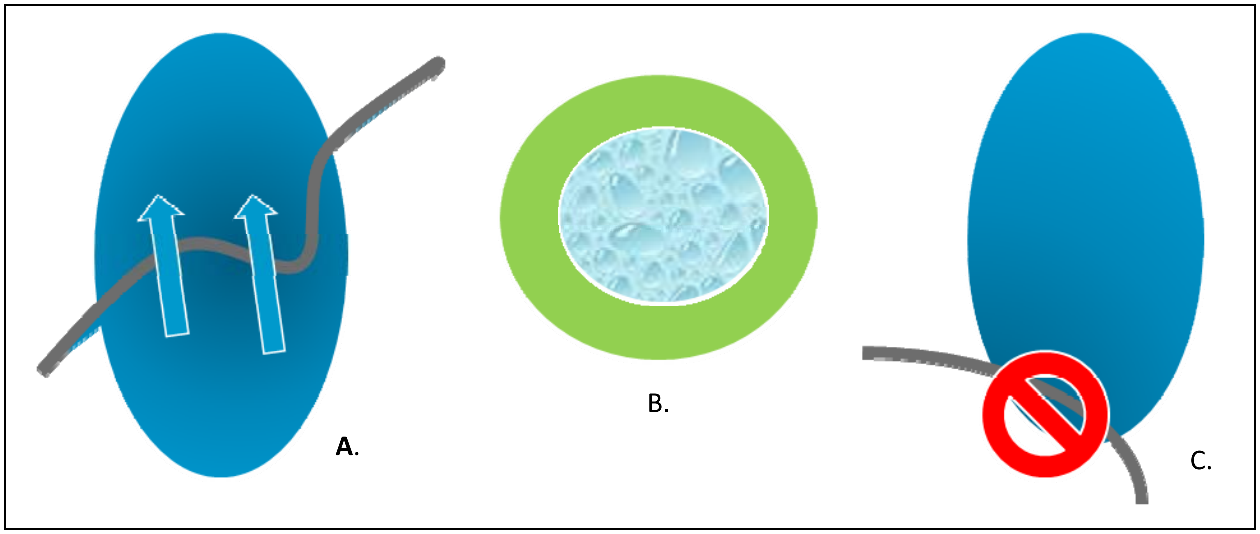

Figure 13. Types of mitigation that will increase the Ecological Integrity of a wetland: A. *Enhancement* The addition of culverts to restore flow within a wetland. B. *Protection* the addition of a protected upland buffer and the wetland itself can increase the overall EIA rating. C. *Restoration*: Removal of a road that has impacted part of a wetland.

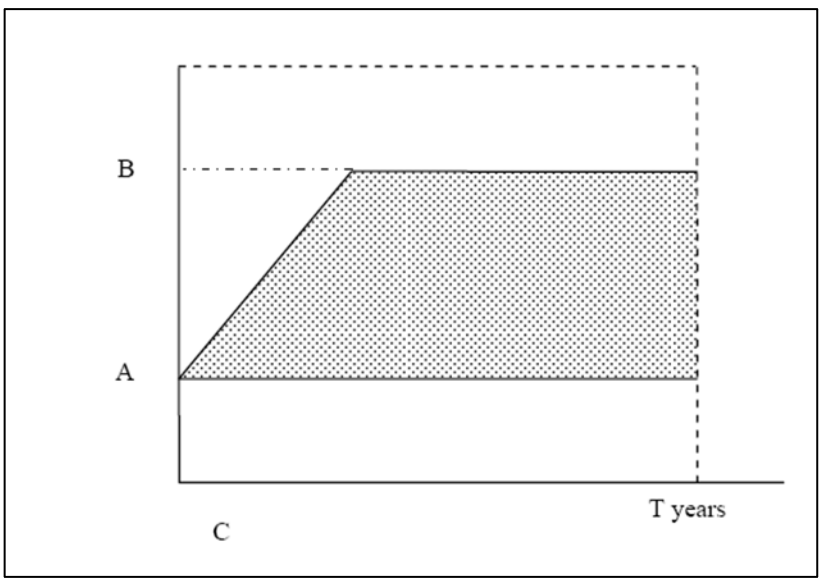

Figure 14. Economic theory applied to Ecology, the ability of restoration to raise the level of ecological integrity. A = starting EIA level, B = resulting level and C= the number of years to reach that level. (Figure from King and Price 2004)

There are challenges to assessing risk (and therefore expected credit) based on an expected increase in ecological integrity. We have drawn from economic theory to assist us in the calculation of wetland credit based on the amount of increase in the ecological integrity (or value) of a wetland, namely that projected increases in various economic investments vary, depending on the kind of investment made and the time available (**Figure 14**). Similarly, ecological restoration work is not straightforward; it is understood there are risks of failure, and it can take a long time for efforts to reach their full potential. By comparing the wetland to a known standard – a reference wetland that is undamaged and fully functional –we can see the comparative value of any mitigation effort. The equation to calculate credit includes not only risk of failure but the differences in location, as the impacted wetland may be in a better position in the watershed to provide functions and services that the mitigation site location cannot provide.

When factors are expressed as a % of a standard, we get a universal "net present value" used in economics to compare investments. By comparing a mitigation site to an existing, pristine wetland (i.e. one that is minimally disturbed and can serve as a reference site), the mitigation site's highest level of integrity is adjusted by the risk of failure to achieve that level, and differences in landscape context of impact wetland and the mitigation site (King and Price 2004).

We have applied this economic theory to the mitigation framework by using a simple assessment of wetland complexity as a measure of the risk of failure (the more complex a wetland, the more difficult it is to succeed at restoration). The ecological integrity rating is already calculated relative to a reference standard (a known, high quality wetland of the same type); in this way the EIA method can serve as a measure of the level of success in restoration (much like success in level of investment as provided in the equation by King and Price (2004). Thus our approach to providing credit says that when a mitigation project proposes to mitigate a highly complex wetland type (e.g., bog) it runs a higher risk of failure of reaching desired performance standards than if the project chose a less complex wetland type (salt marsh). In addition the time needed for mitigation activity to become fully realized is usually also greater for more complex wetlands, and can be considered part of the risk. Mitigation that will take several (> 5) years will not be able to use those credits until performance standards indicate a new higher level of integrity has been achieved.

The Ecological Integrity Score takes into account the current status of a wetland's soils, hydrology, condition, threats and landscape context. Poor scores indicate the need for restoration or establishment but they do not take into account the ease, difficulty, or even the probability of correcting any problems. This is handled through the complexity rating. In addition to the complexity of the type of wetland, the mitigation site and surrounding landscape need to be scrutinized for the likelihood of success of these actions. Can the threats be removed? Can the hydrology be restored? Can a buffer be created or increased? A professional restoration ecologist should be brought in for the design of any enhancement, restoration or establishment project. The better the design of a restoration project by an experienced restoration practitioner, the higher the degree of success, and the lower the risk of failure.

3 DEBIT/CREDIT COMPARISONS

We have developed a system of debit and credit ratios based on the Watershed Priority which includes the watershed profile rating, the wetland complexity rating, and the ecological integrity rating. These ratings are all on the same scale and use these values to calculate the "value" of a loss (i.e. the amount of debt) which must be compensated. The same scale can be used to indicate the potential increase in wetland value (increase in the Watershed Priority via an increase in the Ecological Integrity Score) along with the risks. This system allows us to compare different types of wetlands and to quantify watershed priority ratings in order to calculate mitigation required to compensate for impact loss. These comparisons assume some level of mitigation will occur (preservation, restoration, enhancement or establishment/creation) that improves its ecological integrity score and potentially the wetland's watershed priority standing.

We introduced the role of wetland complexity in Step 2- Wetland Type Rating (page 20). The complexity of the type of wetland determines just how much potential credit is possible; where more complex wetlands carry a greater risk of mitigation failure and therefore require a higher ratio of compensation. We developed an excel spreadsheet to calculate the ratio for in-kind and out-of-kind mitigation scenarios (details and results of this method are outlined in Appendix III). The resulting ratio indicated higher ratios needed to compensate the high priority wetland with similar wetlands, and lower ratios for mitigation with lower valued wetlands. However, within the watershed framework, we would rather see required compensatory mitigation occur in the best interest of the watershed, and thus encourage compensation to occur on higher priority wetlands while at the same time discourage impact on high priority wetlands.

We simplified the ratio development by starting with the lowest values from the excel spreadsheet (comparing lower priority wetland impact debt with low priority wetland compensation credit; see Table 11 in Appendix III) and inverted them to encourage mitigation action on high priority wetlands for the impact incurred on a low priority wetland. For the next priority wetlands we multiplied those values by 2 (because medium priority wetlands are double the value of lower priority wetlands according to the watershed priority rating). We doubled those values again for highest priority wetlands (x 4) -- as the highest priority wetlands ranked >4 times more valuable by the watershed priority rating (Figure 5 on page 8). These values are designed to emphasize: 1) avoid impact of highest priority wetlands, and 2) mitigation of high priority wetlands (through preservation, enhancement, restoration or establishment).

We recognize these values are higher than current Alaska District Army Corps guidance of 1.5:1 – 3:1 which does incorporate wetland categories (I-IV, based on amount of functions) and justifies higher ratios because of the risks of failure in mitigation (USCOE 2009). The ratios proposed in Table 3 are similar, if higher, based on the watershed profile, wetland type complexity and level of ecological integrity.

The design of this framework is to reward the mitigation of high priority wetlands and encourage the improvement of higher priority wetlands over the creation of lower priority wetlands. At the same time the framework is designed to discourage impact of high priority wetlands. Table 3 proposes mitigation ratios based on a watershed approach that includes the watershed perspective, and differences in wetland type. By using wetland valuation we hope to direct compensatory mitigation in a direction that improves the status of high priority wetlands and water resources for the watershed.

Table 3. Watershed Priority based Debit/Credit ratios to encourage preservation and appropriate restoration on high priority wetlands and to discourage impact of high priority wetlands.

Debit / Credit Acre to acre basis	**Mitigation Site**		
Impact Site	High Priority Wetland	Medium Priority Wetland	Low Priority Wetland
High Debit (High priority) Wetland (4x)	4	8	12
Medium Debit (Medium Priority) Wetland (2x)	2	4	6
Low Debit (Low Priority) Wetland	1	2	3

4 NEXT STEPS

The mitigation framework we propose requires some basic information on the watershed. We have attempted to insure that the information required is readily accessible for most, if not all, parts of the country. The watershed profile we developed is a first approximation of the kinds of information needed on wetland types, condition and functions within a watershed. It provides the basic level of information that can inform a watershed based mitigation framework. Although not required, a next step can be to develop a watershed plan where the goal is to gather additional information and make informed decisions and create catalogs of potential restoration and conservation areas. Additional data may include the City and Borough of Juneau Wetland Management Plan, local conservation organizations priority areas, and future planned road and airport expansions (Table 4). With a comprehensive plan in place, managers and decision makers will have the knowledge of current and cumulative acre loss by wetland type, current abundance or extent, watershed and site-scale hydrologic characteristics for each mapped wetland, the overall condition of wetlands for the watershed, and individual wetland ecological integrity rating.

With this information, wetlands can be prioritized into high, medium and low categories, based on wetland type (complexity) and abundance (current and historic). Two map products are generated: a Conservation Catalog – an inventory of wetlands indicating relative irreplaceability and therefore, along that continuum, wetlands that must be avoided, and a Mitigation Catalog -- the full range of sites were wetland enhancement or restoration could be feasibly contemplated as well as sites where wetland rehabilitation is clearly needed and feasible (i.e., where a emergent marsh would be helpful for improved hydrologic function within the watershed, or re-create an historic wetland). For SE Alaska, the need for and the opportunity for preservation is high, so the conservation catalog may serve as the goal for mitigation banking and other lands for in-lieu-fee acquisition.

Table 4. Potential flow of data and information during a watershed plan development, resulting in spatial catalogs of priority conservation and restoration sites.

WATERSHED PROFILE – MEASURES of:	WATERSHED PROFILE PRIORITY METRICS	COMBINED INTO:	RESULTING Watershed Plan Catalogs
1-Wetland Type (NWI, NVC)*	--Proportional abundance	**Watershed Priority Rating**	**Conservation Catalog** (Specific locations of the Highest Priority Wetlands to be protected) **Mitigation Catalog** (Specific locations of wetlands to be restored, enhanced or
2- Landscape Condition Model (or EIA Level-1)*	--Percentage of watershed in good condition		
3-Hydrologic function (HGM)	--Proportions of hydrological types		
4- Watershed Position (GIS measured distance from headwater)	-- Proportion by watershed position (coastal, headwater, etc.)		
5-Special Biodiversity Features --endangered species --wildlife habitat --other	--Rare wetland types --Special condition (e.g. old growth, high salmon productivity reaches)		

6-Development Features --protected areas --future urban growth --educational sites --recreational sites --other	--Wetland Site proximity -- Future potential land use conflicts		rehabilitated)

* Used in Juneau pilot Assessment

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6 APPENDIX I. ECOLOGICAL INTEGRITY ASSESSMENT - OVERVIEW

The following section is taken directly from Faber-Langendoen et al. (2008) Performance Standards for Wetland Mitigation. For over twenty-five years, NatureServe has advanced the Natural Heritage Methodology for documenting the viability and integrity of individual occurrences of species and ecosystems. Our ecological integrity assessment method builds on that methodology, but has adapted them by building on a variety of existing rapid assessment methods (Mack 2001, Collins et al. 2006, 2007), and the 3-level approach of the U.S. Environmental Protection Agency and others (Brooks et al. 2004, US EPA 2006, Faber-Langendoen et al. 2006, 2008a).

6.1 The Ecological Integrity Assessment Approach.

The Ecological Integrity Assessment (EIA) approach focuses on two key aspects: 1) a landscape context and 2) setting performance expectations (Faber-Langendoen et al. 2008). The EIA approach outlines methods to structure the selection of indicators for all U.S. wetland systems, including a) use of an improved hierarchical framework for wetland classification; b) a three-level approach to the development of metrics (remote, rapid, intensive); c) ecologically comprehensive rapid (Level-2) field-based metrics and ratings for all broad wetland types, with suggested metrics for Level-1 and Level-3; and d) a report card structure for aggregating metrics by major ecological attributes (landscape context, size, vegetation, hydrology, and soils). This method builds on the variety of existing rapid wetland assessment and monitoring materials, particularly those in the California Rapid Assessment Method (CRAM)(Collins et al. 2006, 2007), the Ohio Rapid Assessment Method (Mack 2001), and prior work by NatureServe (Faber-Langendoen et al. 2006).

6.2 Ecological Integrity Defined*.*

Building on the related concepts of biological integrity and ecological health, ecological integrity is a broad and useful endpoint for ecological assessment and reporting (Harwell et al. 1999). “Integrity” is the quality of being unimpaired, sound, or complete. Ecological integrity can be defined as “an assessment of the structure, composition, and function of an ecosystem as compared to reference ecosystems operating within the bounds of natural or historic disturbance regimes” (adapted from Lindenmayer and Franklin 2002, Young and Sanzone 2002, Parrish et al. 2003). To have ecological integrity, an ecosystem should be relatively unimpaired across a range of ecological attributes and spatial and temporal scales.

Our approach to assessing ecological integrity is similar to the Index of Biotic Integrity (IBI) approach for aquatic systems. The original IBI interpreted stream integrity from twelve metrics that reflected the health, reproduction, composition and abundance of fish species (Karr and Chu 1999). Each metric was rated by comparing measured values with values expected under relatively unimpaired (reference standard) conditions, and the ratings were aggregated into a total score. Building upon this foundation, others suggested interpreting the integrity of ecosystems by developing suites of indicators or metrics comprising key biological, physical and functional attributes of those ecosystems (Harwell et al. 1999, Andreasen et al. 2001, Parrish et al. 2003). We follow that lead by developing an index of ecological integrity based on metrics of biotic and abiotic condition, size, and landscape context.

6.3 ***Functional assessments vs. Ecological Integrity assessments.***

Functional assessments have been widely developed for wetlands (e.g., the Hydrogeomorphic Approach Brinson et al. 1993). Similar to ecological integrity assessments, functional assessments estimate the structure, composition, and processes of ecosystems. However, these methods use this information to evaluate the capacity of wetlands to perform certain functions or ecosystem services, independently of how those services relate to ecological integrity. For example, metric ratings that assess flood / storm water control or wildlife habitat utilization may not have a direct correspondence to metrics for hydrologic condition as it relates to ecological integrity (Hruby 2001, Hruby 2004). In an ecological integrity assessment, an ecosystem is considered to have excellent integrity if it performs all of its functions or processes within an expected range of natural variation for that type.

In the context of an overall assessment of natural resources and biodiversity, consideration will need to be given to balancing the relative goals of any assessment, and determining where on the landscape these various goals may be achieved. Ecological integrity assessments provide an important piece of information on the historic, natural ranges of variation on ecosystem composition, structure, and processes.

6.4 ***Ecological Classification***

The success of developing indicators of wetland ecological integrity depends on understanding the structure, composition, and processes that govern the wide variety of ecosystem types (we use the term "ecosystem" in a generic sense to refer to both ecological communities and systems). Ecological classifications can be helpful tools in categorizing this variety. They help ecologists to better cope with natural variability within and among types so that differences between occurrences with good integrity and poor integrity can be more clearly recognized. Classifications are also important in establishing "ecological equivalency," for example, in providing guidance on how an impacted salt marsh can be restored to a salt marsh with improved integrity. There are a variety of classifications and ecoregional frameworks for structuring ecological integrity assessments. Here we focus on two classifications in particular: the International Vegetation Classification (IVC) and Ecological Systems.

The **International Vegetation Classification** covers all vegetation from around the world. In the United States, its national application is the **USNVC**, supported by the Federal Geographic Data Committee, NatureServe, and the Ecological Society of America, with other partners (FGDC 2008, Faber-Langendoen et al. 2009, Jennings et al. 2009). The IVC and NVC were developed to classify both wetlands and uplands, and identify types based on vegetation composition and structure and associated ecological factors. At the highest level of Formation Class there are 8 broad classes, and 7 other nested hierarchical levels permit resolution of types from broad-scale formations to fine-scale associations (Table 5).

Table 5. Eight levels of the USNVC hierarchy.
Using salt marshes as an example, this table shows as an example of how Ecological Systems can be linked to the Hierarchy. The Temperate Pacific Tidal Salt and Brackish Marsh System falls within the North American Pacific Coastal Salt Marsh macrogroup.

USNVC Hierarchy	Pilot NVCTypes
Upper Levels	
Formation Class	Shrubland & Grassland
Formation Subclass	Temperate & Boreal Shrubland & Grassland
Formation	Salt Marsh
Mid-Levels	
Division	Temperate & Boreal Pacific Coastal Salt Marsh
Macrogroup	North American Pacific Coastal Salt Marsh
Group	Temperate Pacific Tidal Salt & Brackish Marsh Group
	Temperate Pacific Tidal Salt and Brackish Marsh System
Lower Levels	
Alliance	*Carex lyngbyei* Tidal Herbaceous Alliance
Association	*Carex lyngbyei* Herbaceous Vegetation

The USNVC meets several important needs for conservation and resource management. It provides:

- -a multi-level, ecologically based framework that allow users to address conservation and management concerns at scales relevant to their work.
- -characterization of ecosystem patterns across the entire landscape or watershed, both upland and wetland.
- -information on the relative rarity of types. Each association has been assessed for conservation status (extinction risk).
- -relationships to other classification systems, particularly state natural Heritage classifications that are explicitly linked to the NVC types, but also other similar classifications, such as the NWI wetland classification (Cowardin et al. 1979), SAF cover type classification (Eyre 1980).
- -a federal standard for all federal agencies, facilitating sharing of information on ecosystem types (FGDC 2008).

A second, related classification approach, the **Ecological Systems** classification (Comer et al. 2003), can be used in conjunction with the IVC and USNVC. Ecological systems provide a spatial-ecologic perspective on the relation of associations and alliances (fine-scale plant community types), integrating vegetation with natural dynamics, soils, hydrology, landscape setting, and other ecological processes. They can also provide a mapping application of the NVC, much as soil associations help portray the spatial-ecologic relations among soil series in a soil taxonomic hierarchy. Systems types facilitate mapping at meso-scales (1:24,000 – 1:100,000). Increasingly, comprehensive systems maps are becoming available across the country (Comer et al. 2007, www.landscope.org). Systems are somewhat comparable to the Group level of the revised NVC hierarchy, and can be linked to higher levels of the NVC hierarchy, including macrogroups and formations. Systems meet several important needs for conservation, management and restoration, because they provide:

- an integrated biotic and abiotic approach that take advantage of the hydrologic and abiotic perspective of HGM and site classifications with that of the vegetation emphasis of the NVC. They can be more effective at constraining both biotic and abiotic variability within one classification unit than either of the two, and they should facilitate development of ecological indicators.
- comprehensive maps of all ecological system types are becoming available.
- explicit links to the USNVC, facilitating crosswalks of both mapping and classifications.

These two classifications can be used in conjunction with ecoregional frameworks to sort out the ecological variability that may affect ecological integrity.

6.5 ***Ecological Integrity Assessments***

Our approach to establishing ecological integrity assessment methods builds on the NatureServe methodology for conducting ecological integrity assessments (Stein and Davis 2000, Brown et al. 2004, Faber-Langendoen et al. 2008b). We develop the assessments using the following steps; we:

1) outline a general conceptual model that identifies the major ecological attributes, provide a narrative description of declining integrity levels based on changes to those ecological attributes, and introduce the metrics-based approach to measure those attributes and assess their levels of degradation.

2) use ecological classifications at multiple classification scales to guide the development of the conceptual models, to allowing improved refinement of assessing attributes, as needed. E.g., the characteristics of vegetation, soils or hydrology for tropical forests differs strongly from that of temperate forests, the characteristics of temperate Red Spruce-Fir Forest differ in many respects from temperate Longleaf Pine Woodland, and the characteristics of montane Red Spruce-Balsam Fir Forest may differ in some respects from that of lowland Red Spruce–Hardwood Forest.

3) use a three level assessment approach – (i) remote sensing, (ii) rapid ground-based, and (iii) intensive ground-based metrics – to guide development of metrics. The 3-level approach is intended to provide increasing accuracy of ecological integrity assessment, recognizing that not all conservation and management decisions need equal levels of accuracy.

4) identify ratings and thresholds for each metric based on "normal' or "natural range of variation" benchmarks.

5) provide a scorecard matrix by which the metrics are rated and integrated into an overall index of ecological integrity.

6) provide tools for adapting the metrics over time as new information and methods are developed.

6.6 ***Conceptual Model and Metrics***

Conceptual Model

A conceptual ecological model that identifies the major ecological attributes and linkages to known stressors or agents of change is a useful tool for guiding ecological integrity methods (Noon 2002). We developed a general conceptual model that identifies a) **major ecological attributes** of ecosystems, including the condition of vegetation, soils (and hydrology for wetlands), landscape context, and size that help characterize overall structure, composition and process, and b) important drivers and stressors acting upon ecosystems (Figure 15, Table **6**). Other major attributes, such as birds, amphibians, and macro invertebrates can also be assessed where resources, time and field sampling design permit. The model is fairly intuitive, but a key component is that integrity incorporates spatial aspects of ecological integrity using both size and landscape context attributes.

Figure 15. Conceptual Model for Assessing Ecological Integrity.
The major ecological attributes of ecosystem integrity are shown for upland and wetland models. Ecosystem drivers, such as climate, geomorphology, and natural disturbances maintain overall integrity, whereas stressors act to degrade it. See also Table **6**.

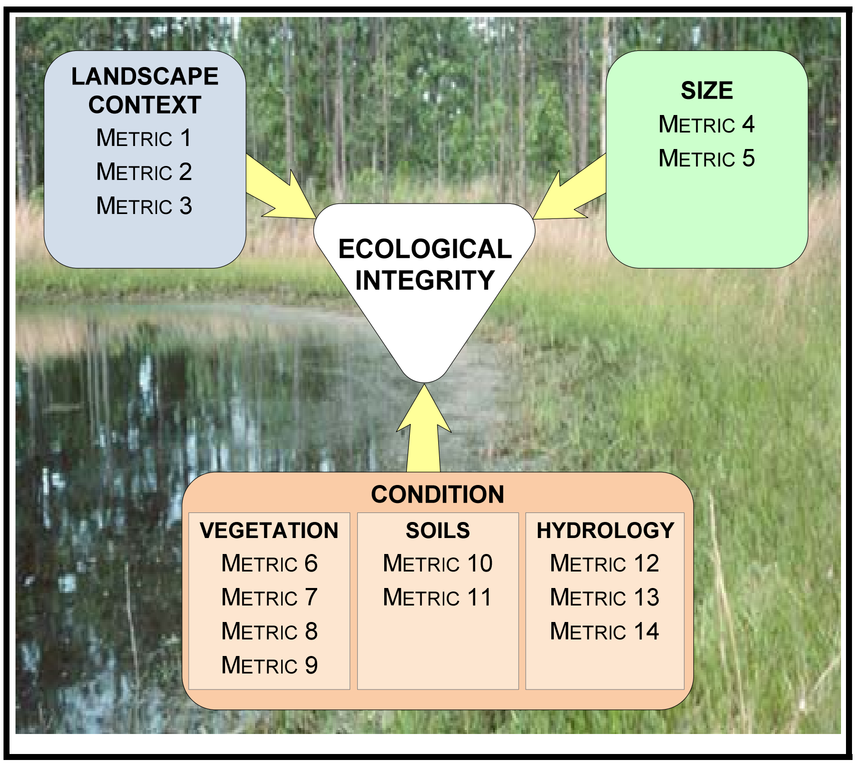


Table 6. Example of an ecological integrity table.
Based on the conceptual model of major ecological attributes and rank factors . Indicators are identified for each major ecological attribute. Stressors can be described using checklists (wetland example).

Rank Factor	Major Ecological Attribute	Indicator
LANDSCAPE CONTEXT	Landscape Structure	Landscape Connectivity
		Buffer Index
		Surrounding Land Use Index
	Landscape Stressors	Landscape Stressors Checklist
SIZE	Size	Patch Size Condition
		Patch Size
CONDITION	Vegetation	Vegetation Structure
		Organic Matter Accumulation
		Vegetation Composition
		Relative Total Cover of Native Plant Species
	Vegetation Stressors	Vegetation Stressors Checklist
	Soils (including physical-chemical)	Physical Patch Types
		Water Quality
		Soil Surface Condition
	Soils Stressors	Soils Stressors Checklist
	Hydrology (wetlands)	Water Source
		Hydroperiod
		Hydrologic Connectivity
	Hydrology Stressors (wetlands)	Hydrology Stressors Checklist

The conceptual model helps guide the selection of indicators, organized across a standard set of ecological attributes and factors (e.g., Harwell et al. 1999, Young and Sanzone 2002, Parrish et al. 2003). The indicators are placed within the interpretive framework provided by the conceptual model, organizing the metric by **major ecological attributes** – broad attributes that have an important (driving) function in the viability or integrity of the element – and by **rank factors** (Table 7).

Indicators and Metrics

Indicators provide the specificity needed to assess the major ecological attributes. **Metrics** can be thought of as the measurable expressions of an indicator. For example, “Relative Total Cover of Native Plant Species” is a compositional indicator of the Vegetation attribute; the metric used to quantify this indicator is “Total cover of exotic species subtracted from total cover of all vegetation and divided by 100.” Similarly, “organic matter accumulation” is a structural indicator of the Vegetation attribute; the metric used to quantify this indicator for forested wetlands may be “coarse woody debris - volume / ha of fallen stems over 10 cm diameter." Metrics and their protocols need to be described to ensure consistency in the assessment and monitoring process (Oakley et al. 2003).

The primary emphasis of the indicators and metrics is on measuring a relevant attribute of the ecosystem itself that responds to stressors. We refer to these as "**condition metrics**." We can also measure the stressors themselves, but information from these metrics provides only an indirect measure of the status of the system – we will need to infer that changes in the stressor correspond to changes in the condition of the system. We refer to these as "**stressor metrics.**" We provide a catalogue of possible stressors at a site (stressor checklists) to guide interpretation and possible correlations between ecological integrity and stressors.

We prefer to use condition metrics separate from stressors, in order to independently assess the effects of stressors on condition, but occasionally a stressor metric is substituted for a condition metric when measuring condition is challenging or not cost-effective. For example, the "Surrounding Land Use Index" is a stressor metric that substitutes for a condition metric characterizing the surrounding landscape. The basic goal is an accurate, cost effective estimate of integrity, rather than concern to keep the model pure.

Definitions of Levels of Ecological Integrity

Occurrences in the natural world vary in their level of integrity due to variety of anthropogenic impacts *i.e.,* the degree to which people have directly or indirectly adversely or favorably impacted the occurrence. Working from the basic concept of ecological integrity, we can begin to define levels of integrity, using a report-card style scale. Occurrences with higher levels of integrity would generally be ranked "A", "B", or "C" (from "excellent to at least "fair" integrity), and those with significant degradation would be ranked "D" ("poor" integrity) (see Table 7). Detailed definitions for each level are provided in Table 8

Table 7. Basic Ecological Integrity ranks

Ecological Integrity (EO) Rank Value	Description
A	Excellent estimated viability or ecological integrity
B	Good estimated viability or ecological integrity
C	Fair estimated viability or ecological integrity
D	Poor estimated viability or ecological integrity
NR	Not yet ranked
U	Unrankable

Table 8. Definition of Ecological Integrity Rank values.

Rank Value	Description
A	Occurrence is believed to be, on a global scale, among the highest quality examples with respect to major ecological attributes functioning within the bounds of natural disturbance regimes. Characteristics include: the landscape context contains natural habitats that are essentially unfragmented (reflective of intact ecological processes) and with little to no stressors; the size is very large or much larger than the minimum dynamic area ; vegetation structure and composition, soil status, and hydrological function are well within natural ranges of variation, exotics (non-natives) are essentially absent or have negligible negative impact; and, a comprehensive set of key plant and animal indicators are present.
B	Occurrence is not among the highest quality examples, but nevertheless exhibits favorable characteristics with respect to major ecological attributes functioning within the bounds of natural disturbance regimes. Characteristics include: the landscape context contains largely natural habitats that are minimally fragmented with few stressors; the size is large or above the minimum dynamic area, the vegetation structure and composition, soils, and hydrology are functioning within natural ranges of variation; invasives and exotics (non-natives) are present in only minor amounts, or have or minor negative impact; and many key plant and animal indicators are present.
C	Occurrence has a number of unfavorable characteristics with respect to the major ecological attributes, natural disturbance regimes. Characteristics include: the landscape context contains natural habitat that is moderately fragmented, with several stressors; the size is small or below, but near the minimum dynamic area; the vegetation structure and composition, soils, and hydrology are altered somewhat outside their natural range of variation; invasives and exotics (non-natives) may be a sizeable minority of the species abundance, or have moderately negative impacts; and many key plant and animal indicators are absent. Some management is needed to maintain or restore[3] these major ecological attributes.
D	Occurrence has severely altered characteristics (but still meets minimum criteria for the type), with respect to the major ecological attributes. Characteristics include: the landscape context contains little natural habitat and is very fragmented; size is very small or well below the minimum dynamic area; the vegetation structure and composition, soils, and hydrology are severely altered well beyond their natural range of variation; invasives or exotics (non-natives) exert a strong negative impact, and most, if not all, key plant and animal indicators are absent. There may be little long-term conservation value without restoration, and such restoration may be difficult or uncertain.[4]

Natural Range Of Variation and Reference Conditions

[3] By ecological restoration, we mean "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed… Restoration attempts to return an ecosystem to its historic trajectory" (SER 2004). As such it may be distinct from rehabilitation, reclamation, creation, mitigation, or ecological engineering, unless these projects have as part of their goal the definition of restoration define above (see SER 2004 for details).

[4] D-ranked types present a number of challenges. First, with respect to classification, a degraded type may bear little resemblance to examples in better condition. Whether a degraded type has "crossed the line" ("transformed" in the words of SER 2004) into a separate, and semi-natural or cultural type is a matter of classification criteria. These criteria specify whether sufficient diagnostic criteria of a type remain, bases on composition, structure, and habitat.

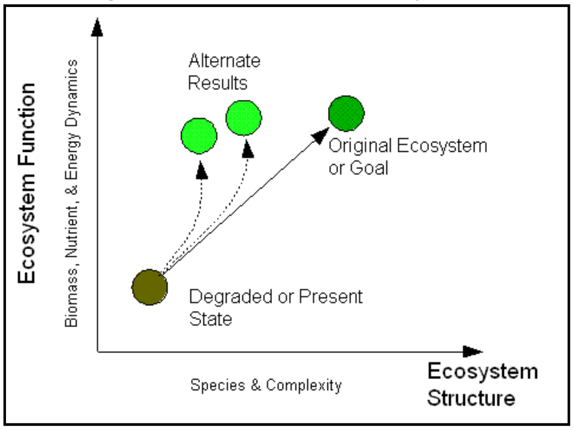
The ecological integrity criteria (the EO rank specifications) should be based on historical evidence and current status of natural variation, and should include threshold values for both the best conceivable occurrences and those having only fair viability or integrity (see Faber-Langendoen et al. 2008b). The criteria should also be developed in a global context. This means that the best occurrence in a particular jurisdiction or geographic area (*e.g.,* ecoregion) may not be highly ranked or even viable. Conversely, from a conservation perspective, if the best existing examples are only ranked C/D, they may still be worthy of protection and management (e.g., California native annual grasslands, Garry Oak woodlands, midwestern Bur Oak savannas, i.e. high priority category systems).

Reference conditions should characterize the full range of common circumstances –from seemingly 'pristine,' or benchmark, sites to highly degraded sites - so that metrics may be developed and applied that adequately characterize that full range. This requires collection of data from a number of locations, ideally from throughout the natural range for the ecological system type. Only through sufficient sampling can the full range of metric values be sufficiently analyzed and interpreted to provide for rigorous and repeatable ecological integrity assessment.

For ecological systems we aim to characterize this A-D scale using the "**expected" natural range of variation** (or **historic range of variation)** concepts, based on based available information. The ecological response to stressors and human alterations can be measured as the degree to which variation in the rank factors and their ecological attributes and indicators/metrics are pushed beyond their natural range of variation. What is natural or historical may be difficult to define for many cases, given our inability to document this range of variation over sufficient spatial and temporal scales and the relative extent of human disturbance over time. However, through reflections on historical data, and analysis of data gathered from with the full range of reference sites, we can often distinguish the effects of intensive human uses and begin to describe an expected natural range of variation for ecological attributes that maintain the occurrence over the long-term.

Too often the characterization of integrity is treated as a static linear function, not unlike the model shown in Figure 16. But such diagrams may be miss-leading with respect to both the ongoing natural, historical processes that shape ecosystems and the human interactions with those systems. It is useful to expand this view by considering how ecology and human culture are "knitted together over time;" that is, both culture and ecology have histories, and consideration of current ecological integrity reflects both histories, without suggesting that they are one and the same (Higgs 2003). What is critical is to ground our ideas of ecological integrity in reference sites; thereby spanning our cultural perspective on integrity with known ecosystem sites in the present, as informed by the past.

Figure 16. Relationship between Ecosystem Function and Ecosystem Structure.
Simple schematic showing how ecosystem structure and function may recover over time to either the more original (historical, natural) system or some altered form.



REFERENCES— All references cited in Appendix I are listed in the main report

7 Appendix II. EIA Level-2 and Level-3 Field Forms

Page numbers on the form refer to the Field Manual page.

Assessment Code: __ __ . __ __ __ L2.___ ___ ___

General Description Form [arrows below indicate info you should have with you, if available]

A. GENERAL INFORMATION page 12	B. LOCATION page 13				
Site Name: → *or* ☐ Use EO Site Name:	Directions [if new site]: *or* ☐ Use EO Directions:				
L2 Assessment Code (e.g. NY.DFL.L2.001) ___ ___ .___ ___ ___.L2.___ ___ ___	State / County:				
→ State EO Code [office] (e.g. EO ID)	USGS quad name(s) [Office]:				
Date 2 0 1 0 . ___ ___ . ___ ___ YEAR MO DAY	GPS Unit: GARMIN V GARMIN GPS76				
Photographer:	UTM Zone:	16	Datum:	NAD83 WGS84	Accuracy:
Team Members: Leader: Co-leader: Assistant(s):	UTM-E: OR Lat:dec.deg.	*Write one centrally located coordinate; store rest in GPS.*			
→ *Ownership [office]*:[picklist]	UTM-N: OR Long: dec deg				

C. ECOLOGICAL COMMUNITY CLASSIFICATION AND CONDITION page 14	
1. State Heritage Name – field assigned, [picklist]: *or* ☐ Same as 2 below.	Classification Change: Y or N. If Y, fill out "Reason..." Reason for Change in Type (e.g. conversion, degradation, succession, misclassified):
→ *2. State Heritage Name – previous visit [office]:*	Classification Comments: (Other comments, even if State Type not changed):
→ *State EORANK / Date: [office]*	Change in EO Rank? Y, N, U, If Y, briefly explain:
→ *State EO Size (acres): [office]*	Change in EO Size ? Y, N, U. If Y, briefly explain:
Size of Assessment Area [complete in office, if needed]: As Percent of EO ___________% (nearest 10%) Acreage___________	
Is spatial area of AA clearly indicated on attached map (e.g. EO polygon) or through GPS points: Y or N (if N, team must provide)	

D. GENERAL DESCRIPTION [be brief, use Sections E and F if details desired] page 15 Include description of what defines the boundaries of the assessment area; that is, what is adjacent to the area being assessed.
Other Types Of Interest at Site: [note types of interest for future visits to this site.]
Did you complete these optional sections on the following page? E. General Drawing Y N F. Detailed Overview Y N

OPTIONAL PAGE : PLEASE INDICATE USE WITH "Y" or "N" ON PREVIOUS PAGE

E. GENERAL DRAWING page 15
Provide a drawing of the assessment area, including its boundaries, as either aerial view or transect view.

F. DETAILED DESCRIPTION page 15
LANDSCAPE CONTEXT AND BUFFER DESCRIPTION
What's your impression of the condition/integrity of the buffer? Circle one: Excellent, Good, Fair, Poor Comments:
SIZE DESCRIPTION [Assess Size of Assessment Area, and the full extent of the area occupied by the type].
ON-SITE COMMENTS [overall description of the community/ecosystem]
Landscape Pattern [within AA] Description
Vegetation Description
Hydrology Description
Soils Description
Animal Description
What's your impression of the condition/integrity of the on-site community/ecosystem? Circle one: Excellent, Good, Fair, Poor Comments: Compare to EO rank?

Assessment Code: __ __ . __ __ __ L2.___ ___ ___

G. VEGETATION COMPOSITION PROFILE page 16				
ALWAYS COMPLETE THESE COLUMNS Cover scale: 0,1-4%, then +5% (5-14 etc)			**Did you skip listing dominant species because an L3 was completed.**	Y N
Growth forms / strata	**Cover (%)**	**Ht (m)**	**Dominant Species:** List **all** species **and** their absolute cover **if ≥5% cover,** to + 5% (e.g. 10% = 5-14 etc). **Optional:** list other characteristic or exotic spp < 5% (T= <1%, or 1-4%).	
Tm. Mature (tall) Tree (>5m)		___ To nearest 5 m.	*e.g. Acer rubrum – 10%*	
Ts. Sapling (medium) Tree (2-5m)				
Te. Seedling (small) Tree (< 2 m)				
S1. Tall Shrub (≥ 2 m)				
S2. Short / Dwarf-shrub (< 2 m)				
H1. Herb (Field, Emergent)				
A1. Floating-leaved Aquatic		X		
A2. Submerged Aquatic		X		
N. Non-vascular - Moss		X		
- Lichen		X		
- Algae		X		
V. Vine / Liana				

H. VEGETATION PROFILE page 17

Structural Stage: Estimate the % aerial cover of all trees in each structural stage to nearest 10%. Evaluate only the top canopy layer (i.e. view canopy from above, but canopy might be sapling layer). Total should add to 100%. [dbh ranges – eastern N.A. temperate]

_____% woody stages **absent** or **seedlings** (i.e. stems < 2m)
_____% **Sapling**: stems < 10 cm (< 4") dbh
_____ %**Pole**: stems 10-30 cm (4 – 12") dbh
_____%**Large**: stems 30—50 cm (12-20") dbh
_____ %**Very Large**: stems >50 cm (20") dbh

Structural Stage Comments: (e.g. is tree or tall shrub structure more or less even across the AA)

Standing Snags Comments: Describe presence & abundance of snags > 30 cm (12") dbh (e.g. do snags appear to be recently dead, etc.).

Dead Fallen Logs (CWD):
Comment on the presence and characteristics of CWD greater than 10 cm dbh.

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Assessment Code: __ __ . __ __ __ L2.___ ___ ___

I. ENVIRONMENTAL PROFILE page 18

Elevation (topo map):______ m /_______ft

Slope:_____ deg *or* ☐flat to <1%

Aspect (compass) downslope. _________ or ___none or _________variable.

Landform Comment [optional]:

___**Organic Soil**
____ muck, sapric (von Post 7-10)
____ peat, hemic (von Post 4-6)
____ peat, fibric (von Post 1-3)

Von Post scale of peat decomposition:________

___**Mineral Soil**
Texture (A -or top - horizon):
___SANDY
____ sand ___ loamy sand
___SANDY LOAM
____ sandy loam
___LOAMY
____ loam __ silt loam___silt
___CLAYEY
___ sandy clay loam ___ clay loam
___ silty clay loam ___ sandy clay
___ silty clay ___ clay

Unvegetated Surface
(does not need to add to 100%; mentally remove plant layers; ignore below water):
_____% Surface Water
_____% Litter, duff, small wood < 10 cm dbh
_____% Wood >10 cm dbh
_____% Rock
_____% Bare surface
_____% Other (describe):

Hydrologic Regime:
[WT=water table; GS=growing season]

___**Saturated**: saturated to surface for extended periods during GS; surface water seldom present
___**Seasonally saturated**: saturated to surface but absent by end of most GS
___**Permanently flooded**: water covers surface throughout year in all years
___**Semipermanently flooded**: surface water persists throughout GS in most years (excl. droughts); when absent, WT usually at/very near surface
___**Seasonally flooded**: surface water is present early in GS, but absent end of season in most years; when absent, WT often near surface
___**Temporarily flooded**: surface water present for brief periods in GS, but WT usually well below surface for most of season; upland & wetland plants present
___**Intermittently flooded**: flooded for variable periods w/out detectable seasonal periodicity; weeks, months, or years may intervene between floods
___**Never inundated** ___**Unknown**

Soil Drainage:

___**Rapidly Drained**: no gleying in entire profile; typically coarse textured or on steep slope
___**Well Drained**: usually free of mottling in upper 3'; B red, brown, or yellowish
___**Moderately Well Drained**: commonly mottled in lower B and C or below 2'
___**Somewhat Poorly Drained**: soil moisture in excess of field capacity remains in horizon for moderately long periods during year; commonly mottled in B and C
___**Poorly Drained**: soil moisture in excess of field capacity in all horizons for large part of year; soils usually very strongly gleyed
___**Very Poorly Drained**: free water remains at/within 12" of surface most of year; strongly gleyed

Hydrological Condition
a. Current Water Depth, approx deepest point: _____ (nearest 0.5 m)

b. Estimated High Water Depth:
From surface water or soil surface (nearest 0.5 m): ______

Evidence of high water depth:_____________

Water Source:
Pick one primary (write "**1**"), up to two others ("**2**"), as needed.
___**Direct precipitation**
___**Surface/overland flow**: run-off
___**Groundwater**
___ Discharge: released into wetland
___ Saturation: wetland near WT surface
___**Water body inundation**: surface water from marsh/swamp due to adjacent river/lake
___**Overbank flow**: flooding river/stream
___**Inbank flow**: contained within river channel
___**Anthropogenic**
____ Direct input: irrigation, pumped
____ Overland flow - urban,
____ Overland flow - rural
___**Other** (describe):

HGM Class:
Pick one primary (write "**1**"); if needed, pick a secondary (write "**2**")
____ **Riverine**
____ **Depressional**
____ **Slope**
____ **Mineral Soil Flats**
____ **Organic Soil Flats**
____ **Estuarine Fringe**
____ **Lacustrine Fringe**

HGM Class Comments:

Environmental Comments (any other characteristics worth noting, e.g., stoniness, hardpans, drainage, water flow):

Assessment Code: __ __ . __ __ __ L2.__ __ __

Ecological Integrity Assessment: Level 2 METRICS

STATE HERITAGE NAME:	HGM CLASS (PRIMARY):

GUIDANCE: CIRCLE THE BEST FIT LETTER FOR EACH METRIC. IF HARD TO DECIDE, MAKE COMMENT, BUT STILL SELECT ONE CHOICE.
COMMENTS/EVIDENCE: NOTES, AS NEEDED, IN SCORING METRIC. **METRICS 2a, 2b, 3b, 3c** have variants; specify type used in circle.

2. VEGETATION

Instructions for Vegetation Metrics are on PAGE 27 of the field manual

2a. VEGETATION STRUCTURE [see veg profile]						
METRIC TYPE = ____		METRIC TYPE 1. SWAMP & FLOODPLAIN FOREST		METRIC TYPE 2. BOG & FEN		METRIC TYPE 3. SHRUB SWAMP, WET MEADOW MARSH, SHRUB/HERB RIPARIAN, AQUATIC OTHER________
A		• Canopy a mosaic of patches of different tree sizes, with variation in gap sizes, AND • # of live stems of medium size (30-50 cm / 12-20") and large size (> 50 cm / >20" dbh) well within expected range.		• Peatland supports vegetation typical of minimally or minor disturbed conditions • Woody vegetation typical and mortality due to natural factors (some very wet peatlands may have little to no woody vegetation).		• Vegetation structure is at or near minimally disturbed conditions. • No structural indicators of degradation evident.
B		• Canopy largely heterogeneous tree sizes; some variation in gap sizes, AND • # of live stems of medium and large size within or very near expected range.				
C		• Canopy somewhat homogeneous in size, AND • # of live stems of medium and large size below but moderately near expected range.		• Peatland vegetation moderately degraded by anthropogenic factors. • Some expected structural classes or woody vegetation not present. • Recovery possible if degrading influences removed.		• Vegetation structure is moderately altered from minimally disturbed conditions. • Several structural indicators of degradation evident.
D		• Canopy very homogeneous in size, AND • # of live stems of medium and large size well below expected range.		• Peatland vegetation much degraded by anthropogenic factors. • Woody regeneration minimal, veg. structure poor, unnaturally sparse, or depauperate. • Recovery questionable without restoration or will take decades.		• Vegetation structure is greatly altered from minimally disturbed conditions. • Many structural indicators of degradation evident
		Comment/Evidence:				

2b. ORGANIC MATTER ACCUMULATION						
METRIC TYPE = ____		METRIC TYPE 1. SWAMP & FLOODPLAIN FOREST		METRIC TYPE 2. BOG & FEN		METRIC TYPE 3. SHRUB SWAMP, WET MEADOW, MARSH, SHRUB/HERB RIPARIAN, AQUATIC, OTHER__________
A/B		• Wide size-class diversity of standing snags and CWD (downed logs). • Larger size class (>30 cm dbh/12" dbh and > 2 m/6' long) present with 5 or more snags per ha (2.5 ac), but not excessive #s. • CWD in various stages of decay.		• Site is characterized by an accumulation of peaty, hummocky organic matter. • Organic matter is of various sizes, some very old.		• Site characterized by moderate amount of litter (fine organic matter), occasional CWD, various sizes. • New litter seems more prevalent than old litter. • Litter and duff layers and leaf piles in pools or topographic lows are thin.
C		• Moderate size-class diversity of standing snags or downed CWD; • Larger size class present with 1-4 snags per ha, or moderately excessive #s. • CWD in various stages of decay.		• Site is characterized by some areas lacking an accumulation of peaty, hummocky organic matter. • Size of organic matter does not vary greatly, nor appear very old.		• Site characterized by either patchy areas of little to no litter or somewhat excessive amounts of fine organic matter or CWD. • Old litter seems more prevalent than new litter
D		• Low size-class diversity of downed CWD and snags. • Larger size class present with <1 snag per ha, or very excessive #s. • CWD mostly in early stages of decay.		• Site is characterized by large areas without peaty, hummocky organic matter. • Size of organic matter does not vary greatly, nor appear very old.		• Site lacks litter accumulation, OR contains excessive litter accumulation.
		Comment/Evidence:				

2c. COVER OF NATIVE PLANT INCREASERS			EVIDENCE List and Percent Cover (to nearest 5%) of native increaser species at site. If a B, C, or D rating is assigned, list species and **percent** cover. Ex: some species of *Acer, Cornus, Dennstaedtia, Rubus, Rhus, Solidago, Toxicodendron, Typha*	
Absent or incidental: <1% cover, and less than 5% relative dominance in any dominant layer.*	A		**Increaser Species and % Cover**	**Increaser Species and % Cover**
Present: <10% total cover and 5-20% relative dominance in any dominant layer.*	B			
Common: <20% total cover and <30% relative dominance in any dominant layer.*	C			
Dominant: >20% total cover and >30% relative dominance in any dominant layer.*	D			
Comments:				

*Dominant layer is any layer with >25% cover

2d. RELATIVE COVER OF NATIVE PLANT SPECIES [see vegetation data]	
Relative Cover of native plants > 99%	A
Relative Cover of native plants 97 to 99%.	B
Relative Cover of native plants 90 to 96%.	C
Relative Cover of native plants 50 to 89%.	D
Relative Cover of native plant spp. < 50%	E
Comments/Evidence:	

2e. COVER OF EXOTIC <u>INVASIVE</u> PLANT SPECIES [see vegetation data]	
Exotic invasive plant species absent (<1% absolute cover).	A
Exotic invasive plant species present, but sporadic (1-2% cover).	B
Exotic invasive plant species prevalent (3–10% cover).	C
Exotic invasive plant species abundant (>10% cover).	D
Comments/Evidence:	

2f. VEGETATION REGENERATION **Swamp & Floodplain Forest only, otherwise N/A** **[see vegetation & stem data]**	
Native saplings and/or seedlings common to the type present in expected amounts; obvious regeneration.	A
Native saplings and/or seedlings common to the type present but less than expected.	B
Native saplings and/or seedling common to the type present but low amounts; little regeneration.	C
No reproduction of native woody species common to the type.	D
Comments/Evidence:	N/A

2g. VEGETATION COMPOSITION [partially integrates 2c – 2f above]	
Vegetation composition minimally to not disturbed. i) Native species indicative of anthropogenic disturbance (increasers, weedy or ruderal species) absent to minor; AND ii) Typical range of diagnostic species present, including those native species sensitive to anthropogenic degradation.	A
Vegetation composition with minor disturbed conditions. i) Some native species indicative of anthropogenic disturbance (increasers, weedy or ruderal species) are present but minor in abundance, AND ii) Some diagnostic species absent or substantially reduced in abundance.	B
Vegetation composition with moderately disturbed conditions. i) Species are still largely native and characteristic of the type, but they also include increasers, weedy or ruderal species, AND ii) Many diagnostic species absent or substantially reduced in abundance.	C
Vegetation composition with severely disturbed conditions. i) Species from entire strata may be absent or species are dominated by ruderal ("weedy") species, or comprised of planted stands of non-characteristic species, or unnaturally dominated by single species, OR ii) Most or all diagnostic species absent, a few may remain in very low abundance.	D
Comment/Evidence: [Also see vegetation data]	

Assessment Code: __ __ . __ __ __ L2.__ __ __

3. HYDROLOGY **Instructions for Hydrology Metrics are on PAGE 28 of the field manual**

3a. WATER SOURCE [For all types], [See "Water Source" in Environmental Profile]	
Source is natural or naturally lacks water in the growing season; no indication of direct artificial water sources	A
Source is mostly natural, but site directly receives occasional or small continuous amounts of inflow from anthropogenic sources	B
Source is primarily urban runoff, direct irrigation, pumped water, artificially impounded water, or other artificial hydrology	C
Water flow has been substantially diminished by human activity	D
Comment/Evidence:	

3b. HYDROPERIOD

METRIC TYPE = ___		Metric Type 1. RIVERINE [channels, shores, open to forested floodplains]		Metric Type 2. NON-RIVERINE [excluding BOG & FEN]		Metric Type 3. NON-RIVERINE [BOG & FEN]* *could apply to poor swamps, basin marshes.		
A		Natural channel; no evidence of severe aggradation or degradation		**Natural patterns** of filling/inundation and drying/drawdown OR saturation / seepage discharge.		Stable, saturated hydrology, or by naturally damped cycles of saturation and partial drying		
B		Most of the channel has some aggradation or degradation, none of which is severe		**Excess** water filling/saturation/seepage, for greater or shorter time periods than natural patterns, but **natural patterns** of drying/drawdown.		Minor altered inflows or drawdown/drying (e.g. ditching)		
C		Evidence of severe aggradation or degradation of most of the channel		**Natural** filling/saturation / seepage but **excess or insufficient** drying/drawdown, OR **Insufficient** water filling / saturation /seepage, but **natural** drying/drawdown.		Moderately altered by increased or decreased inflow from runoff or drawdown or drying (e.g. ditching)		
D		Concrete, or artificially hardened, channels through most of the site		Both filling/inundation/saturation/ seepage discharge deviate (greater or less than) and drying/drawdown deviate from natural.		Substantially altered by increased or decreased inflow from runoff, or large drying/drawdowns (e.g. ditching)		
		Comment/Evidence:						

3c. HYDROLOGIC CONNECTIVITY

METRIC TYPE = ___		Metric Type 1. RIVERINE [channels, shores, open to forested floodplains]		Metric Type 2. NON-RIVERINE [excluding BOG & POOR FEN]		Metric Type 3. BOG & POOR FEN		
A		Completely connected to floodplain; no geomorphic modifications made to contemporary floodplain.		No obstructions to the lateral movement of water with adjacent wetlands or uplands.		Little to no connectivity		
B		Minimally disconnected from floodplain; up to 25% of streambanks are affected.		Lateral movement is partially restricted; but < 25% of the site is restricted by barriers to drainage into wetland.				
C		Moderately disconnected from floodplain due to multiple geomorphic modifications; 25 – 75% of streambanks are affected.		Lateral movement is partially restricted; **and** 25-75% of the site is restricted by barriers to drainage into wetland.		Human caused partial connectivity (e.g. ditching or where duripan is broken by drilling or blasting)		
D		Extensively disconnected from floodplain; > 75% of streambanks are affected.		Essentially no hydrologic connection to adjacent wetlands or uplands. Most water stages contained, or > 75% of wetland is restricted by barriers to drainage into wetland.		Substantial to full connectivity.		
		Comment/Evidence:						

4. SOIL / SUBSTRATE CONDITION **Instructions for Soil/Substrate Metrics are on PAGE 28 of the field manual**

4a. SUBSTRATE / SOIL DISTURBANCE		4b. WATER QUALITY [If water not present on AA, circle N/A]	
Bare soil areas are limited to naturally caused disturbances such as flood deposition or game trails at natural densities.	A	No evidence of degraded water quality. Water is clear; no strong green tint or sheen.	A
Some bare soil due to human causes but the extent and impact is minimal. The depth of disturbance is limited to only a few inches and does not show evidence of ponding or channeling water.	B	Some negative water quality indicators are present, but limited to small and localized areas. Water may have a minimal greenish tint or cloudiness, or sheen.	B
Bare soil areas due to human causes are common. There may be bare soil trampling due to livestock resulting in several inches of soil disturbance. ORVs or other machinery may have left some shallow ruts.	C	Negative indicators or wetland species that respond to high nutrient levels are common. Water may have a moderate greenish tint, sheen or other turbidity with common algae.	C
Bare soil areas substantial & contribute to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock soil trampling and/or trails are widespread. Water will be channeled or ponded.	D	Widespread evidence of negative indicators. Algae mats may be extensive. Water may have a strong greenish tint, sheen or turbidity. Bottom difficult to see during due to surface algal mats and other vegetation blocking light to the bottom.	D
Comment/Evidence:		Comment/Evidence:	N/A

4c. PHYSICAL PATCH TYPE DIVERSITY [Assess based on the expected patch types possible at the site [not in general for the type]]	
Physical patch types typical of wetland type at site are present [e.g. riverine features, hummocks, wallows, pools, channels.	A / B
Some physical patch types at site are lacking based on expected natural conditions at site (give evidence)	C
Many physical patch types at site are lacking based on expected natural conditions at site (give evidence)	D
Comment/Evidence:	

5. SIZE **Instructions for Size Metrics are on PAGE 29 of the field manual**

5. SIZE [office metrics, field checked]

5a. ABSOLUTE PATCH SIZE		5b. RELATIVE PATCH SIZE [Degree (if any) reduced in size due to human activity]	
Very large compared to other examples of the same type (e.g., top 10% based on known and historic occurrences, or area-sensitive indicator species very abundant).	A	Occurrence is at, or only minimally reduced from, its full original, natural extent (retains >95% of original extent), and has not been artificially reduced in size.	A
Large compared to other examples of the same type (e.g. within 10-30%, based on known and historic occurrences, or most area-sensitive indicator species moderately abundant).	B	Occurrence is only modestly reduced from its original natural extent (retains 80-95% of original extent).	B
Moderate compared to other examples of the same type, (e.g., within 30-70% of known or historic sizes; or many area-sensitive indicator species are able to sustain a minimally viable population, or many characteristic species are sparse but present).	C	Occurrence is substantially reduced from its original, natural extent (retains 50-80% of original extent).	C
Too small to sustain full diversity and full function of the type. (e.g., smallest 30% of known or historic occurrences, or both key area-sensitive indicator spp. and characteristic spp. sparse to absent).	D	Occurrence is heavily reduced from its original, natural extent (retains <50% of its original extent).	D
Comments:		Comments:	

1. BUFFER OF AA **Instructions for Buffer Metrics are on PAGE 29 of the field manual**

1d. BUFFER LENGTH [typically, ignore breaks in buffer <5 m wide, unless very strong impact]. Assess perimeter of AA		1e. BUFFER CONDITION (WITHIN BUFFER LENGTH I.E. DO NOT INCLUDE CONDITION OF NON-BUFFERS, SUCH AS LAWNS, CROPLAND ETC.). Estimate condition within that part of the perimeter that has a buffer (see 1d), up to 200 m depth. Condition based on cover of native, non-native vegetation, disruption to soils, trash, or intensity of human activities.	
Buffer is 90 – 100% of Assessment Area.	A	Abundant (>95%) cover native vegetation, little or no (<5%) cover of non-native plants, intact soils, AND very little or no trash or refuse.	A
Buffer is 75 – 89%	B	Substantial (85–95%) cover of native vegetation, low (5–15%) cover of non-native plants, minimally disrupted soils, minimal trash, OR minor intensity of human visitation or recreation.	B
Buffer is 50 – 74%	C	Moderate (50–85%) cover of native plants, mod. (15–50%) cover of non-native plants, mod. soil disruption, mod. trash refuse, OR moderate intensity of human visitation or recreation.	C
Buffer is 25 – 49%	D	Low/moderate (25–50%) cover of native plants, substantial (50–75%) cover of non-native plants, extensive barren ground and highly compacted or otherwise disrupted soils, mod -great amounts of trash or refuse, moderate or greater intensity of human visitation or recreation.	D
Buffer is < 25%	E	Low (<25%) cover of native plants, dominant (>75%) cover of non-native plants, extensive barren ground and highly compacted or otherwise disrupted soils, moderate - great amounts of trash, moderate or greater intensity of human visitation or recreation, OR no buffer at all.	E
Comment/Evidence:			

Assessment Code: __ __ . __ __ __ L2. __ __ __

LEVEL 2 STRESSOR CHECKLIST

Stressors: *direct threats*, "the proximate (human) activities or processes that have caused, are causing, or may cause the destruction, degradation, and/or impairment of biodiversity and natural processes."

Instructions begin on page 30 of the Field Manual.

Some Important Points about Stressors Checklists.

1. Stressors checklists must be completed for all 4 categories (B, V, S, H).
2. Buffer Perimeter is the entire perimeter **around the AA**, up to a distance of 200 m. Rely on imagery as much as possible beyond what you can see from the edge of the AA.
3. Assess Buffer Perimeter stressors and their effects within the Buffer Perimeter (NOT how buffer stressors may impact the AA).
4. Stressors for Vegetation, Soils, and Hydrology are assessed across the **assessment area; AA**.
5. Some stressors may overlap. E.g. 10 (Passive recreation) may overlap with 24 (Trampling). Choose only 1 and note the overlap.

Assess for up to next 10 yrs	Threat Scope (% of AA affected)	Assess for up to next 10 yrs	Threat Severity (within the Scope) (degree of degradation of AA
A = Small	Affects a small (1-10%) proportion	A = Slight	Likely to only slightly degrade/reduce
B = Restricted	Affects some (11-30%)	B = Moderate	Likely to moderately degrade/reduce
C = Large	Affects much (31-70%)	C = Serious	Likely to seriously degrade/reduce
D = Pervasive	Affects all or most (71-100%)	D = Extreme	Likely to extremely degrade/destroy or eliminate

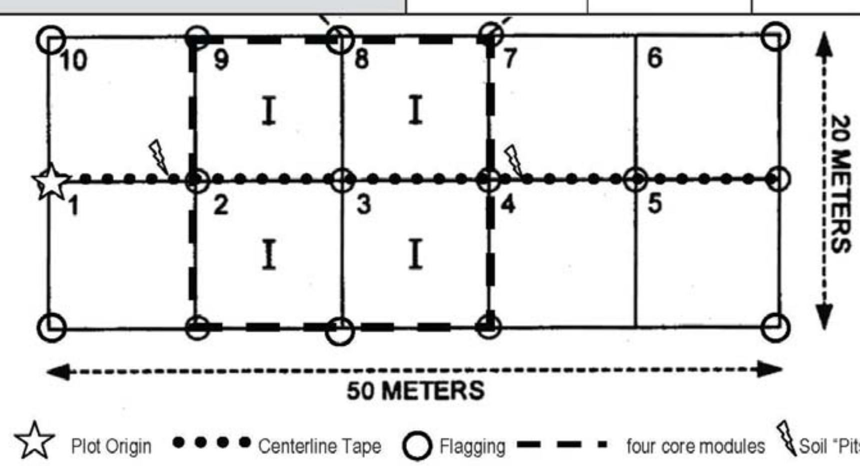
6.

		Buffer Perimeter			Vegetation [AA]			Soil / Subs. [AA]			Hydrology [AA]			
	STRESSORS CHECKLIST	Scope	Sever		Scope	Sever		Scope	Sever		Scope	Sever		Comments (circle stressor #)
	1. Residential, recreational buildings, associated pavement													1
D	2. Industrial, commercial, military buildings, associated pavement													2
E	3. Utility/powerline corridor													3
V	4. Sports field, golf course, urban parkland, lawn													4
E	5. Row-crop agriculture, orchard, nursery													5
L	6. Hay field													6
O	7. Livestock, grazing, excessive herbivory													7
P	8. Roads (gravel, paved, highway), railroad													8
	9. Other [specify]:													9
R	10. Passive recreation (bird-watching, hiking, trampling, camping)													10
E	11. Active recreation (ATV, mountain biking, hunting, fishing, boats)													11
C	12. Other [specify]:													12
	13. Woody, non-woody resource extraction: trees, shrubs, herbs													13
V	14. Vegetation management: cutting, mowing													14
E	15. Excessive animal herbivory, insect pest damage													15
G	16. Invasive exotic plant species													16
	17. Pesticide or vector control, chemicals (give onsite evidence)													17
	18. Other [specify]:													18

	STRESSORS CHECKLIST	Buffer [200 m] Scope	Buffer [200 m] Sever	Vegetation [AA] Scope	Vegetation [AA] Sever	Soil / Subst. [AA] Scope	Soil / Subst. [AA] Sever	Hydrology [AA] Scope	Hydrology [AA] Sever	Comments (circle stressor(s)
	CONTINUED									
Nat	19. Altered natural disturb regime [specify expected regime]									19
Dis	20. Other [specify]:									20
	21. Excessive sediment or organic debris (recently logged sites), gullying, erosion									21
S	22. Trash or refuse dumping									22
O	23. Filling, spoils, excavation									23
I	24. Soil disturbance: trampling, vehicle, pugging, skidding, etc									24
L	25. Grading, compaction, plowing, discing									25
	26. Physical resource extraction: rock, sand, gravel, etc									26
	27. Other [specify]:									27
H	28. PS discharge: treatment water, non-storm discharge, septic									28
Y	29. NPS discharge: urban runoff, farm drainage									29
D	30. Dam, ditch, diversion, dike, levee, unnatural inflow, reservoir									30
R	31. Groundwater extraction (water table lowered)									31
O	32. Flow obstructions (culverts, paved stream crossings)									32
L	33. Engineered channel (riprap, armored channel bank, bed)									33
O	34. Actively managed hydrology (e.g. lake levels controlled)									34
G	35. Tide gate, weir/drop structure, dredged inlet/channel									35
Y	36. Other [specify]:									36
	Stressors Very Minimal or Not Evident (check box, if true)	☐		☐		☐		☐		

LEVEL 3 ASSESSMENT FORM

General Information page 32			
Site Name	Photographer: _____(Y/N) Photographs taken at 0 and 50 m points, looking inward to plot.		
L3 Assessment Code (e.g. NY.DFL.L3.001) _ _ .__ __ __.L3.__ __ __	*GPS Location* Set GPS to : UTM Zone = 16	Datum = NA83, or	WGS84
L2 Assessment Code: _ _ .__ __ __.L2.__ __ __		0m	50
Date __ __ __ __.__ __. __ __ YEAR MO DAY	UTM-E:		
Team Members: Leader: Co-Leader: Assistant:	UTM-N:		
	LAT:		
Ownership [office]:	LONG:		
	Accuracy:		



Plot Notes: Standard Layout__YES / NO: If NO, explain Alternative Layout. Alternative Layout should preferentially retain the overall 0.1 ha area and the four core 100 m² modules.

Plot Representativeness- Is plot typical of assessment area:
__YES __ NO, but variation part of type at site (e.g. shrubby area in prairie; sedge depressions in swamps)
__ NO, variation atypical or includes parts of other types, but less than 10% in core modules
__ NO, variation atypical or includes parts of other types, > 10% in core modules

VEGETATION SPECIES PROFILE: Level 3 page 33								
Cover Classes 1: trace 2: 0.1–<1% 3: 1–<2% 4: 2–<5% 5: 5–<10% 6: 10–<25% 7: 25–<50% 8: 50–<75% 9: 75–<95% 10: >95%								
Cover = Canopy Cover - percentage of ground covered by the vertical projection of outermost perimeter of natural spread of foliage of plants.		Module 100m2 Estimate Cover either for each of the four 100 m² modules OR for a single 400m² plot				400 m2	1000m2 Estimate cover for additional spp.	Asst A List
Species	Collect Info	%Cover	%Cover	%Cover	%Cover	%Cover	%Cover	Present
Start module list with mature trees first (≥ 10 cm), but record cover on stem profile page). Record sapling and seeding here.		2	3	8	9	Total	Rest	Nearby
Unvegetated surface (% cover) across MODULE 2,3,8,9:: ____Surface Water ____Litter, duff, small wood < 10 cm diameter ____Dead Wood > 10 cm diameter ____Rock ____Bare Surface ____Other(describe):								
TREE								
E.g. Acer rubrum (mature)		X						
Acer rubrum (seedling)		2						
SHRUB								

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L3 Assessment Code___ . __ . __ . __ . L3. ___

VEGETATION SPECIES PROFILE: Level 3 page 33

Cover Classes 1: trace 2: 0.1–<1% 3: 1–<2% 4: 2–<5% 5: 5–<10% 6: 10–<25% 7: 25–<50% 8: 50–<75% 9: 75–<95% 10: >95%

Cover = Canopy Cover - percentage of ground covered by the vertical projection of outermost perimeter of natural spread of foliage of plants.		Module 100m2 Estimate Cover either for each of the four 100 m² modules OR for a single 400m² plot				400 m2	1000m2 Estimate cover for additional spp.	Asst A List
Species	**Collect Info**	%Cover 2	%Cover 3	%Cover 8	%Cover 9	%Cover Total	%Cover Rest	Present Nearby
Start module list with mature trees first (≥ 10 cm), but record cover on stem profile page). Record sapling and seeding here.								

K. VEGETATION STEM PROFILE. Level 3: 10 x 10 m for saplings, 20 x 20 for stems > 10 cm dbh, 20 x 50 for stems > 30 cm dbh
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	10 x 10	20 x 20					Rest of plot			Entire plot
Species	1-9.9 cm dbh (2-5 m tall)	10-19	20-29	30-39	40-49	50+ cm dbh (write each stem)	30-39	40-49	50+ cm write each stem	Canopy Cover % (≥ 10 cm dbh)*
Example: Acer rubrum		III	I		III	*71, 53*			*56, 85*	*45%*
Standing snags ≥ 10 cm dbh Species ID not needed.	X									X
Fallen Logs ≥ 10 cm diameter (dia): record dia. and length within plot (only include length where stem is ≥ 10 cm dia.). Species ID not needed.	X									X
Example (note: if ≥ 50 cm, record both the dbh and the length)	*X*	*7*	*3, 9*	*11, 5*	*6*	*61-10, 52-6*				*X*

*Include overhanging trees. A 10 x 10 module is 10% of the plot

L. Soil Profile Level 3. A soil auger or soil core may be used instead of digging a pit.
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Pit 1 and Pit 2 should be in separate modules just outside the 400 m^2 area.

Soil Characteristic	Note:	Pit 1	Pit 2
Depth to Impervious Layer (cm)	**If > 50 cm, put > 50 cm**		
Depth to Saturated Soils (cm)	**If > 50 cm, put > 50 cm**		
Depth to Water Table(cm)	**If > 50 cm, put > 50 cm**		
Is Soil Organic? Y or N	**Type (S= sapric, H = hemic or F= fibric)**		
	Thickness of Organic Layer (cm)		
If Mineral: Texture of Soil			

Comments: additional substrate characteristics (e.g. marl layers, isolated depressions, etc):

8 APPENDIX III. CREDIT / DEBIT CALCULATOR RATIOS

We have developed a system of debit and credit ratios based on the Watershed Priority which includes the watershed profile rating, the wetland complexity rating, and the ecological integrity rating. These ratings are all on the same scale and use these values to calculate the "value" of a loss (i.e. the amount of debt) which must be compensated. The same scale can be used to indicate the potential increase in wetland value (increase in the Watershed Priority via an increase in the Ecological Integrity Score) along with the risks of mitigation failure. This system allows us to compare different types of wetlands and to quantify watershed priority ratings in order to calculate mitigation required to compensate for impact loss. These comparisons assume some level of mitigation will occur (preservation, restoration, enhancement or establishment/creation) that improves its ecological integrity score and potentially the wetland's watershed priority standing.

We introduced the role of wetland complexity in Section 2.2 Step 2- Wetland Type Rating above (page 20). The complexity of the type of wetland determines just how much potential credit is possible; where more complex wetlands carry a greater risk of mitigation failure and therefore require a higher ratio of compensation.

We developed an excel spreadsheet to calculate the ratio for in-kind and out-of-kind mitigation scenarios. The excel spreadsheet has automatic calculations based on user input of the wetland type and the current EIA score. With this tool we could compare many types of "impact" wetlands to many types and amounts of "mitigation." The following explains the numeric values used in the excel calculator based on the concepts described in the main body of the report.

1. Watershed Priority. Relative Weighting is based on information from the Juneau watershed profile (Figure 5, page 8):

- Tidal Salt Marsh (317 acres, 6%) = 11 x less abundant than Freshwater Forest/Scrub
- Wet Meadow & Marsh (1738 acres, 31%) = 2 x
- Floodplain & Swamp Forest/Bog & Fen (3210 acres, 61%) = 1 x

2. Wetland Type Complexity Rating based on difficulty and risk of restoration failure. The EIA score is a 1-5 score of ecological integrity so we have designed the complexity rating on the same scale, where 5 is the maximum obtainable score, a pristine wetland, the reference point.

The complexity of a wetland is based on the wetlands' type classification (NWI and/or NVC) and the vegetation, hydrology and soil structure expected for that type. The more complex these qualities are the more likely there is a higher risk of failure in a restoration effort and it takes more time to reach maturity and/or full complexity. The relative value of each wetland is the maximum level of ecological integrity that can be achieved through mitigation (preservation, restoration, enhancement or establishment/creation) times the difficulty of obtaining that complexity. The maximum level is always lower than 5, because we know created and restored wetlands are never as complex as undisturbed natural wetlands (Campbell et al. 2002, Bruland and Richardson 2006, Hossler and Bouchard 2010, Hoeltje and Cole 2007, Hartzell et al. 2007). This is the Cap to the EIA level achievable based on wetland type. Secondly, reaching that goal can be difficult as more complex wetlands are more difficult to mimic, so we have the

increment, the amount of ecological integrity that a wetland can be "pushed" through restoration or the abatement of threats.
Thus the Relative Value = Max obtainable Complexity (5-CAP) * Difficulty of obtaining that complexity (5-Increment)

- **Wet Meadow & Marsh** (5 - 4.5)*(5 – 3.5) **= 0.75**
- **Tidal Salt Marsh** (5 - 4)*(5 – 3) **= 2.0**
- **Floodplain & Swamp Forest** (5 - 4)*(5 – 0.5) **= 4.5**
- **Bog & Fen** (5 - 4)*(5 -0.5) **= 4.5**

3. How well is the wetland Performing? Now that we know a wetland type complexity rating, we can add how well a wetland is performing by multiplying the EIA score of a wetland expressed as a percentage, Ecological Integrity Score (High 100%, Medium 60%, Low 30%)

4. Prioritize Wetlands we can prioritize wetlands based on their watershed priority, the wetland type complexity rating and the EIA score:
Watershed weight * Complexity * EIA%

- **Tidal Salt Marsh** 11*2 * 1 **= 22 (High)**
- **Bog & Fen** 1*4.5 * 1 **= 4.5 (Med)** (we set the watershed priority rating to 1 as the NWI map did not differentiate Bogs and Fens, but we wanted to include them in this analysis)
- **Floodplain & Swamp Forest** 1*4* 1 **= 4 (Med)**
- **Wet Meadow & Marsh** 2* 0.75 * 1 **= 2.7 (Low)**

Table 9. Watershed Priority values (these values differ slightly form Table 2, which has been modified to fit the conservation and restorations literature.

Wetland Type	Watershed Priority	Complexity Rating	EIA Score (expressed as a %)	Watershed Priority (rounded values)
Tidal Salt Marsh	11	2	5 (100%)	22 (High)
Tidal Salt Marsh	11	2	3 (60%)	13 (High)
Tidal Salt Marsh	11	2	2 (30%)	7 (Mod)
Wet Meadow & Marsh	2	1	5 (100%)	2 (Mod)
Wet Meadow & Marsh	2	1	3 (60%)	1 (Low)
Wet Meadow & Marsh	2	1	2 (30%)	<1 (Low)
Floodplain & Swamp Forest /Bog & Fen	1	5	5 (100%)	5 (High)

Wetland Type	Watershed Priority	Complexity Rating	EIA Score (expressed as a %)	Watershed Priority (rounded values)
Floodplain & Swamp Forest /Bog & Fen	1	5	3 (60%)	3 (Mod)
Floodplain & Swamp Forest /Bog & Fen	1	5	2 (30%)	1 (Mod)

5. Impact Debit – for any wetland we can calculate the per acre debit value by multiplying the Watershed Priority by the Complexity rating by the EIA score (expressed as a percentage) to get the "net present' value of the wetland. Example "debit values" can be seen in Table 9.

6. Credit Values. The amount of increase available in the EIA score is limited based on the wetland complexity. Table 10 lists some of the credit values available depending on wetland complexity and the different EIA starting points. These values assume restoration and enhancement that affects the EIA scores of wetlands. The limit to credit is a way of incorporating the risk of failure as stated by King and Elizabeth (2009). Here we used these limited quantities of credit to test a complexity-based debt to credit ratios.

Table 10. Credit Values available for mitigation action that increase the EIA score.

Type of Wetland	EIA Change	Credit
Low Complexity	Low -> High	2.5
(Cap 4.5, increment 3.5)	Med->High	1
	High->High	0.5
Medium Complexity	Low -> High	2.0
(Cap 4, increment 1.5)	Med->High	0.5
	High->High	0.2
High Complexity	Low -> High	1.5
(Cap 3.5, Increment 1.0)	Med->High	0.5
	High->High	0.1

7. Debt to Credit Ratios—The excel spreadsheet calculates the impact and credit using the watershed profile, wetland complexity and EIA scores. This spreadsheet uses lookup tables to bring in the appropriate Watershed Profile values and Complexity rating values based on the NWI or NVC classification name. The credit earned was limited by the increment and cap set forth by the complexity rating (above). Once programmed, the spreadsheet could then compare any combination of wetlands, and we could see the "credit value" from any type of mitigation action that improves the EIA score. We summarized our findings by High, Med and Low priority wetlands with their EIA score indicated separately in order to illustrate the value of the credit being applied. By dividing the credit values gained for any type of wetland into the debt values, we arrive at the debt/credit ratios in Table 11. Here we take the full debt (impact) value and *divide it only by the increase in wetland value (credit*) incurred with increase in EIA score.

These values illustrate that very complex and highly valued wetlands cost more in terms of their Debt (impact) and that taking an existing, pristine wetland does not "earn" much credit (because it already exists on the landscape). The greatest amount of credit in these calculations can be earned by restoring or creating the least complex type of wetland.

Table 11. Debit/Credit Ratios Summarized by Watershed priority and Site Ecological Integrity Score. Ratios are impact site Debt based on the watershed priority and the Ecological Integrity Score and Credit earned through increasing wetland's EIA score on different priority wetlands on an acre per acre basis.

	Debit/Credit Ratio (acres)	Mitigation Site-- increase in wetland value								
	Wetland Priority & Ecological Integrity Score	High Priority Wetland EIA from High to Protected	High Priority Wetland EIA from Med to High	High Priority Wetland EIA from Low to High	Moderate Priority Wetland EIA from High to Protected	Moderate Priority Wetland EIA from Med to High	Moderate Priority Wetland EIA from Low to High	Low Priority Wetland EIA from High to Protected	Low Priority Wetland EIA from Med to High	Low Priority Wetland EIA from Low to High
Impact Site (1 acre)	High Priority Wetland EIA High	31	19	15	16	21	8	16	28	13
	High Priority Wetland EIA Med	22	14	11	12	15	6	12	20	10
	High Priority Wetland EIA Low	16	10	8	9	11	4	8	14	7
	Moderate Priority Wetland EIA High	29	18	14	15	19	8	15	26	12
	Moderate Priority Wetland EIA Med	21	13	10	11	14	6	11	19	9
	Moderate Priority Wetland EIA Low	15	9	7	8	10	4	8	14	6
	Low Priority Wetland EIA High	6	4	3	3	4	2	3	5	3
	Low Priority Wetland EIA Med	4	3	2	2	3	1	2	4	2
	Low Priority Wetland EIA Low	3	2	2	2	2	1	2	3	1

However in practice, in the regulatory world, we do not want to encourage the creation of less complex wetlands, in fact, nation-wide, we have created too many poorly functioning cat-tail rimed ponds. Therefore we took the range of values indicated in Table 11 to guide us to more practical and simple policy driven ratios (Table 3, page 30). By using wetland valuation we hope to direct compensatory mitigation in a direction that improves the status of high priority wetlands and water resources for the watershed.

References

All references cited in Appendix III are listed in the References section in the main body of the report (Section 5, page 33).