HUMBOLDT STATE UNIVERSITY

Application of the California Rapid Assessment Method on Strawberry Creek

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Introduction

The California Rapid Assessment Method (CRAM) is a diagnostic tool used to quickly assess wetland health within a short amount of time. This streamlined approach provides quick and useful information about the overall health of a wetland. Information gathered this way can then be used to better equip land managers with the tools to enhance or restore their wetlands. The goal of CRAM is to "provide rapid, scientifically defensible, standardized, cost-effective assessments of the status and trends in the condition of wetlands and related policies, programs and projects throughout California." (CWMW 2012) Information gathered using CRAM methods allows for recurring and consistent data to be used and evaluated over the long term. CRAM assesses several variables important to the proper function of a healthy wetland: buffer and landscape context, hydrology of immediate area, overall physical structure, and the biotic structure of the system. All of these variables have subset qualities that are looked at and then graded based on tables provided within the CRAM handbook. Scores collected this way are then interpreted on a grading scale ranging from 30-100, higher being "healthier" (CWMW, 2012).

The application of CRAM is used to assess impacted wetlands and the results can help guide restoration efforts. The process was developed with a module system and within each module are metrics which allow the user to apply the method step by step. Following CRAM guidelines breaks down the information into several categories that can dictate restoration efforts based on severity of degradation. The options of utilizing CRAM can vary from determining project areas, reference conditions, or long term monitoring. The overall simplicity of CRAM makes it a great tool for anyone to use. Periodic field courses are open to the public throughout the year in order to provide the basic level of understanding of wetlands and applying CRAM (CWMW, 2012).

Our project was a unique application on a wetland with characteristics not typical for the modules provided within CRAM. Strawberry Creek is located in Orick, CA. ~34 miles north of Arcata. Strawberry Creek is currently impacted from having the channel relocated, ranching, sedimentation from historical logging, and dominated by invasive species. One particular feature that makes Strawberry Creek unique is its floating vegetation. Although there are some characteristics similar to a fen, there is no open channel and only seasonally standing water. There is no open channel due to the invasive plant reed canary grass (*Phalaris arundinacea)*. The plant is highly invasive and one of its characteristics is to create a mat by weaving together (Reinhardt 2004). Parts of the system go beyond 5' deep below the vegetation mat. Although there is no real evidence as to how the system was formed, it is believed that sediment for up in the water shed was able to collect in the mat and over time slowly close over the channel (Reinhardt 2004). Currently Strawberry Creek flows under a layer of vegetation up to a meter thick. Walking on the wetland feels similar to that of a water bed, as each step creates ripples in the vegetation. Modules within the CRAM assessment are fit to systems with defined characteristics; however Strawberry Creek poses an interesting test of the CRAM assessment because it does not conform to typical wetlands occurring in California. In this analysis we used from CRAM, the Wet Meadow Module and Riverine Module. By applying these two modules at the Strawberry Creek site, we are able to compare the results of each to determine which one better represents the system. Our conclusions will determine which module better fits Strawberry Creek; while simultaneously determining the accuracy of CRAM by comparing it to non-rapid methods of landscape level restoration planning.

Alternative Methods to CRAM

Strawberry Creek's unique habitat, consisting of a massive floating mat of vegetation, leaves habitat assessment and analysis open and susceptible to a myriad of different approaches. One alternative is to focus on experiments and habitat assessments that have been performed on floating vegetation environments throughout the United States. Although, floating mats found within the United States probably do not share the same evolutionary processes and are generally not as large as Strawberry Creek's mat, the qualities and methods to analyze them may be extremely useful for assessments. Additionally, floating vegetative mats are rare to the west coast of America yet towards the southern and eastern states habitats and ecological processes are relatively similar and can be used as a potential reference. Furthermore, the ecology of fens and bogs share similar characteristics and successional patterns with Strawberry Creek's floating mat, and thus information and studies about these environments can be utilized to further understand abiotic and biotic factors involved with these types of ecosystems.

Another alternative to CRAM is to combine a series of habitat evaluation methods for each type of assessment within an area of interest. For instance, for each component of a habitat assessment (e.g. soils and geology, hydrology, vegetation, etc.) use a different method of evaluation, such as using the *Army Corps of Engineers Site Evaluation checklist for Wetland Soils* for the soil assessment and *BLM vegetation analysis* checklist for determining hydrophytic vegetation (U.S. Army Corps of Engineers 1987). This combination of different methods of assessing particular features of an environment is the most traditional form of assessment, in which specialist scientists and contract crews are hired to conduct surveys in their area of expertise (e.g. hydrology, geology, botany, GIS, etc). Although hiring professionals to conduct surveys on the environment can be rather time consuming and costly, the results are often accurate and quite representable of the area being studied. In theory applying, combining, and comparing the results of a diverse group of assessments may be the most precise way to develop an understanding and proper analysis procedure for Strawberry Creek's unique environment.

Problem:

- Wetland health needs to be assessed prior to restoration.
- New methods of assessment need fine tuning to improve and standardize the effectiveness and efficiency.

Problem Statement

Wetlands are those areas that are inundated or saturated by surface of groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils. Wetlands play a unique role in regulating global biogeochemical cycles, the cyclical transfer between living and non-living components of the biosphere. A wetland acts as a source and a sink for life giving elements including carbon, nitrogen, oxygen, sulfur, and phosphorus depending on the ecological health of the system (U.S. Army Corps of Engineers 1987).

1) Strawberry Creek is a unique wetland where three tributaries meet in an alluvial fan from its headwaters, forming an extensive floating mat before it empties into the lower reaches of Redwood Creek Slough. The assessment of the Strawberry Creek wetland is an important factor for future restoration plans by interested stakeholders to improve fish passage and coho rearing habitat.

2) Piloting the new methods proposed by the authors of CRAM becomes a problem because of the unique situation of the floating mat wetland. The CRAM authors have developed modules for specific wetland sites, but not for the floating mat wetland. For the purposes of developing a standardized, cost efficient tool to assess the health wetlands and riparian habitats, the authors require feedback from regional experts.

Goals and objectives

Goals

- Establish baseline information for restoration efforts of wetland health
- Improve and standardize the CRAM modules applicable to floating mat wetlands located I Orick, CA.

Objectives

- Complete both the "Wet Meadow" and "Riverine" modules of CRAM assessment **(October 19, 2012)**
- Complete/Submit final CRAM analysis report to Redwood National Park, Humboldt State University, and Estuary Institute **(October 31, 2012)**
- Complete Alternative method of wetland assessment **(November 9, 2012)**
- Compare/Contrast results of all assessment methods **(November 16, 2012)**
- Provide recommendations for improvements of CRAM assessment methods **(November 30, 2012)**

Our goals and objectives are twofold based on the problem statement; first we are tasked to use a new rapid method for assessing wetland health or function based on physical attributes or structure under the CRAM guidelines, second is to provide adequate feedback to the developers of CRAM based on our experiences piloting the new method in our region. California being a large state spanning approximately 1000 miles from the southeast corner the northwest corner encompasses vastly different ecology from the coast to the mountains, desert to temperate rainforest, and numerous types of wetlands associated with several variations in ecotones and land use histories. In our North Coast region alone exists several typical wetlands such as vernal pools, estuarine, riverine, and wet meadow just to name a few, but because of the land use history each type might be impacted to differing levels of severity. Piloting new methods of standardized rapid assessment requires using two types of assessment for two types of systems on one site providing comparable outcomes for each because of the uniqueness of Strawberry Creek. Based on these comparable results discovered under each module provide constructive feedback to help the authors finalize the methods outlined in CRAM (CWMW, 2012).

Site Description

Strawberry Creek is a small tributary that drains into Redwood Creek near the estuary on the west side of the town of Orick. The dominant soil type within the wetland adjacent to Strawberry Creek is the Arlynda series. Typical for the northern California coast, this soil series is very poorly drained with frequent ponding and a very high water capacity (11in). The soil texture is dominantly silty clay loam with a restrictive feature more than 80 inches below. Annual precipitation ranges between 35-80 inches, but is typically around 60.5 inches, and has about 275-330 frost-free days (CDEC, 2003: Soil Survey Staff, 2009). Historically the wetland was dominated as a spruce and alder system. With what is believed to be an old floodplain for Redwood Creek. However, after European settlement much of the wetlands within Orick valley were diked and leveed for agricultural use, especially following the Christmas flood of 1964. The land owner adjacent to the project area excavated and moved the Strawberry Creek channel to the furthest boundaries of his property. After Redwood National Park acquired the land for their operations center, Strawberry Creek became the target for restoration with the purposes of restoring historic salmon rearing habitat. Current efforts are moving forward, on adjacent private property, to excavate the channel by removing the mat and planting early successional riparian tree species along the channel such as Red alders (Alnus rubra) thus controlling the shade intolerant mat forming invasives encroaching the channel (Love,2008).

Methods

Scoring the wetlands

Establishing the Assessment Area

The first step of CRAM is to determine which wetland typology our project area fits into. Following a table of physical features, we were able to determine our particular project area was closest to non-confined riverine system, as well as a wet meadow (Figure 1). The reason we selected two wetland types was based on the first question, is there a channel? Since the floating mat completely covers the system there is no open flowing water that could be considered a "channel", although we do believe there are physical features of the historical channel underneath the vegetation. We classified it as a riverine simply because the inlet and outlets outside of our project area are distinguished. We therefore concluded that water has to be moving through the matted system, just not in an identifiable channel. Since there is a close proximity to the ocean we believed there was tidal influence, even if that influence is minimal. Wet meadow was

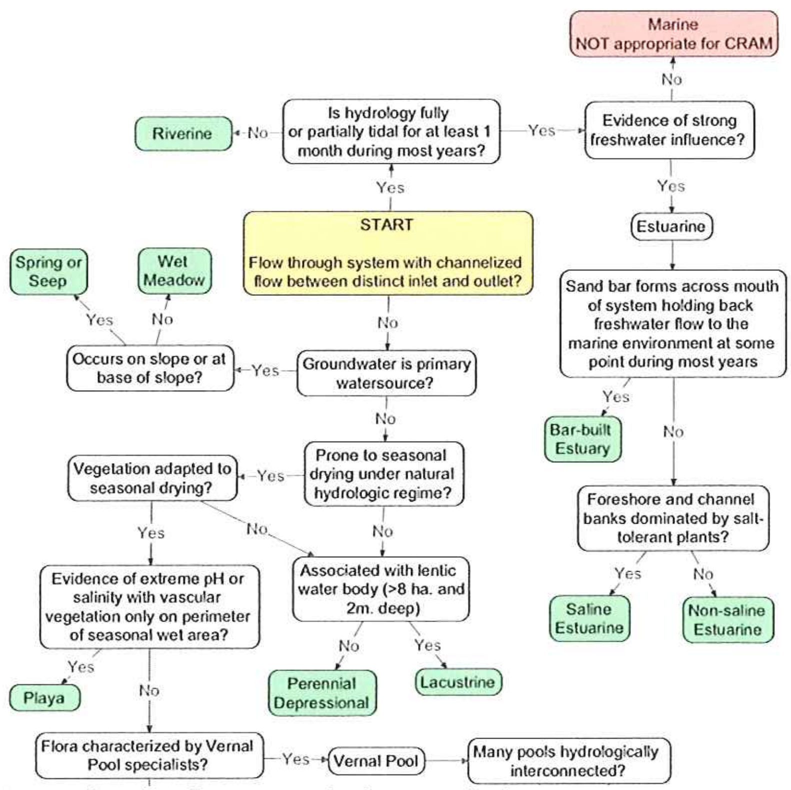


Figure 1: flow chart for CRAM wetland types and sub-types

selected by selecting no as an answer to the first question. Since there was no channelized flow, and is groundwater fed, as well as not occurring at or on a slope, we chose wet meadow.

Now that we had identified what wetland types we will be using, we began following the steps within each module. Each module requires an Area of Assessment (AA). Selecting AA's requires the user to be "rapid" in their approach, and not consider historical, future, or anything influencing their decisions. However, for our purposes of comparing modules and testing the method we did stop to consider where the AA's should be. Our selection had to encompass what we believed to be most representative of the area. For riverine we chose three different sites, one for each reach of Strawberry Creek (Appendix A). Reach A and B represent tributaries coming from the developed side as well as the forested side, and reach C is below the confluence in order to capture any change. Since the Riverine Module wants to encompass a channel, our AA's were along each reach of the channel. A similar approach was used to establish the AA for the Wet Meadow Module. The Wet Meadow Module aims at capturing the entire wetland adjacent to the channel, or where the channel is supposed to be. Our AA for Wet Meadow extends perpendicular from the channel across the entire wetland, from upland to upland (Appendix B). Once the AA's were established we could begin the CRAM assessment metrics.

Attribute 1: Buffer and Landscape Context

Aquatic Area Abundance

Wet Meadow Module:

This attribute is determined by accounting for all contact with hydrologic features within 500m in each cardinal direction. To score the aquatic area abundance we had to estimate the percent of each transect that passes through a wetland or aquatic habitat of any type (Appendix C). Once we calculated how much of the transect intersected an aquatic feature, the average percent for each direction is graded (Table 1).

Table 1: rating break down for aquatic area abundance metric

Rating	Alternative States
A	An average of 46 – 100 % of the transects is an aquatic feature of any kind.
B	An average of 31 – 45 % of the transects is an aquatic feature of any kind.
C	An average of 16 – 30 % of the transects is an aquatic feature of any kind.
D	An average of 0 – 15 % of the transects is an aquatic feature of any kind.

Riverine Module:

The Riverine Module is slightly different from the Wet Meadow, since part of the description involves a channel. The Riparian Continuity metric (aka aquatic area abundance) involves determining how much of the channel length upstream and downstream from the AA's are "broken" by development. This metric is attempting to determine how much interaction with adjacent aquatic features aren't being impacted by unfavorable habitat (Appendix D). In order for a segment to be considered a break in continuity, it must be at least 10m wide. Also, anything that is inhibiting interaction with adjacent features is considered a break (e.g. development, roads, and culverts). Once we identified the breaks in continuity our results are plugged into a table for an overall grade (Table 2)

Table 2: Grading break down for aquatic area abundance within the Riverine Module

Rating	For Distance of 500 m Upstream of AA:	For Distance of 500 m Downstream of AA:
A	The combined total length of all non-buffer segments is less than 100 m for wadeable systems ("2-sided" AAs); 50 m for non-wadeable systems ("1-sided" AAs).	The combined total length of all non-buffer segments is less than 100 m for wadeable systems ("2-sided" AAs); 50 m for non-wadeable systems ("1-sided" AAs).
B	The combined total length of all non-buffer segments is less than 100 m for "2- sided" AAs; 50 m for "1-sided" AAs.	The combined total length of all non-buffer segments is between 100 m and 200 m for "2- sided" AAs; 50 m and 100 m for "1-sided" AAs.
	OR	
	The combined total length of all non-buffer segments is between 100 m and 200 m for "2-sided" AAs; 50 m and 100 m for "1-sided" AAs.	The combined total length of all non-buffer segments is less than 100 m for "2-sided" AAs; is less than 50 m for "1-sided" AAs.
C	The combined total length of all non-buffer segments is between 100 m and 200 m for "2-sided" AAs; 50 m and 100 m for "1-sided" AAs.	The combined total length of all non-buffer segments is between 100 m and 200 m for "2- sided" AAs; 50 m and 100 m for "1-sided" AAs.
D	The combined total length of non-buffer segments is greater than 200 m for "2- sided" AAs; greater than 100 m for "1- sided" AAs.	any condition
	OR	
	any condition	The combined total length of non-buffer segments is greater than 200 m for "2-sided" AAs; greater than 100 m for "1-sided"

Buffer to assessment area
Percent of AA with buffer

Riverine Module:

In order to determine what percent of the AA perimeter has a buffer, we used Geographic Information System (GIS). By using GIS we were able to determine adjacent land types to the AA, and based on the land cover type table in CRAM document, delineate actual buffer amounts (Appendix E). Land types that aren't considered buffers are commercial development, fences that interfere with wildlife, and anything physically interfering with the natural system (Table 3). Small trails and roads with infrequent use do not act as an inhibitor to the buffer. Once all sides of the AA have been identified as buffer or non-buffer, the CRAM score is acquired from the document based on the amount of percent buffer around the perimeter (Table 4).

Table 3: Examples of land buffer and non-buffer types

Examples of Land Covers Included in Buffers	**Examples of Land Covers Excluded from Buffers** Notes: buffers do not cross these land covers; areas of open water adjacent to the AA are not included in the assessment of the AA or its buffer.
• at-grade bike and foot trails, or trails (with light traffic) • horse trails • natural upland habitats • nature or wildland parks • range land and pastures • railroads (with infrequent use: 2 trains per day or less) • roads not hazardous to wildlife, such as seldom used rural roads, forestry roads or private roads • swales and ditches • vegetated levees	• commercial developments • fences that interfere with the movements of wildlife (i.e. food safety fences that prevent the movement of deer, rabbits and frogs) • intensive agriculture (row crops, orchards and vineyards) • golf courses • paved roads (two lanes or larger) • active railroads (more than 2 trains per day) • lawns • parking lots • horse paddocks, feedlots, turkey ranches, etc. • residential areas • sound walls • sports fields • urbanized parks with active recreation • pedestrian/bike trails (with heavy traffic)

Table 4: Percent of AA perimeter that is adjacent to a buffer

Rating	**Alternative States (not including open-water areas)**
A	Buffer is 75 - 100% of AA perimeter.
B	Buffer is 50 – 74% of AA perimeter.
C	Buffer is 25 – 49% of AA perimeter.
D	Buffer is 0 – 24% of AA perimeter.

Wet Meadow Module:

The Wet Meadow Module requires users to establish a 250m buffer to the AA. Within this buffer we delineated several types of land covers, and determined which types were buffer or non-buffer segments (Appendix F). Non-buffer areas are developed areas, residential areas, sports fields, essentially the same things considered in the Riverine Module. Based on the amount of buffer segments, anything natural and undisturbed is considered bugger, is then scored (Table 4).

Average buffer width

Wet Meadow & Riverine Modules

This metric is the same for both modules. Determining the average buffer width involves running 250 meter lines perpendicular to the AA's. The line runs until it hits a non-buffer land type. This metric is determined easily by referring to the previous metrics result. Once you identify non-buffer segments within the perimeter, this metric can then run 250m lines from the buffer segments in order to save time. Both modules determine its score by taking the average length of each line and summing each value (Table 5). (Appendix G and H)

Table 5: Rating system for average buffer width metrics for both the Wet Meadow and Riverine Modules

Rating	Alternative States
A	Average buffer width is 190 – 250 m.
B	Average buffer width 130 – 189 m.
C	Average buffer width is 65 – 129 m.
D	Average buffer width is 0 – 64 m.

Buffer condition

Wet Meadow & Riverine Modules

Both modules buffer condition is an analysis of its health from a vegetation perspective. The overall quality of the AA is determined by whether or not it's dominated by invasive species, disturbance to soils, and frequency of human visitation (Appendix I and F). Our Wet Meadow and riverine AA's were analyzed by walking each area and assessing the conditions relative to table 6.

Table 6: Rating system for buffer condition

Rating	Alternative States
A	Buffer for AA is dominated by native vegetation, has undisturbed soils, and is apparently subject to little or no human visitation.
B	1) Buffer for AA is characterized by an intermediate mix of native and non-native vegetation (25-75%), but mostly undisturbed soils and is apparently subject to little or low impact human visitation.
	OR
	2) Buffer for AA is dominated by native vegetation, but shows some soil disturbance and is apparently subject to little or low impact human visitation.
C	Buffer for AA is characterized by substantial (>75%) amounts of non-native vegetation AND there is at least a moderate degree of soil disturbance/compaction, and/or there is evidence of at least moderate intensity of human visitation.
D	Buffer for AA is characterized by barren ground and/or highly compacted or otherwise disturbed soils, and/or there is evidence of very intense human visitation.

Attribute 2: Hydrology

Water source
Wet Meadow & Riverine Modules

This metric required our delineation of the watershed draining into Strawberry Creek and our AA's. We utilized Terrain Navigator Pro to determine the total area of the watershed and its boundaries. Then allowing us to interpret the entire area and figure out what rating each AA gets for both modules (Table 7). By delineating the watershed, we were able to determine from the aerial photography what diversions or impacts to the hydrology for this system were occurring.

Table 7: Wet Meadow and Riverine water source rating table

Rating	Alternative States
A	The freshwater sources that affect the dry season moisture regime of the AA, such as the extent and duration of groundwater-affected moisture in the root zone, are mainly natural groundwater fluctuations, but might also include direct precipitation, natural runoff, or natural flow from an adjacent freshwater body, or the AA naturally lacks water in the dry season. There is no indication that dry season conditions are substantially controlled by artificial or modified water sources.
B	The freshwater sources that affect the dry season moisture regime of the AA are mostly natural, but also obviously include occasional or small effects of modified hydrology, as evidenced by developed land or irrigated agricultural land that is likely to provide runoff or groundwater to the AA, but which comprises less than 20% of the immediate drainage basin within about 2 km upstream of the AA, or that is characterized by the presence of a few small storm drains or scattered homes with septic systems adjacent to or nearby the AA.
C	The freshwater sources that affect the dry season moisture regime of the AA are substantially affected by such factors as urban runoff, direct irrigation, pumped water, artificially impounded water, water remaining after diversions, regulated releases of water through a dam, artificial recharge, or other artificial hydrology. Indications of substantial artificial groundwater hydrology include developed or irrigated agricultural land that comprises more than 20% of the immediate drainage basin within about 2 km upstream of the AA. OR The groundwater in the root zone of the AA during the dry season is substantially controlled by injection wells, recharge basins, subsurface drains, upstream diversions of water or other artificial processes within, adjacent to, or nearby the AA.
D	Natural groundwater sources that affect the dry season moisture regime of the AA have been eliminated, or nearly eliminated, based on presence of extraction wells, siphons, or artificial surface or subsurface drainage.

Channel Stability
Riverine Module

This particular metric posed some interesting problems for our analysis. Since the AA's we chose do not have open channels we had to make assumptions about the overall structure. There are three variables that are considered for the overall score of channel stability: channel equilibrium, active degradation, and active aggradation. In order to effectively rate this metric, we determined that vegetation is encroaching into the channel to meet a criterion for aggradation. We also assumed that there had to have been avulsion taking place since water seemed to move through the entire wetland underneath the floating mat. Based on these assumptions we were able to determine a score based on the CRAM ratings (Table 8).

Table 8: Rating break down for channel stability for the Riverine Module

Rating	Alternative State (based on the field indicators listed in the worksheet above)
A	Most of the channel through the AA is characterized by equilibrium conditions, with little evidence of aggradation or degradation.
B	Most of the channel through the AA is characterized by some aggradation or degradation, none of which is severe, and the channel seems to be approaching an equilibrium form.
C	There is evidence of severe aggradation or degradation of most of the channel through the AA or the channel bed is artificially hardened through less than half of the AA.
D	The channel bed is concrete or otherwise artificially hardened through most of AA.

Hydroperiod

Wet Meadow Module

The Wet Meadow Module is a non-channeled approach to our wetland assessment. It therefore does not include channel stability metric, but instead has a hydroperiod metric. This metric is an analysis of how long and frequently the wetland is inundated or saturated. Other indicators used for the rating include physical impacts such as diversions, redirecting the channel, and other physical impacts. Indirect evidence would be loss of aquatic life, late-season vitality of annual vegetation, and fine grain deposits (Table 9). Based on the observed indicators the system is then rated within CRAM (Table 10).

Table 9: field indicators of an altered hydroperiod

Direct Evidence	Indirect Evidence
Reduced Extent and Duration of Inundation or Saturation	
• Upstream spring boxes • Impoundments that reduce the amount of water available to the meadow • Pumps, diversions, ditching that move water ***from*** the wetland • Incision or widening of adjoining fluvial channels	• Evidence of aquatic wildlife mortality • Encroachment of upland vegetation well into the meadow • Stress or mortality of hydrophytes or wetland plant species • Compressed or reduced plant zonation • Transition to fewer wetland obligate plant species
Increased Extent and Duration of Inundation or Saturation	
• Berms, dikes, levees • Pumps, diversions, ditching that move water ***into*** the wetland • Aggradation of adjoining fluvial channels	• Late-season vitality of annual vegetation, given the water year • Increase in extent and abundance of wetland obligate plant species • Recently drowned wetland vegetation • Extensive fine-grained sediment deposits on the wetland surface • Formation of surface pools, pannes, etc • Increased wetness outside of non-channeled meadows due to overflow (e.g. into adjacent non-meadow areas) • Standing surface water that extends into the late summer months (e.g. July or August) and not associated with a recent storm event

Table 10: Ratings for the Wet Meadow hydroperiod

Rating	Alternative States (based on Table 13)
A	All indications are that the hydroperiod, or duration of shallow groundwater within the AA is characterized by natural patterns of rise and fall, without alterations OR Due to restoration activities, the amount and duration of shallow groundwater is increased and extended, so that the hydroperiod mimics natural conditions, or allows the meadow to be wetter than under natural conditions.
B	The amount of water supplied to the meadow via the surface (as opposed to via groundwater) is enhanced compared to natural conditions, but thereafter, the AA is subject to natural drawdown or drying. OR The duration of groundwater supply or inundation is extended later into the year than would be expected for natural conditions.
C	The amount of water supplied to the meadow is consistent with natural supply, but thereafter, the AA is subject to more rapid drawdown or drying OR The duration of groundwater supply or inundation is shortened compared to what would be expected for natural conditions.
D	Both the patterns of groundwater rise and fall are altered compared to natural conditions, with alterations to the amount or timing of filling and drawdown of groundwater within the meadow OR The groundwater is generally artificially lowered below the root zone for most of the AA due to pervasive artificial groundwater extraction or artificial drainage or diversions.

Hydrologic Connectivity
Wet Meadow & Riverine Modules

The hydrologic connectivity is analyzed by determining bankfull width, depth, height, and the bank height ratio. All of these variables are useful with determining the channels connectivity to the wetland or floodplain. This information was not collected in the field. Since the floating mat posed a problem for determining channel characteristics. In order to determine bankfull measurements we utilized cross sections carried out by a private contractor, Mike Love & Associates. This provided the information we needed to fulfill the calculations necessary to determine a rating for CRAM. Calculations within this metric use bankfull height and divides by bankfull depth to determine the ratio. The final result is three height ratios averaged and plugged into the rating table (Table 11).

Table 11: Rating of hydrologic connectivity for Riverine Module

Rating	Alternative States (based on the bank height calculation worksheet above)
A	Bank height to bankfull depth is ≤ 1.19
B	Bank height to bankfull depth is 1.2 to 1.5
C	Bank height to bankfull depth is 1.6 to 2.0
D	Bank height to bankfull depth is ≥ 2.1

Attribute 3: Physical Structure

Structural Patch Richness
Wet Meadow & Riverine Modules

The structural patch richness metric looks at physical features within the wetlands. Some of the features looked at are large woody debris, open water, animal mounds, and other distinguishing features. This metric is looking at physical features to reflect ecological complexity within the wetland (Table 21). We identified several features by simply walking each AA and looking for obvious structures from the list. The overall score for the metric is based on the total number of physical features that are found and then rated (Table 12).

Table 12: Rating of structural patch richness for riverine and Wet Meadow Module

Rating	Number of Patch Types Observed in the AA
A	≥ 8
B	6 – 7
C	4 – 5
D	≤ 3

Topographic Complexity
Wet Meadow & Riverine Modules

Determining the topographic complexity requires a cross sectional image of the AA's. This was accomplished by walking each AA and sketching the starting elevation by simple observation. Since the wetland exists between two uplands, our cross sections were relatively simple to conduct. Once we had an idea of our wetland topography we can then assess it based on the rating table (Table 13).

Table 13: rating table for topographic complexity of riverine and Wet Meadow Modules

Rating	Alternative States (based on diagrams in Figure 14 above)
A	Cross-sectional profile of AA contains abundant macro and micro topographic features such as swales, oxbows, or pannes/pools AND abundant vegetation roughness. The profile is at least as complex as the line labeled "A" in Figure 14.
B	Cross-sectional profile of AA contains moderate macro and micro topographic features such as swales, oxbows, or pannes/pools, AND/OR moderate vegetation roughness. The profile resembles the line labeled "B" in Figure 14.
C	Cross-sectional profile of AA contains minor macro and micro topographic features such as swales, oxbows, or pannes/pools, AND/OR minor vegetation roughness. The profile resembles the line labeled "C" in Figure 14.
D	Cross-sectional profile of AA lacks macro and micro topographic features such as swales, oxbows, or pannes/pools, AND lacks any vegetation roughness. The profile resembles the line labeled "D" in Figure 14.

Attribute 4: Biotic Structure
Plant community Metric

Riverine Module:

The Plant community metric is composed of three submetrics: Number of Plant Layers, Number of Co-Dominant Plant Species, and Percent Invasion. According to Cram, a "plant" is defined as an individual of any vascular macrophyte species of tree, shrub, herb/forbs, or fern, whether submerged, floating, emergent, prostrate, decumbent, erect, including non-native (exotic) plant species. For the purposes of Cram, a "plant layer" is a stratum of vegetation indicated by a discrete canopy at a specified height that comprises at least 5% of the area of the AA. Additionally CRAM describes "invasive" species as non-native species that " (1) are not native to, yet can spread into, wildland ecosystems, and that also (2) displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes" (CalIPC 2012). Cram uses the California Invasive Plant Council (CalIPC) list to determine the invasive status of plants, with the aid of regional experts.

Plant layers are divided up into five categories based off of plant height and whether the vegetation is floating in an aquatic layer or not. The five plant layers are Floating, Short Vegetation (<0.5 m), Medium Vegetation (0.5-1.5 m), Tall Vegetation (1.5-3.0 m), and Very Tall Vegetation (>3.0 m). The AA for the Riverine Module comprises of three reaches: Reach A, Reach B, and Reach C. Plant layers were determined by walking along the entirety of each reach and estimating which possible layers (floating, short, medium, tall, very tall) comprised at least 5% absolute cover of each reach. Co-dominate plant species per layer within each reach were determined by identifying species that represented at least 10% of the relative area of plant cover within that layer. Thus, every species represented by living vegetation that comprised of at least 10% relative cover within that layer was considered a dominant species within that layer. Additionally, utilizing the Cal-IPC list for invasive plant species, each co-dominant plant for each layer was determined to be invasive or not. The number of invasive co-dominant species for all plant layers combined was then assessed as a percentage of the total number of co-dominants, based on the results of the Number of Co-dominant Species sub-metric (Table 14).

Table 14: rating system for plant metric within the Riverine Module

Rating	Number of Plant Layers Present	Number of Co-dominant Species	Percent Invasion
Non-confined Riverine Wetlands			
A	4 – 5	≥ 12	0 – 15%
B	3	9 – 11	16 – 30%
C	1 – 2	6 – 8	31 – 45%
D	0	0 – 5	46 – 100%
Confined Riverine Wetlands			
A	4	≥ 11	0 – 15%
B	3	8 – 10	16 – 30%
C	1 – 2	5 – 7	31 – 45%
D	0	0 – 4	46 – 100%

Wet Meadow Module:

Although the break down for Wet Meadow vegetation is similar to the Riverine Module, their emphases differ, in which the Wet Meadow Module is more concerned with overall dominance and less concerned with plant layers. The Plant Community Metric for Non-Channeled Meadows is composed of three submetrics: Number of Co-dominant Species, Percent Invasive Species, and Number of Upland Encroachment Species. All plant species that comprised of at least 10% relative cover of the AA were considered to be dominant. This process was performed by walking up and down the entire AA and noting for plant species that appeared to take up at least 10% of the assessment area. Additionally, only living vegetation in growth position is considered in this metric, thus dead or senescent vegetation was disregarded, as well as areas of bare soil or open water. By utilizing the Cal-IPC list for invasive plant species each co-dominant plant was determined to be invasive or not. Finally, the presence of specific plat types within the AA (e.g. Conifers, Sagebrush, Butterbrush, Upland grasses, and Rabbitbrush) indicated the degree of encroachment of upland vegetation to the meadow. Thus the number of indicator plant types present, and comprising at least 5% relative cover of the AA were considered for this sub-metric (Table 15).

Table 15: rating for Wet Meadow Module vegetation metric

Rating	**Number of Co-dominant Species**
A	≥ 8
B	5 – 7
C	3 – 4
D	0 – 2
Rating	Percent Invasive Species
A	0 – 15%
B	16 – 35%
C	36 – 55%
D	56 – 100%
Rating	Number of Species
A	0
B	1
C	2-3
D	>4

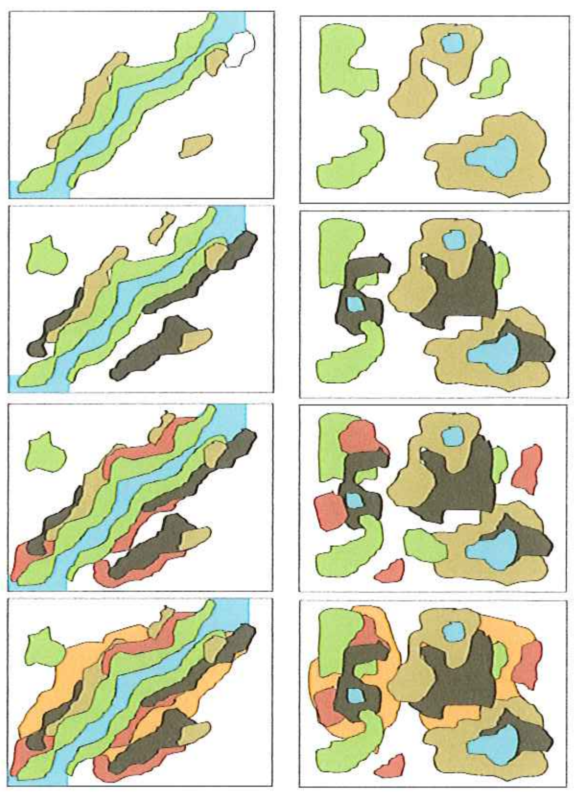
Horizontal Interspersion

Wet Meadow & Riverine Modules

The horizontal interspersion in Wet Meadow, or plant mosaic in riverine, looks at how complex the vegetation community is within each AA. As we were walking the AA noting dominant species we would note the distribution of the species on a hand drawn map. I then used my map to digitize an actual map in GIS in order to determine how complex each AA was. Rating the map is relatively easy for our system due to high amounts of invasive species (Appendix J and K).

Table 16: rating for riverine and Wet Meadow Modules plant mosaic (horizontal interspersion) metrics

Rating
D
C
B
A



Vertical Biotic Structure

Wet Meadow & Riverine Modules

The vertical biotic structure aims and determining the various plant types within the AA's. Vegetation classes are broken down to herbs, grasses, sedges, shrubs, deciduous trees, coniferous trees, and bryophytes. This metric is simple simply because every AA is made up of monocots. In order to be scored within the rating system a plant type has to make up at least 5% of the AA. The number of co-dominant life forms is scored based on the amount that exists within each AA (Table 17).

Table 17: rating table for the vertical structure metric for riverine and Wet Meadow Modules

Rating	Number of Co-dominant Life Forms
A	≥4
B	3
C	2
D	0 – 1

Results and Discussion

Module Comparison

Table 18: Summary table for CRAM scores of Wet Meadow and Riverine Modules. (Grading: A=12, B=9, C=6, D=3)

		Riverine			**Wet Meadow**
		Reach A	Reach B	Reach C	
Attribute 1: Buffer and Landscape Context	Riparian Continuity (WM: Aquatic Area Abundance)	9	12	12	12
	Submetric A: % with Buffer	12	12	12	9
	Submetric B: Avg Buff Width	12	9	12	6
	Submetric C: Buff Condition	6	6	6	6
Attribute 2: Hydrology	Water Source	12	12	12	12
	Channel Stability (WM: Hydro Period)	6	6	6	12
	Hydrologic Connectivity	12	12	12	12
Attribute 3: Physical Structure	Structural patch Richness	6	6	6	9
	Topographic Complexity	3	3	3	6
Attribute 4: Biotic Structure	*Submetric A: # Plant Layers*	9	9	12	n/a
	Submetric B: # Co-Dom Spp.	3	6	3	9
	Submetric C: % invasion	3	3	3	3
	Submetric D: # Encroachment Species	n/a	n/a	n/a	12
	Horizontal interspersion	3	3	3	3
	Vertical Biotic Structure	6	6	6	9
	Overall AA Score (%)	**57**	**61**	**59**	**73**

Wet Meadow VS. Riverine

Attribute 1: Buffer and Landscape Context

Aquatic Area Abundance

Table 19: Summary table for transect lengths (WM) and riparian segments (riverine)

Riparian continuity	Reach A	Reach B	Reach C		Wet Meadow
Segment no.	Upstream Length (m)	Upstream Length (m)	Upstream Length (m)	WM Cardinal Direction	Upstream Length (M)
1	20	0	0	N	50%
2	60	0	0	S	40%
3	30	0	0	W	40%
4	0	0	0	E	100%
Total	110	0	0	Avg	57%

The aquatic area abundance score is defined the same between both modules. This particular metric is comparable to both modules, which makes their scores relatable. Reaches B and C scored a 12 (Table 18) for riverine, and Wet Meadow scored a 12 as well. The only lower score was reach A scoring a 9 (Table 18). Reach A had three segments interrupting the riparian continuity, totaling 110m which resulted in a lower score. All other AA's had no interruption or disconnection from adjacent wetlands or aquatic habitats (Appendix D). Breaks in riparian continuity were all at least 10m wide, meeting the criteria to be a segment. The old operations center only impacted reach A due to proximity. Reaches B and C do have roads next to them but do not meet the specifications to be considered a break in continuity. This is also the reason the only breaks in riparian continuity occur upstream of reach A. The roads are both used sporadically and do not inhibit wildlife. Wet Meadow had a higher score simply because the 250m transects were mostly intersecting the wetland adjacent to Strawberry Creek. The Wet Meadow AA exists within the middle of the wetland, and would therefore increase contact with wetland. If this module were to establish an AA the extent of the wetland, the transects intersecting hydrological features would decrease, reducing the overall score. However, Wet Meadow also takes into account a much larger area adjacent to the AA when compared to the Riverine Module. Since Wet Meadow provides a larger picture of the wetland it is a better fit for this system based on the extent of analysis within this metric.

Buffer to assessment area:

Submetric A: Percent of AA with buffer

The amount of buffer around each AA varies in method, but still relates as a result. Riverine AA's only look at adjacent boundary around the perimeter of the AA. Wet Meadow looks at a 250m max radius around the AA to account for types of land cover, but both still yield buffer and non-buffer segments. All reaches for riverine scored 12's (Table 18); While the Wet Meadow scored a 9(Table 18; Appendix F). There were no significant non-buffer segments around any of the AA segments based on adjacent land use types. Wet Meadow scored lower due to a wildlife inhibiting fence on the north side of the AA, as well as development on the south side of the 250m buffer. Since the buffer for Wet Meadow extends further than riverine, it captures more land cover type differences. For this reason the Wet Meadow provides a better picture of the wetland since it differentiates different buffer types. The Riverine Module only looks at the immediate boundary; this poses a limitation for this wetlands application. Since all the riverine reaches scored a 12 the lack of depth in the analysis provides misleading information. However, when considering the final score of the wetland, Wet Meadow does score higher overall. This difference when comparing two specific metrics seems to be balanced out in the final result. Using Wet Meadow also seems to favor this system over riverine based on the physical characteristic of the wetland.

Submetric B: Average buffer width

Table 20: Summary table of buffer lengths for both modules

Buffer lines	Reach A (m)	Reach B (m)	Reach C (m)	Wet Meadow (m)
A	250	250	250	0
B	250	250	250	0
C	250	250	250	0
D	250	250	250	0
E	250	125	250	250
F	250	90	250	250
G	250	100	250	250
H	250	100	250	250
Avg Buffer Width (m)	250	176	250	120

Average buffer width measures the total lengths of each buffer segment. Riverine reaches A and C scored 12, while reach B scored a 9 (Table 18). Wet Meadow scored a 6 (Table 18). Reach B buffer segments ran into developed areas reducing its score. Wet Meadow segments also ran into developed areas as well as inhibiting fences. Utilizing the Riverine Module's multiple AA approach provides a more detailed analysis of the wetland when compared to Wet Meadow. Although the AA for Wet Meadow is larger in extent it only captures one section of the area. Using multiple AA's allowed us to capture different areas of the wetland. Reach B was adjacent to the development and was affected as a result. However, reaches A and C also showed that the rest of the wetland was relatively unaffected. The riverine metric for average buffer width gives more useful information when compared to the Wet Meadow Module.

Submetric C: Buffer condition

This metric is defined the same for both modules, making the scores relatable. All AA's for both modules scored a 6 (Table 18). A large portion of the AA's is dominated by non-native vegetation with some disturbance, resulting in a lower score. Since this part of the park is not visited by humans very often, that was not a factor in determining a low score. Mainly the vegetation determines the low score for all AA's. As long as the dominant vegetation is invasive or there is human impact, both modules will score this metric the same.

Attribute 2: Hydrology

The hydrological characteristics of the system are the most direct determinant of wetland functions (Mitch and Gosselink, 1993). The quantities, and flows impact the movement of water in the system affect the transport of water born materials such as sediment as bed load and suspended load. The physical structure is determined mainly by these hydrologic dynamics; magnitude, duration, and intensity of water movement. The physical structure of any wetland system is influenced by hydrological processes including saturation, inundation, nutrient cycling, sedimentation entrapment, scouring, channel forming, dissolved oxygen levels, pollution filtering etc. The hydrology develops the landscape and processes that create habitat for the various plants and animals found at different wetland sites. Natural water sources include precipitation, snow melt, groundwater, and surface water flows. Acceptable unnatural sources include storm drains and diversions because they affect the quantity and intensity of the water flows. Unnatural sources other than the fore mentioned can be used to demarcate AAs but should not be used as water sources for the scoring because they have regional affects rather than site specific sources (CWMW, 2012).

Metric 1: Water Source

Both Wet Meadow and Riverine Modules follow the same basic rating indicators and methods for determining the water source quality. The scores for both module methods in this metric are identical achieving the best score, (A/12), because there are significant sources via tributaries and groundwater likewise there are no artificial sources affecting the dry season conditions. Lower scores for the Water Source Metric would be given to a site affected by factors such as runoff from a source other than natural. This additional water source would be associated with agriculture, urban runoff, upstream diversions, and artificial recharge by injection wells or storage dams with regulated releases. Though the stream reaches are effectively fed by different sources, reach A the main stem of Strawberry Creek, reach B the groundwater flow, and reach C the culmination of all plus an additional no name Creek, they all are located within the floating mat system therefore all water sources end up in the storage of the wetland and are slowly drained through the channel outlet at the south west end of the site (CWMW, 2012).

Metric 2: Hydroperiod

Hydroperiod is specific to the Wet Meadow Module. This is a characteristic relating to the wetlands frequency and duration of inundation or saturation of the wetland during an average year. Groundwater typically varies throughout the year but can vary diurnally as well. Changes that occur over small periods of time are the result of evapotranspiration of local vegetation and by the variability of rainfall. The metric is measured by considering deviations from the average rainfall year based on field indicators of reduced or increased extent and duration of ground water. At the Strawberry Creek site we found that the hydroperiod, extent and duration of shallow groundwater, fluctuates on seasonal rainfall cycles. This site characterized by a natural hydroperiod is not presently influenced by anthropogenic drainage or drying as it was in the past by ranching on site, nor is there any water stored or added during dry seasons. Some of the field indicators for lack of water would be diversions or spring boxes upstream, evidence of wetland plant species mortality or the encroachment of upland species on site. Indicators for water adding include standing surface water during the dry season, recently drowned wetland species, increase in extent of wetland obligate species or saturation outside the wetland area. For this metric we considered the current condition without alterations to the hydroperiod scoring it with the highest score of an A (numeric 12). Although the hydroperiod is also important for the Riverine Module data for many stream systems is not available. Like the Wet Meadow Module field indicators are essential for determining the hydroperiod but with the stream system the channel morphology provides the evidence for frequency, duration and extent of the hydroperiod (CWMW, 2012).

Metric 2: Channel Stability

Channel Stability is specific to the Riverine Module. The hydrological variation throughout the year and the ability to transport bed and suspended sediment load materials determine the channel form, including the floodplain, and control the overall ecological function and structure of the river system. The Channel stability metric is the assessment of the systems aggradation or degradation under the dynamic equilibrium of the hydroperiod. This is based on channel form, cross section, plan view, and longitudinal profile. The degree to which the channel is stabilized can be determined by field indicators. A stable channel will have conditions such as a well-defined bankfull contour that clearly defines the active floodplain, perennial riparian vegetation is well established and abundant, large woody debris is present and embedded. Indicators of degradation consist of deep undercut banks causing slumps or slides, riparian trees leaning in on or falling into the channel, thalweg is deeply cut to bedrock or down to dense clay. The Strawberry Creek site shows evidence of aggradation. Though a channel exists it is beneath the thick vegetation mat. The dense mat of vegetation acts as a catch for the sediment load transported downstream choking and spreading the flow across and under the mat. There is a redwood snag out in the middle of the wetland area that is just barely clinging to life, and there is no discernible bankfull transition to the floodplain. Under the Channel stability metric all reaches received a low score of a C (6), due to the severe reduction in discharge velocity as the streams hit the dense vegetative mat (CWMW, 2012)

Metric 3: Hydrologic Connectivity

Hydrologic Connectivity describes the ability of water to flow in and out of the system or to accommodate flood waters without changing water levels enough to stress plants or animals occupying the wetland habitat. To score this metric for the Wet Meadow we had to decide whether this was a channeled meadow or non-channeled system. It seemed for our purposes since the channel flowed below the wetland that a non-channeled system more closely represented the area. The major concern for hydrologic connectivity in a channeled Wet Meadow is the persistence of incising and erosion resulting in less water for the wetland by consolidating the flow eventually unable to reach the outer portions of the meadow. Strawberry Creek on the other hand is a choked off channel that is in the process of aggradation where water reaching out to the edges is not the problem but the transportation of suspended load (fine particulates), bed load (gravel and cobbles), and nutrients is. The wetland hydrologic connectivity metric for the non-channeled Wet Meadow functions as a source area fed by natural springs, seeps, or flooding stream water for downstream surface flows and is not cut into braids or a series of channels that isolate the system discharges. Under the guidelines of CRAM the connectivity metric scores an A (12). In the Wet Meadow scenario the water should remain in the system and drain slowly (CWMW, 2012).

The Riverine Module places emphasis on the ability of the stream to overtop its bankfull height. The system is rated by an entrenchment depth to floodplain width. These measurements at our site on Strawberry Creek are difficult to determine do to the mat. For this metric we had to use estimates from previous monitoring sources. Channel cross sections where determined by estimating the elevation of the mat above the actual ground surface by probing the depths below. As a result a graphical stream channel profile was developed for stream reach C allowing us to estimate an entrenchment ratio. From the profile produced for the Mike Love report we were able to estimate bankfull width, max bankfull depth, flood prone depth, and flood prone width for the four cross sections. The CRAM module only requires estimations so we felt we could use this information with confidence. The entire mat and floodplain are identical therefore we estimated the width at approximately 1000 feet give or take for the flood prone area. After averaging out the ratio for the four profiles we found about 28 feet of floodplain width for every one foot of bankfull width which surpasses the rating for the non-confined riverine wetland entrenchment ratio of >2.2 to 1. This metric in CRAM would be more accurate if the stream was exposed but as we used the data provide plus field, and GIS based measurements and the fact that the floodplain is wet year round, the stream is not entrenched. The measurements for this metric came only from reach C as provided in the Mike Love report, and since the area is basically a homogenous floating mat floodplain each reach A,B,C get the same score of an A (12) with and entrenchment ratio greater than 1.19 (CWMW, 2012).

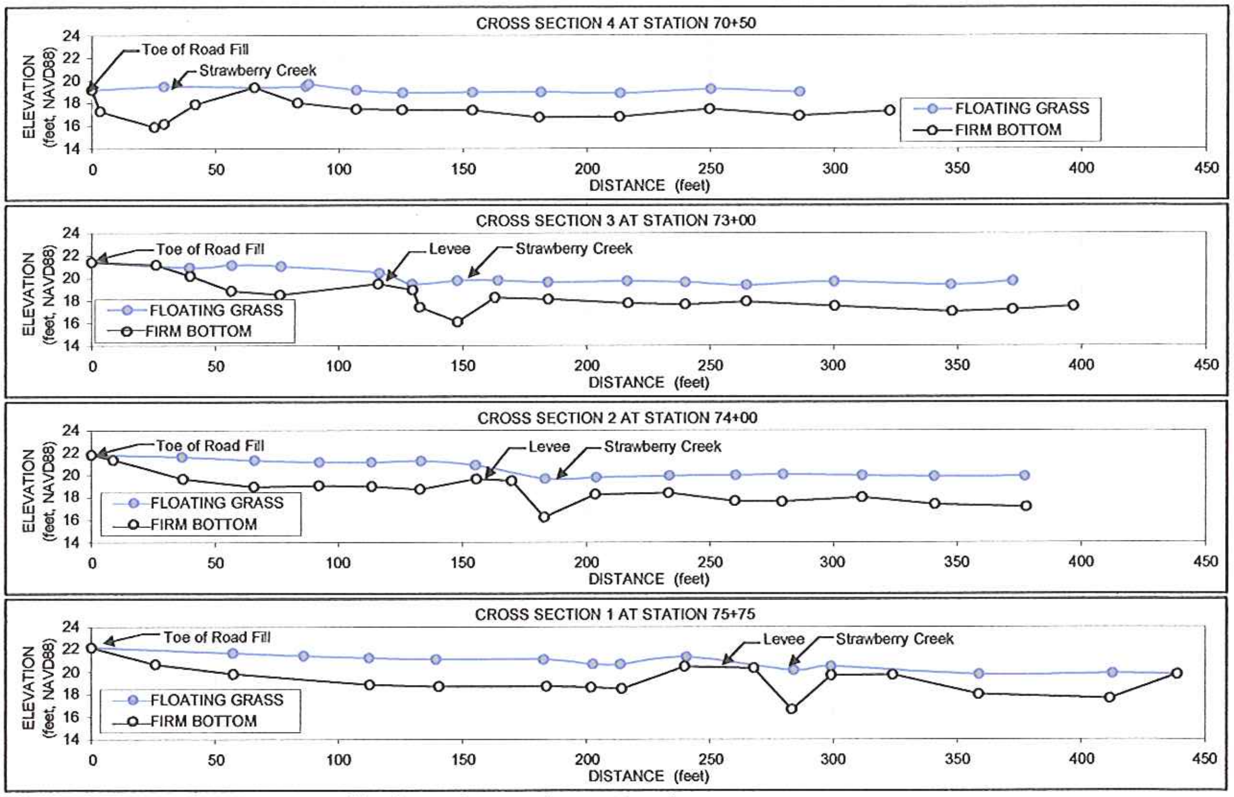


Figure 2: Cross sectional profile data of Strawberry Creek

Attribute 3: Physical Structure

Structural Patch Richness

Table 21: summary table of physical structures encountered within each module

Structural Patch Type	Reach A	Reach B	Reach C	Wet Meadow
Filamentous microalgae or algal mats	×	×	×	×
Gravel or Cobble				×
pannes or pools on floodplain	×	×	×	×
plant hummocks and/or sediment mounds	×	×	×	×
Large Woody Debris				×
pools or depressions in channels	×	×	×	
secondary channels on floodplains or along shorelines	×	×	×	
standing snags (at least 3m tall)	×	×	×	×
submerged vegetation	×	×	×	×
vegetated islands (mostly above high water)	×	×	×	
Total	8	8	8	7

All AA's within the Riverine Module scored a 6 (table 18). Wet Meadow scored a 9 (Table 18). The Wet Meadow has a higher score based on covering a larger area with the AA. Its grading threshold is also lower than riverine, needing fewer structures to score higher. The similarities between both modules were varied, based on the size difference between both AA's. Features in one were sometimes found or not found in the other AA's. The only main difference between the two modules here is the extent of the AA's. Since the Wet Meadow AA is much larger than the riverine it was easy to encounter more patch types. However, the fact that the Wet Meadow AA only stretched in one part of the wetland it did not capture the same features as riverine. Wet Meadow is still the better module here simply because it encompasses more of the wetland when compared to the riverine method.

Topographic Complexity

The riverine AA's were all relatively flat due to the wetlands physical structure. This feature shared throughout all the riverine AA's resulted in a score of a 3 for each reach (Table 18). The Wet Meadow Module scored a 6 due to its longer range from upland to upland resulting in a more diverse topography (Table 18). Each module AA did not yield defining characteristics typical for channeled wetlands, as there were no benches or banks. Since the Wet Meadow stretches from upland to upland, it provides a better picture of the wetland and this system. The riverine only provides a cross section for a smaller area and is therefore not the right module for this system.

Attribute 4: Biotic Structure
Riverine Module

Within **Reach A** there were three plant layers identified that comprised of at least 5% absolute cover, the floating or canopy-forming, short (<0.5 m), and medium (0.5-1.5 m). The plant community metric for the number of plant layers present was given a B (score of 9), because the reach contained three plant layers. Within the floating/ canopy-forming layer two invasive co-dominant species, *Agrostis stolonifera* and *Ranunculus repens,* were identified for comprising of at least 10% of plant cover in that layer. The short (<0.5 m) layer contained four invasive co-dominant species, *Agrostis stolonifera, Glyceria fluitans, Holcus lanatus,* and *Ranunculus repens.* The medium (0.5-1.5 m) layer contained three invasive, *Agrostis stolonifera, Glyceria fluitans, Holcus lantus,* and one native co-dominant species, *Scirpus microcarpus.* There was a total of 5 different co-dominant species for all the layers combined, giving the plant community metric for the number of co-dominant species a D (score of 3). Of the five species identified, four of them were invasive, resulting in a percent invasion of 80% and a D (score of 3) grading (Table 18). The horizontal interspersion metric was given a D (score of 3), based on the diversity of distinct zones and the amount of edge between them in the reach. The vertical biotic structure metric was given a C (score of 6) based on the degree of overlap among plant layers in the reach. The sum of the numeric scores, the raw attribute score, was 14. The raw attribute score was then divided by 36, the total possible amount of points, to determine the final attribute score, 39. The overall AA score for Reach A was 57 (Table 22).

Table 22: Summary table of biotic structure for reach a (riverine)

Attribute 4: Biotic Structure					
Plant Community Composition (based on sub-metrics A-C)					
	Alpha.	Numeric			
Plant Community submetric A: Number of plant layers	B	9			
Plant Community submetric B: Number of Co-dominant species	D	3			
Plant Community submetric C: Percent Invasion	D	3			
Plant Community Composition (*average of submetrics A-C rounded to nearest whole integer*)			5		
Horizontal Interspersion		D	3		
Vertical Biotic Structure		C	6		
Raw Attribute Score = sum of numeric scores			14	**Final Attribute Score = (Raw Score/36) x 100**	39%
Overall AA Score (average of four final Attribute Scores)				57	

Within Reach B there were three plant layers identified that comprised of at least 5% absolute cover, the floating or canopy-forming, short (<0.5 m), and medium (0.5-1.5 m). The plant community metric for the number of plant layers present within the AA was given a B (score of 9). The floating or canopy-forming layer contained two invasive co-dominant species, *Agrostis stolonifera* and *Ranunculus repens*. The short (<0.5 m) layer consisted of six co-dominant species in which four were invasive, *Agrostis stolonifera, Phalaris arundinacea, Ranunculus repens,* and *Holcus lanatus,* and two were native, *Scirpus microcarpus* and *Juncus bolanderi.* The medium (0.5-1.5 m) layer contained five co-dominant species in which four were invasive, *Agrostis stolonifera* Phalaris *arundinacea, Holcus lanatus, and Glyceria fluitans* and one was native, *Scirpus mircocarpus.* Of the total seven different species recorded for the combined layers, five of them were invasive, resulting in a percent invasion of 71%, a D (score of 3). The plant community metric for co-dominant species was given a D (score of 3), because there were only five different species identified. The horizontal interspersion metric was given a D (score of 3) due to the lack of diversity of distinct zones and the amount of edge between them within the reach. The vertical biotic metric was given a C (score of 6) based on the moderate degree of overlap amongst plant layers within the reach. The sum of the numeric scores, the raw attribute score, was 15. The raw attribute score was then divided by 36 to determine the final attribute score, 41%. The overall AA score for Reach B was 61 (Table 23).

Conventional Methods vs. CRAM

Attribute 1: Buffer and Landscape Context

Riparian vegetation adjacent to each AA within the riverine and Wet Meadow Module have been impacted. This has been found using CRAM. However, CRAM failed to account for historical use, which was considered by Mike Love and Associates (MLA). There consideration of historical land use let them discover dominant vegetation to be Sitka spruce within our project area. This changed over time as land users harvested and converted wetland into agricultural land, altering the physical composition. This type of information could be invaluable to project development. Although CRAM methods yielded several segments of fragmented riparian habitat adjacent to the old operations center, MLA found this while also discovering altered conditions over time. MLA methods also considered culvert size as well as sedimentation within the channel, causing aggradation due to a culvert that is too small (Love 2008).

Overall CRAM yielded useful results for the assessment, but failed to consider historical impacts to the riparian corridor adjacent to the channel. Our analysis using CRAM came to similar conclusions within a day. MLA utilized an entire longitudinal cross section of the reach adjacent to the old operations center over a much longer period of time (Love 2008). CRAM does not utilize historical information, as well as telling the user to specifically consider historical conditions. CRAM only analyzes current conditions due to its rapid approach, and its analysis only aims at determining breaks in the riparian corridor. The lack of historical consideration does not affect the results for this particular area due to land use not affecting the riparian corridor. CRAM captures the developmental impact to the riparian corridor without considering historical use. Since MLA discovered problems with the culvert, this poses another significant comparison between CRAM and traditional methods. There is no consideration of wildlife within CRAM, which would require an analysis of other variables such as culverts for fish passage.

Adjacent land cover or buffer is also considered within the MLA report and found to be comparable to the results of the CRAM assessment. The MLA staff conducted cross sectional surveys across the entire wetland, as well as each tributary near the old operations center (Love 2008). Each property adjacent to Strawberry Creek was analyzed in order to provide a broader picture of adjacent land use and cover types affecting Strawberry Creek. Although MLA analyzed adjacent land use along the entire stream, CRAM only looked at areas affecting the established AA's. Buffers adjacent to the AA's reach a length of 250m at a max. This provided a refined area to conduct analysis yielding more useful for purposes of CRAM when compared to MLA. CRAM allows the users to determine possible point sources or areas to begin analysis to determine degrading variables directly affecting the wetland of interest. Buffer conditions are also considered in more detail within CRAM. MLA looks at broad land covers types adjacent to Strawberry Creek, while CRAM looks at specific land cover types to determine quality of buffer conditions.

Attribute 2: Hydrology

The methods applied for the Strawberry Creek wetland restoration for RNP were performed by a number of federal and professional agencies with an entire watershed scope. Assessing the wetland function under CRAM guidelines narrows the scope down to just one section. Where CRAM must be applied to several reaches of a stream, the agencies focus on the drainage conditions from its headwaters to its mouth. The design of CRAM allows it to be applied in a repetitive fashion along a stream in the form of the AA. For the entire restoration project to be a success the all portions of the stream need to be restored. For the scope of the CRAM module comparison we concentrated on one of the most ecologically complex stretches along the stream. Of the modules proposed by the CRAM coordinator neither fit exactly to the system of a choked up Creek nor floating mat conditions.

Both modules required AAs but each where determined by the ecological parameters based on their particular system. The Wet Meadow Module is not limited to the hydrological break in structure that is associated with channel discharge and sediment transport such as the Riverine Module suggests as a starting point. Instead for small wetlands such as Strawberry Creek the Wet Meadow CRAM module requires the AA to encompass the whole wetland from upland to core to upland. The Riverine CRAM module the AA should be established where the reach has more or less the same hydrology and geology and extend up or downstream a distance of ten times the average bankfull width, or a minimum of 100 meters. Though these modules only take a snapshot view of the system, their design purpose is to be streamlined for cost and time efficiency, while much time and money have been spent assessing this wetland for more than six years.

The preparation reports for the restoration project go into far greater detail then the rapid assessment methods. The report takes into account historic variables via historic accounts and records as well as historic aerial imagery. This insight allows for restoration plans to recreate historic conditions. Historical accounts from the Barlow family, landowners adjacent to the site, and imagery dating back to 1936 confirm the historic conditions prior to a heavily agricultural land use where a wet Sitka spruce forest. Based on local forest and plant ecology, it is believed that there was a mixed transition from redwood to Sitka spruce to red alders along Strawberry Creek as it moves down slope. This historical structure and function is the ecological trajectory that would ideally support the fish populations (Love 2008).

Attribute 3: Physical Structure

MLA conducted cross sectional surveys of the Strawberry Creek and adjacent tributaries (Love 2008). There were no elevational surveys conducted on the wetland adjacent to the believed location of the channel. CRAM methods require users to walk AA's and look for physical features indicating structural diversity. MLA methods are collecting information to influence management decisions, to be used for restoration planning. CRAM methods are collecting information to assess the health of the wetland, which also may influence restoration efforts. However, summarizing their findings MLA concluded that floating mat vegetation impedes flows, altering the physical structure of the wetland (Love 2008). Similar findings using CRAM show that the overall health of the wetland is impeded. MLA's methods did not involve such extensive analysis of the wetland where is CRAM was solely focused in the same area. Results from both methods yielded similar conclusions, but also produced different information. CRAM provided a list of factors affecting the negative score which may influence project developers by guiding objectives towards specific factors. MLA only provided an overall statement regarding the wetland health.

Attribute 4: Biotic Structure

MLA conducted a visual inspection of the existing vegetation within the Strawberry Creek floating mat area in the fall of 2007 (Love 2008). Additionally, in 2011, Redwood National Park conducted an Army Corps of Engineer's Wetland Delineation Survey, in which plants were identified to help determine the presence of hydric soils (U.S. Army Corps of Engineers 1987). The results from the visual survey conducted by MLA and Redwood National Park's soil survey plant list were nearly identical, in which both assessments determined the same presence and dominance of species. Both vegetative assessments determined that reed canary grass, *Phalaris arundinacea,* was the dominant species amongst the floating mat region of Strawberry Creek.

The methods to determine the vegetative composition and structure from CRAM were rather similar to the MLA's visual inspection. Additionally, the results from CRAM's biotic structure metric yielded the same conclusions as the MLA's and National Park's vegetation surveys. CRAM's methods for conducting vegetation surveys are straight forward and set up in a manner in which exact species identification is not necessary while in the field. Furthermore, the vegetation assessment within CRAM modules are extremely time and cost efficient, which makes it a desirable candidate for developing a state-wide consensus for vegetative monitoring in wetlands. Lastly, the results from CRAM provided more information than MLA's visual survey, because CRAM focused and recorded species based off of percentages of co-dominance as well as determined horizontal and vertical depictions of the vegetative distribution and composition for the different plant zones within the assessment area.

Monitoring and evaluation

The end result for comparing different methods and modules produces recommendations for this wetland type. Gauging and monitoring these recommendations come from collecting quality information which informs our suggestions. Although the CRAM process is relatively straight forward in guiding good data collection, there were still questions during certain processes. These questions for quality control purposes were directed towards two professionals and authors of CRAM Joe Seney (Chief of Geology for Redwood National Park) and Sarah Pearce (San Francisco Estuary Institute). Both of these professionals acted as our quality control in terms of data collection and field application of CRAM. Their expertise provided guidance regarding wetland characteristics and what to include/exclude carrying out the CRAM process.

Acting as quality control, Joe and Sarah both allowed us to conduct a more in depth analysis of Strawberry Creek. Vegetation analysis proved difficult due to limited knowledge, but Joe was able to provide us with the resources necessary to achieve identification of known plants in the area. This provided a much more detailed picture of the vegetation within the project site. Sarah Pearce acted as the CRAM professional providing us with adjustments to AA boundaries, buffer segments, and other aspects of CRAM metrics. This approach to utilizing CRAM provided us a basis to learn more about the process and the wetland. Her adjustments to our collection or analysis methods yielded a much higher quality final product. This information can now be used to influence and provide feedback to the other authors of CRAM due to this quality control.

Our project is providing a comparison of different wetland assessment methods, as well as providing feedback regarding the overall CRAM process. Long term monitoring regarding this type of project is mild in the sense we aren't utilizing restoration techniques requiring us to view the changes over time. However, since our recommendations are influencing project developers and authors of CRAM we may conduct a similar analysis in the future. Our findings will provide recommendations for CRAM which may influence authors to adjust methods. This should be the basis for reapplying CRAM on the same wetland in order to identify changes to the process.

Evaluating the success of our project will rely on the changes, if necessary, made to CRAM methods. Our recommendations will provide a basis to analyze rapid assessment methods, while comparing it to more traditional methods. Evaluating these results will rely on the quality of field application and outputs. Streamlining the process of assessment comes with problems, but providing recommendations to the process may yield a higher quality final product. Achieving this goal requires a much broader analysis of CRAM methods and utilizations. Although our project analyzed CRAM methods as well as alternative methods, one facet of CRAM yet to be considered is its role in baseline information. Utilizing CRAM for collecting baseline information for restoration projects can act as both monitoring and evaluation.

Future efforts and restoration project

CRAM is a useful and valuable tool for the purposes of a low cost, time efficient alternative to standard wetland assessment of ecological function using site specific structure. It would work as an excellent post project evaluation and monitoring alternative being stream lined by nature. Strawberry Creek proposed restoration project could utilize the methods of CRAM as a method of evaluation, as well as a tool for post project monitoring. When restoration efforts are complete the use of the Wet Meadow Module would become obsolete and the Riverine Module would be ideal to monitor during and post restoration. The evaluation we made using CRAM can be used as baseline information. The scores for the Riverine Module will increase as restoration progresses in weaker areas such as the buffer condition, stream channel morphology, and especially the biotic structure as a riparian forest ages. The buffer condition will increase after the removal of the buildings on site. The channel will be designed to incorporate the complexities one would expect to find in a natural stream such as large woody debris, hummocks, back water areas, and free from channel choking invasive species. As the velocity of the discharge increases Strawberry Creek will be able to transport the sediment load and reach a state of equilibrium. The test piloting of these rapid assessment methods will help establish benchmarks for restoring the wetland back to a riverine system. The attributes in the CRAM assessment method will help guide future monitoring of the project by being a low cost, rapid method, of monitoring progress or hindrances along the riverine ecological trajectory.

Conclusions

CRAM provides a rapid alternative to conventional methods for wetland assessment. Rapid assessment methods have been utilized in other states, but CRAM is the first for California. This method provides a unique analysis of common and consistent wetland types. Creating a streamlined assessment method in a state with a broad range of unique wetland types has proved to be difficult. However, CRAM does provide a unique opportunity to utilize its methods in order to determine a general summary of a wetlands health. Information collected this way can then instigate further analysis or project development. Based on the information found in Strawberry Creek's application of CRAM the results will influence further investigation into the process of CRAM and potential restoration efforts.

A streamlined process provides an excellent basis to conduct analysis if the system fits the criteria. Most wetlands share physical characteristics allowing them to be classified as marshes, swamps, fens, and bogs. However, not all wetlands can be easily fit into a specific type, making CRAMs application problematic. CRAMs approach starts with selecting wetland type and moving through a module appropriate for the wetland identified. Strawberry Creek is one of these examples due to its unique floating mat and lack of obvious channel. This physical ambiguity allowed analysis to consider two different modules within CRAM, Wet Meadow and Riverine. Since it shares some characteristics to fit both criteria, the results yielded interesting conclusions. Wet Meadow provided a higher overall score due to its ability to encompass more details of the wetland. While the Riverine Module required a channel and the scores suffered as a result, Wet Meadow lacked adequate buffer analysis. Both modules lacked in certain areas, but overall Wet Meadow provides a better analysis for Strawberry Creek. Due to its floating mat, there were more closely graded metrics that fit a Wet Meadow description yielding higher quality data.

Data collected this way could cautiously be used for restoration planning due to its rapid and general application. CRAM may lack specific detail necessary to inform the actual restoration process of project development, but it has useful qualities. Based on the analysis of Strawberry Creek, information collected could now be considered general baseline information. CRAM can act as a monitoring program that analyzes broad physical characteristics of a wetland for very little cost. This aspect of rapid assessment has very useful applications for restoration projects. Restoration projects these days lack effective monitoring plans due to budgetary constraints. CRAM can act as solution for this shortfall of current restoration projects. Although CRAM may be highly useful for low budget monitoring or capturing broad implications of restoration projects, its lack of detail may inhibit its usefulness for project planning. Attempting to create a rapid assessment method will affect the details when compared to conventional methods. Conventional methods require time and money in order to provide the highest quality data, which informs restoration projects. CRAM provides a unique alternative to these conventional methods.

After completing our analysis of CRAM and its methods, we have determined its appropriate use for Strawberry Creek. Our analysis also yielded interesting information when comparing it to conventional methods. However, the Wet Meadow Module used for our assessment was a draft document that wasn't fully completed. Methods were still being developed for Wet Meadow, and are currently still in the development process. We believe that based on our findings, as well as the improvements made by CRAM authors, Wet Meadow will be improved. CRAM will also keep improving with every assessment carried out based on the feedback provided by the users.

The findings of our study did yield interesting results, however we believe that further investigation is necessary. Time constraints did not allow us to conduct the thorough comparison of other wetland assessment methods to CRAM. Extrapolating information on more precise methods from Mike Love and Associates, as well as Redwood National Park documents was effective. However, this approach lacked significant detail due to the fact we could not conduct our own field assessment method on the wetland. We believe if this analysis was carried out the results would yield more conclusive information regarding the quality of CRAM. This study provides useful information for each party involved. Since Redwood National Park is on the verge of carrying out their restoration work on Strawberry Creek, our analysis could have provided more useful baseline information from conducting a conventional method ourselves. Information gathered this way would provide better quality information to compare CRAM too, as well as baseline information for project monitoring for Redwood National Park.

CRAM provides the information that could be useful in certain circumstances. CRAMs strength is speed and consistency with gathering broad information about a wetland. It is very straightforward and simple to use which makes it a quality product for a broad base of researchers. Its final product offers a consolidated and easy to catalogue data sheet with information regarding each metric analyzed. These strengths make CRAM very useful on many levels within wetland management. Despite CRAMs strengths, its weaknesses vary. Some of the components lack variation to encompass unique wetland systems. This approach to rapid assessment forces systems to fit the criteria provided by CRAM, and may overlook a variable particular for that system. Certain parameters within CRAM may be influenced by the variables being overlooked resulting in a misrepresented score. This type of weakness comes with attempting a method that covers a very broad range of wetland types. As long as CRAM is used for rapid assessment and to act as a catalyst for further investigation it will always be useful. CRAM has the potential to become a new standard for restoration projects and wetland assessments within California.

Similar Ecology

The formation of floating vegetative mats is a rare phenomenon that occurs in only a few areas across the planet. Research and knowledge about the ecology, function, and origin of these sparse environments is minimal, yet on the verge of expansion. Floating mats also referred to, as tussocks, floatons, or suds, are natural floating islands that are composed of vegetation which grow on a buoyant mat of plant roots, peat, and organic detritus. Wetland vegetation such as cattails, bulrush, sedge, and reeds are characteristic inhabitants in these environments. Furthermore, it has been hypothesized that the stoloniferous growth habit and subsequent adventitious root formations of many of these characteristic plants are responsible for creating these thick floating mats, that can vary anywhere from several centimeters to several feet in thickness (Huffman and Leonard 1983). The formation of floating mats is thought to begin with a physical disturbance that promotes excessive sediment to be deposited into a wetland area. As the sediment accumulates around the peripherals of the wetland, hydrophytic plants begin to succeed to these newly soiled areas. Overtime, a mat begins to grow from the peripherals towards the center of the wetland. As the mat grows into the water, it floats at the surface by air in the plant tissues. Upward growth shades the lower parts and these die, forming an increasingly thick floating mat, in which the top remains only a few inches above the level of the water surface (Maltby and Baker 2009).

Bogs and Fens are wetlands commonly located in the Eastern states of the U.S. that share similar characteristics and structure to floating vegetative mats. Bogs are defined as wetland areas having a wet, spongy, acidic substrate composed chiefly of sphagnum moss and peat in which characteristic shrubs and herbs and sometimes trees usually grow. Fens are very similar, yet fens receive water from their surrounding watershed in inflowing streams and groundwater, while bogs receive water primarily from precipitation. Due to their similar qualities as wetlands, analyses on both bogs and fens can be utilized to better understand the functions and formations of floating vegetative mats (U.S. Army Corps of Engineers 1987).

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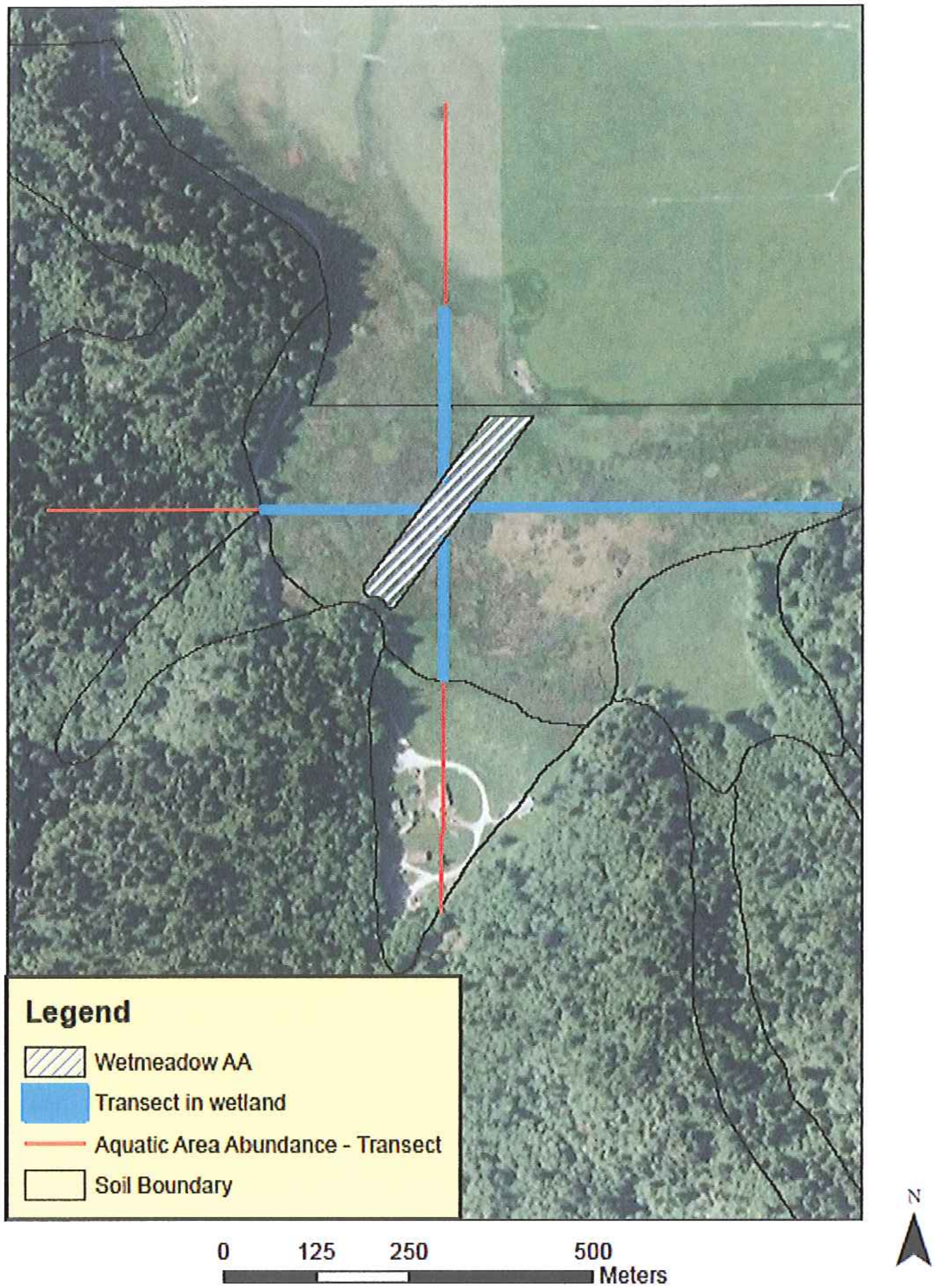
Appendix A

Riverine AA on Strawberry Creek

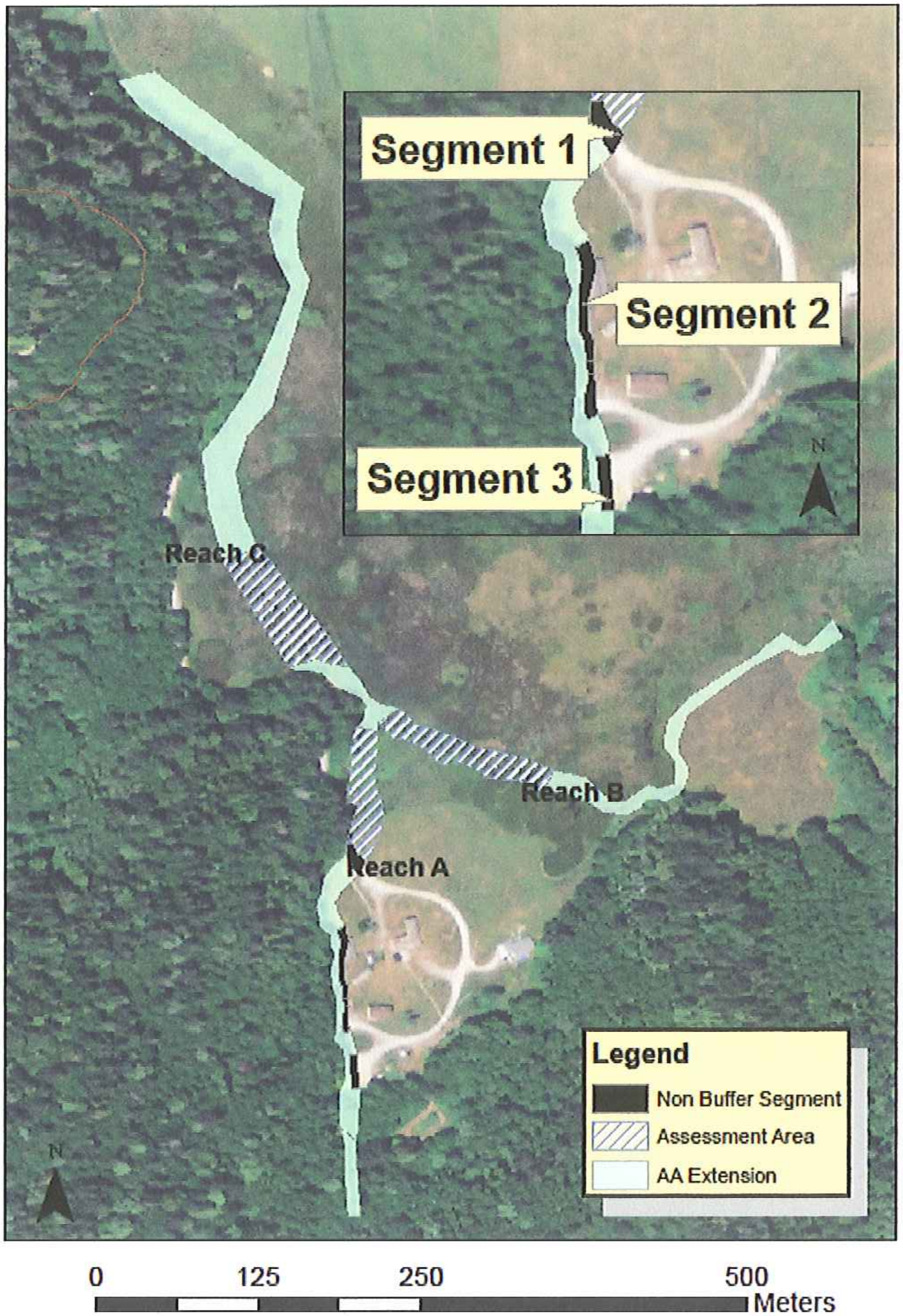
Appendix C

Att-1 (Metric 1) Aquatic Area Abundance



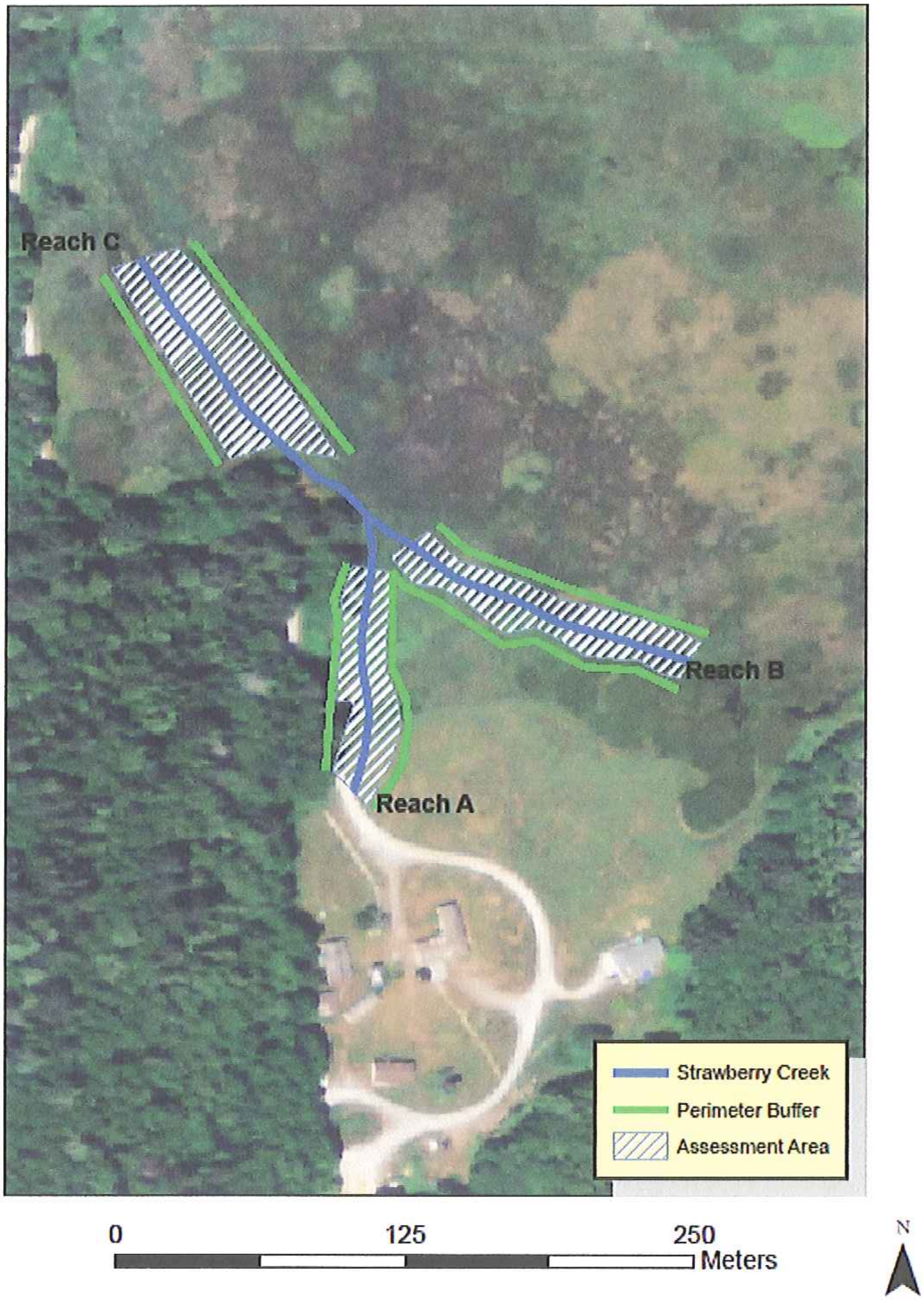
Appendix D

Buffer and Landscape Context



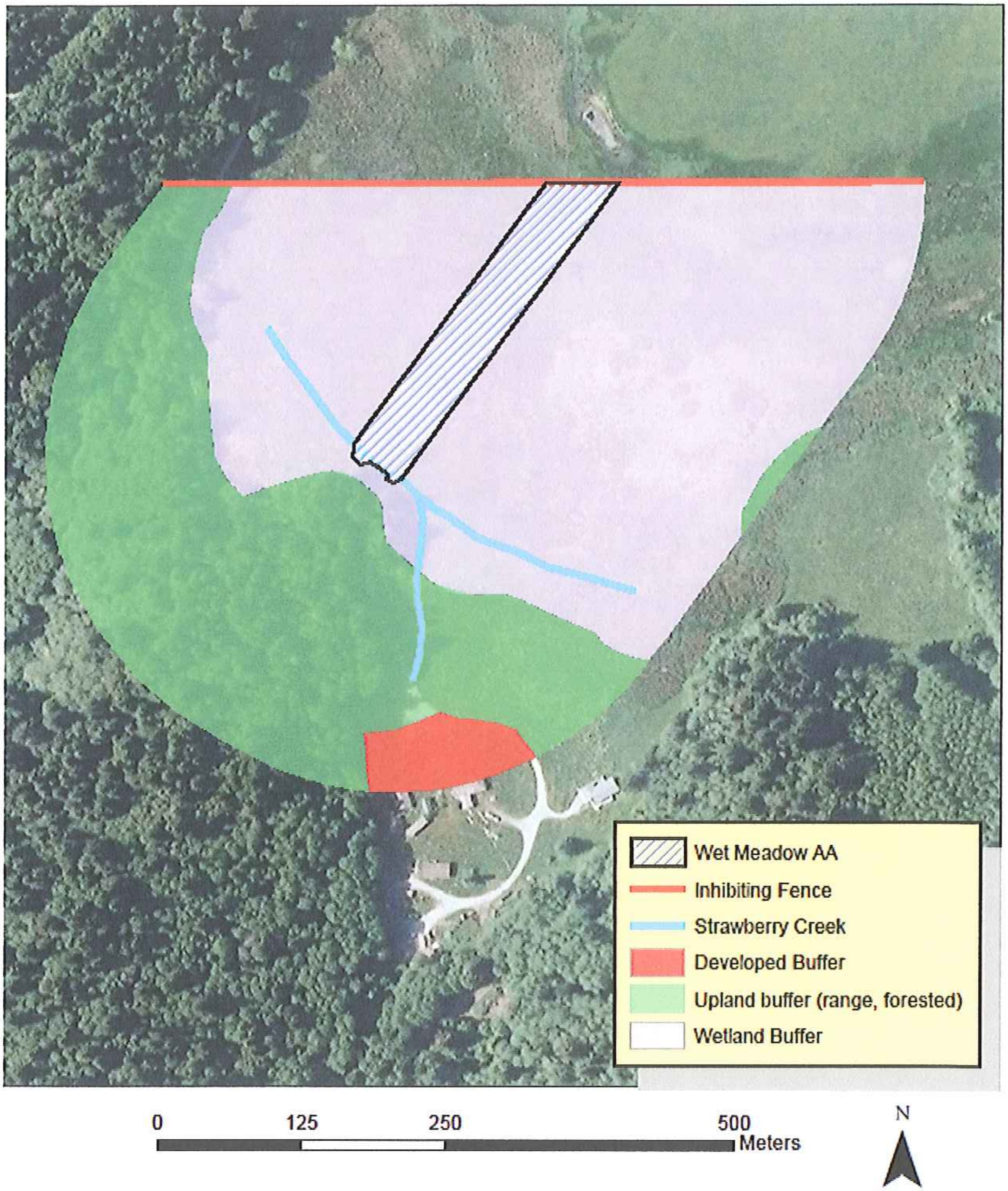
Appendix E

Percent of AA with Buffer

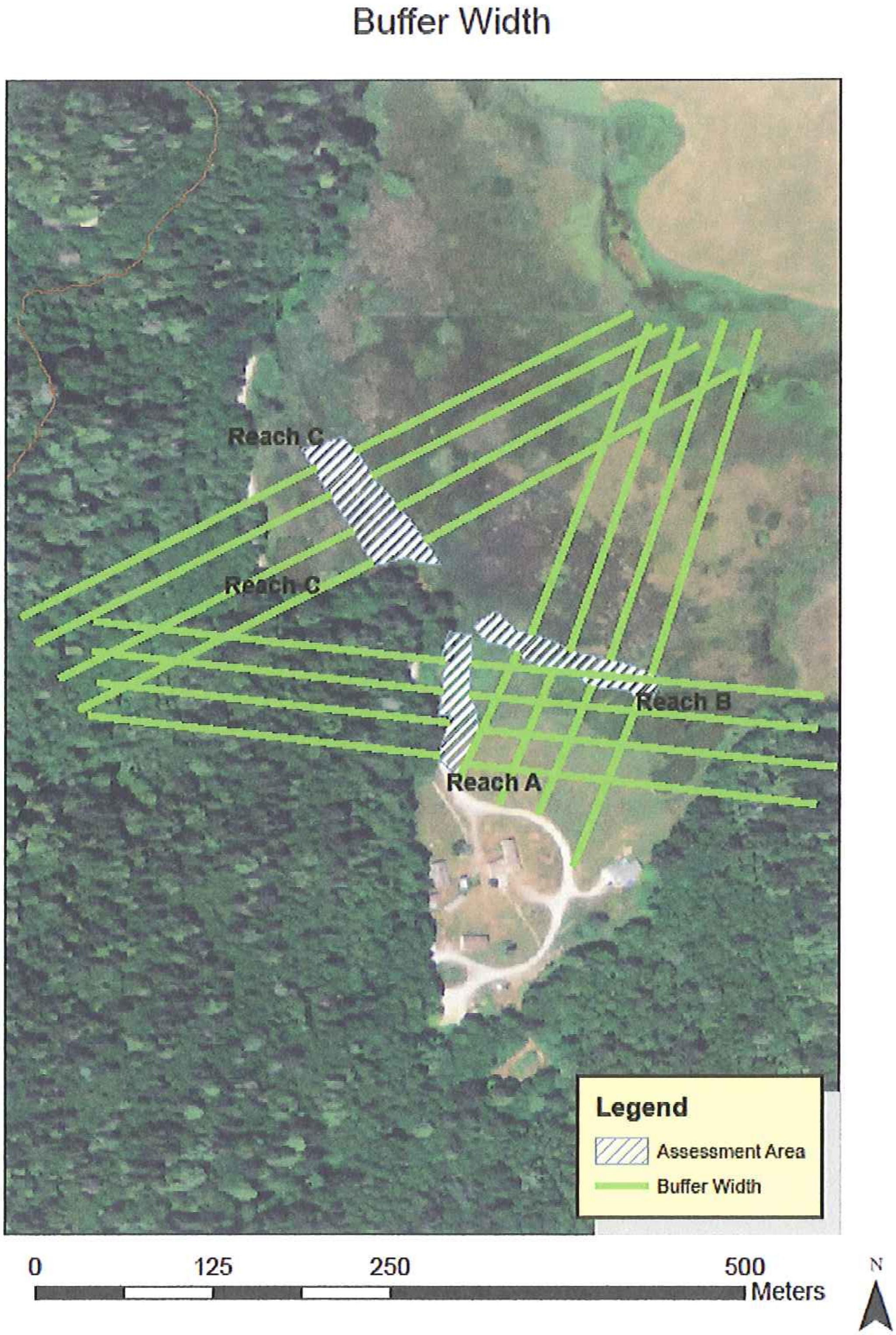


Appendix F

Wet-Meadow % of AA with Buffer

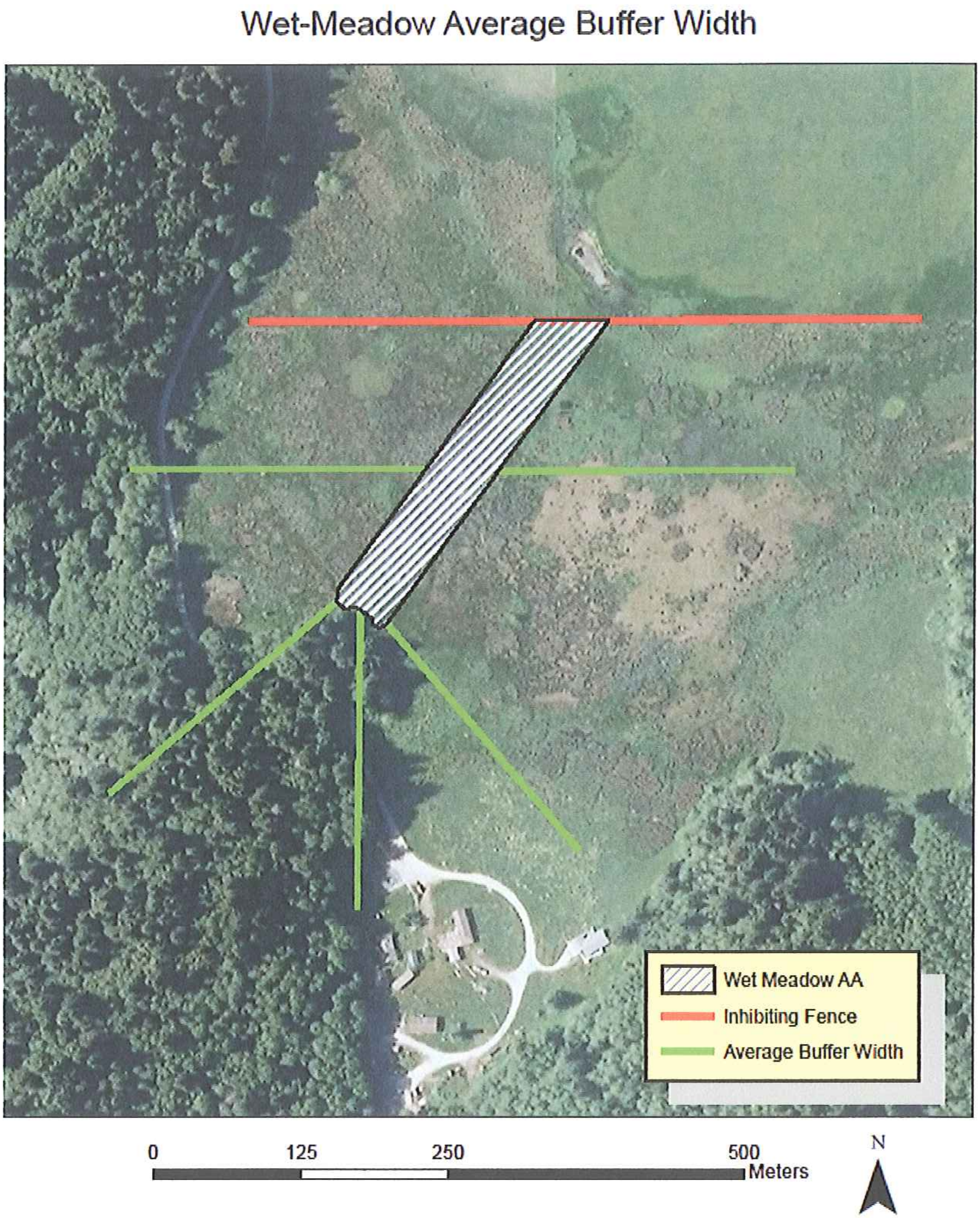


Appendix G



Buffer Width
Reach C
Reach C
Reach B
Reach A
Legend
Assessment Area
Buffer Width
0
125
250
500
Meters
N

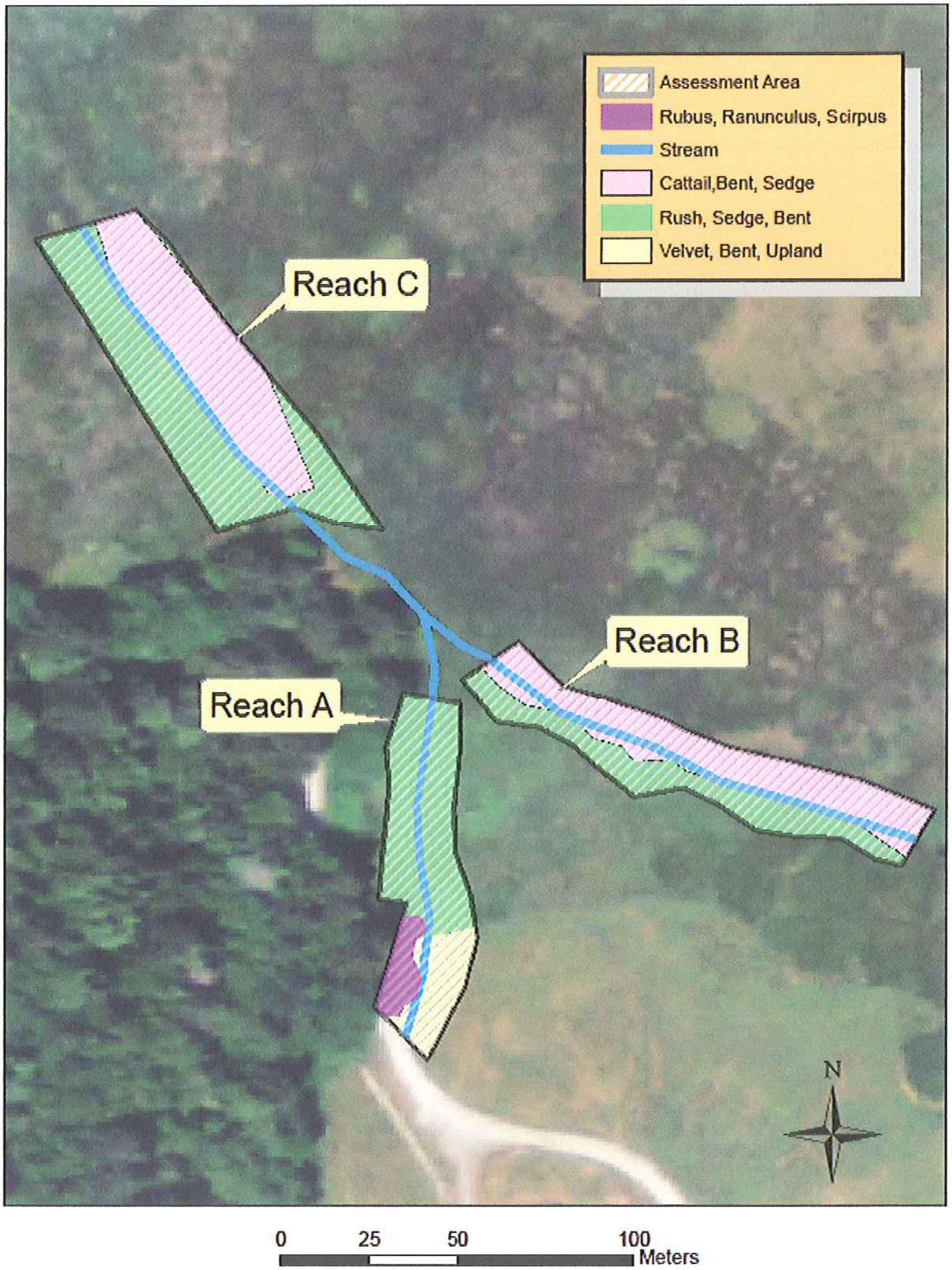
Appendix H


Wet-Meadow Average Buffer Width
Wet Meadow AA
Inhibiting Fence
Average Buffer Width
0
125
250
500
Meters
N

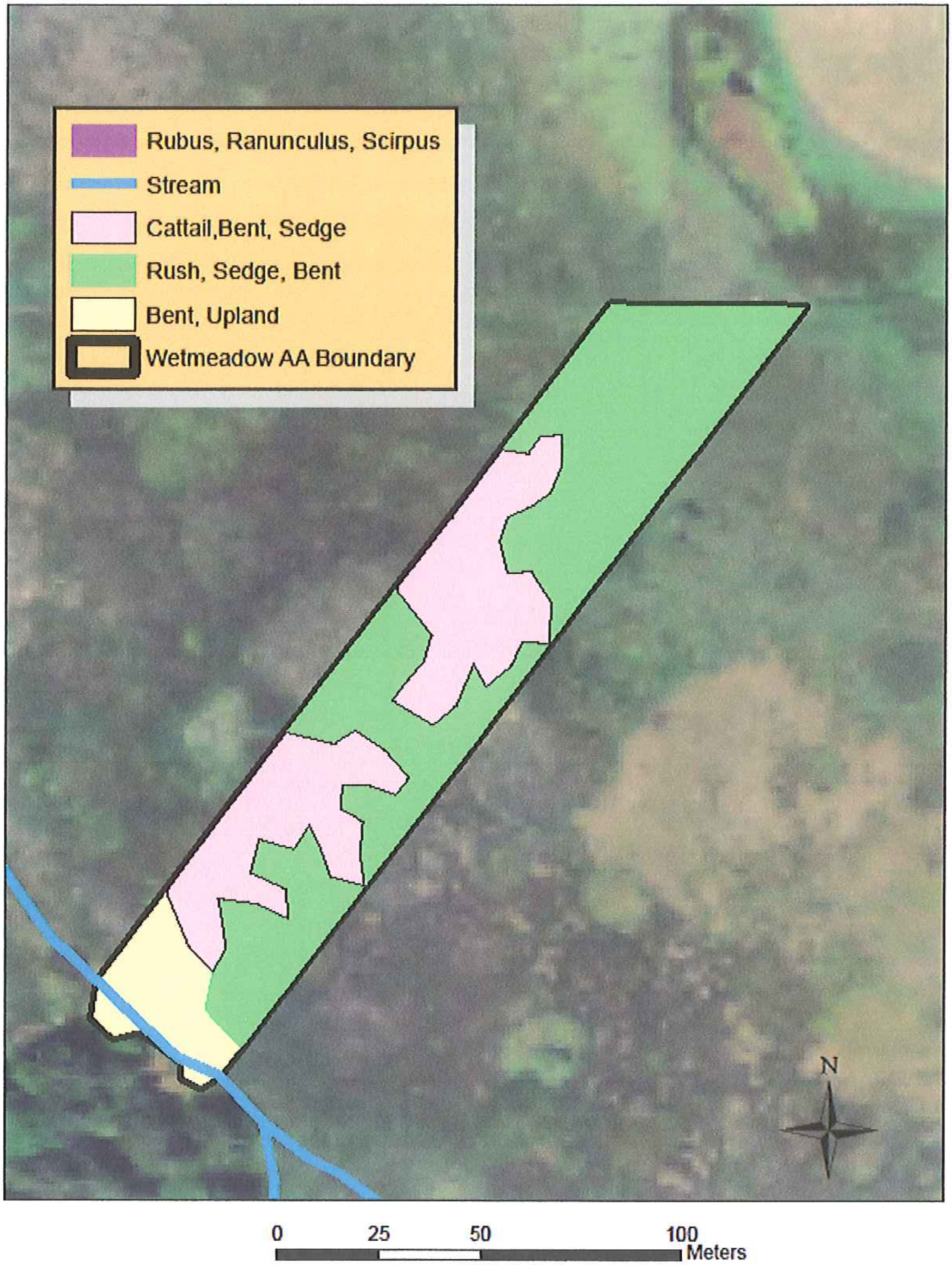
Appendix I


AA Buffer Condition
Reach C
Reach B
Reach A
Legend
Assessment Area
Buffer Condition
0
125
250
500
Meters

Appendix J


Assessment Area
Rubus, Ranunculus, Scirpus
Stream
Cattail,Bent, Sedge
Rush, Sedge, Bent
Velvet, Bent, Upland
Reach C
Reach B
Reach A
N
0
25
50
100
Meters

Appendix K



Rubus, Ranunculus, Scirpus
Stream
Cattail,Bent, Sedge
Rush, Sedge, Bent
Bent, Upland
Wetmeadow AA Boundary
N
0
25
50
100
Meters

Group Time Sheet:	
Name	Hours
Nathan Hancock	122
Charles Brown	130.5
Jean-Paul Ponte	112