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Technical Memorandum:

Condition Assessment of the Wetland Habitats in the Ballona Wetlands Ecological Reserve, Los Angeles, CA

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Introduction

Over 96% and 98% of the vegetated and unvegetated estuarine wetlands, respectively, have been lost over the past century and a half in the Los Angeles region. This loss is mainly attributed to conversion of wetland habitat to uplands through fill deposition or development (Stein et al. 2014). The Ballona Wetlands Ecological Reserve (Reserve) located on the Los Angeles County coast is an example of this phenomenon, having suffered from over a century of abuse and land degradation. Historically a bar-built estuary of over 2,100 acres (Grossinger 2010, Dark et al. 2011), the Reserve has been reduced in size to less than 600 acres of open space. Currently, only approximately one quarter of the site, (153 acres), is considered wetland habitat as delineated by Army Corps of Engineers wetland delineation methods (WRA 2011). Of the remaining wetland habitat, only a small portion (approximately 15 acres) at the western edge of the property is still tidally influenced (Medel et al. 2014).

Channelization of Ballona Creek through the installation of concrete levees in the 1930's effectively eliminated almost all tidal connectivity between the ocean and wetland habitats within the Reserve. These changes permanently altered the mouth of the Creek and converted the estuary from a seasonal to a perennially open system. In addition, impacts such as the dredging of Marina del Rey in the 1950's and '60's and subsequent displacement of millions of cubic yards of sediment, as well as its disposal on the northern portion of the Reserve in combination with local developments, have converted the formerly estuarine marsh habitat to a system dominated by upland habitats interspersed with seasonal, depressional wetlands. The Reserve's current condition and function must be understood through monitoring and assessment to inform scientifically-based restoration planning efforts.

California (State) has adopted monitoring and assessment strategies developed by the United States Environmental Protection Agency (US EPA) that provide consistent approaches to the monitoring and assessment of wetlands (CWMW 2010, US EPA 2006), including standardized rapid assessment methods to facilitate information transfer between projects, while allowing for a condition-level comparison to reference or more 'natural' wetland sites (Sutula et al. 2006). In California, the California Rapid Assessment Method (CRAM) was developed by the California Wetland Monitoring Workgroup (CWMW) as a field-based diagnostic tool that can be used to cost effectively monitor the condition of streams and wetlands throughout California (CWMW 2013). CRAM supports the State's Wetland and Riparian Area Monitoring Plan (WRAMP) as developed by the CWMW. All CRAM testing, validation, and implementation are coordinated on an ongoing basis by an oversight committee of the CWMW that focuses on the development and implementation of RAMs in California.

CRAM can be used as a measure of general aquatic resource health and produces condition scores that are comparable and repeatable for all wetlands and regions in California, yet accommodates special characteristics of different regions and types of wetlands. For the purposes of CRAM, *condition* is defined as the state of a wetland assessment area's buffer and landscape context, hydrology, physical and biological structure relative to the best achievable states for the same type of wetland. Condition is evaluated based on observations made at the time of the assessment, the results of which can be used to infer the ability to provide various functions, services, values, and beneficial uses to which a wetland is most suited (CWMW 2013), although these are not measured directly by CRAM. CRAM also identifies key anthropogenic stressors that may be affecting wetland condition with a checklist.

CRAM "modules" have been developed for various wetland types in direct response to California's assessment and policy needs. The modules for estuarine and depressional wetlands and have been validated against site-intensive monitoring protocols. According to Solek et al. 2012, "the integration of rapid assessment methods with probability-based regional survey designs provides a cost-effective means for making unbiased assessments of wetland condition over a relatively large area within a short period of time."

CRAM was used to assess the condition of wetlands within the Ballona Wetlands Ecological Reserve in 2012 and 2014, with a primary objective similar to those cited directly from the CRAM User's Manual (CWMW 2013): "… to provide rapid, scientifically defensible, standardized, cost-effective assessments of the status and trends in the condition of wetlands and the performance of related policies, programs and projects throughout California." The specific survey goal of this program was to use Level-2 estuarine and depressional CRAM data to provide condition assessments of the wetland habitat areas within the Reserve.

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Methods

Three distinct wetland sub-areas within the Reserve were identified based on differences in dominant hydrology, elevation, and historic general impacts such as hydrological modifications or fill sediment placement (Table 1); and multiple Assessment Areas (AAs) were established within each of the three sub-areas (Figures 1 and 2).

Table 1. Area descriptions for wetland habitats at the Reserve.

Wetland Sub-Area	**Dominant Hydrology**	**Elevation (NAVD 88 ft.)**	**General Impacts**
Area B – Tidally influenced	Muted tidal	3 – 7	Muted tide and restricted hydrology; some man-made channels; some fill placement
Area B – Seasonal	Seasonal stormwater ponding	5 – 7	Tidal disconnection; previously used for agriculture; some fill placement
Area A – Seasonal	Seasonal stormwater ponding	12 – 15	Tidal disconnection; large volumes of fill sediments placed throughout Area A

Assessment Areas one hectare each in size were mapped in ArcGIS 10.1 according to the CRAM guidelines (CWMW 2013). These procedures are summarized below:

1. Wetland boundaries were identified using a 2007 habitat map created by the Department of Fish and Wildlife (DFW 2007).
2. Wetland areas were subdivided using the criteria described in Table 1.
3. All potential AAs were identified for each wetland sub-area (i.e. grid comprised of non-overlapping one hectare circles were overlain on each wetland sub-area).
4. Potential AAs with more than 50% of their respective area outside of wetland habitat boundaries were rejected and deleted.
5. Unique identifiers were assigned for all remaining potential AAs. Three AAs were randomly selected for each wetland sub-area.
    a. Several additional AAs were also selected for each sub-area but not used. In accordance with the User’s Manual (CWMW 2013), the assessment of three AAs per wetland area was appropriate, as the average scores of the first two AAs differed by less than 15% of the third AA.
6. Selected AAs not covering 80% of wetland habitat were redrawn to one hectare using wetland habitat boundaries (e.g. Area A – seasonal; Figure 1).

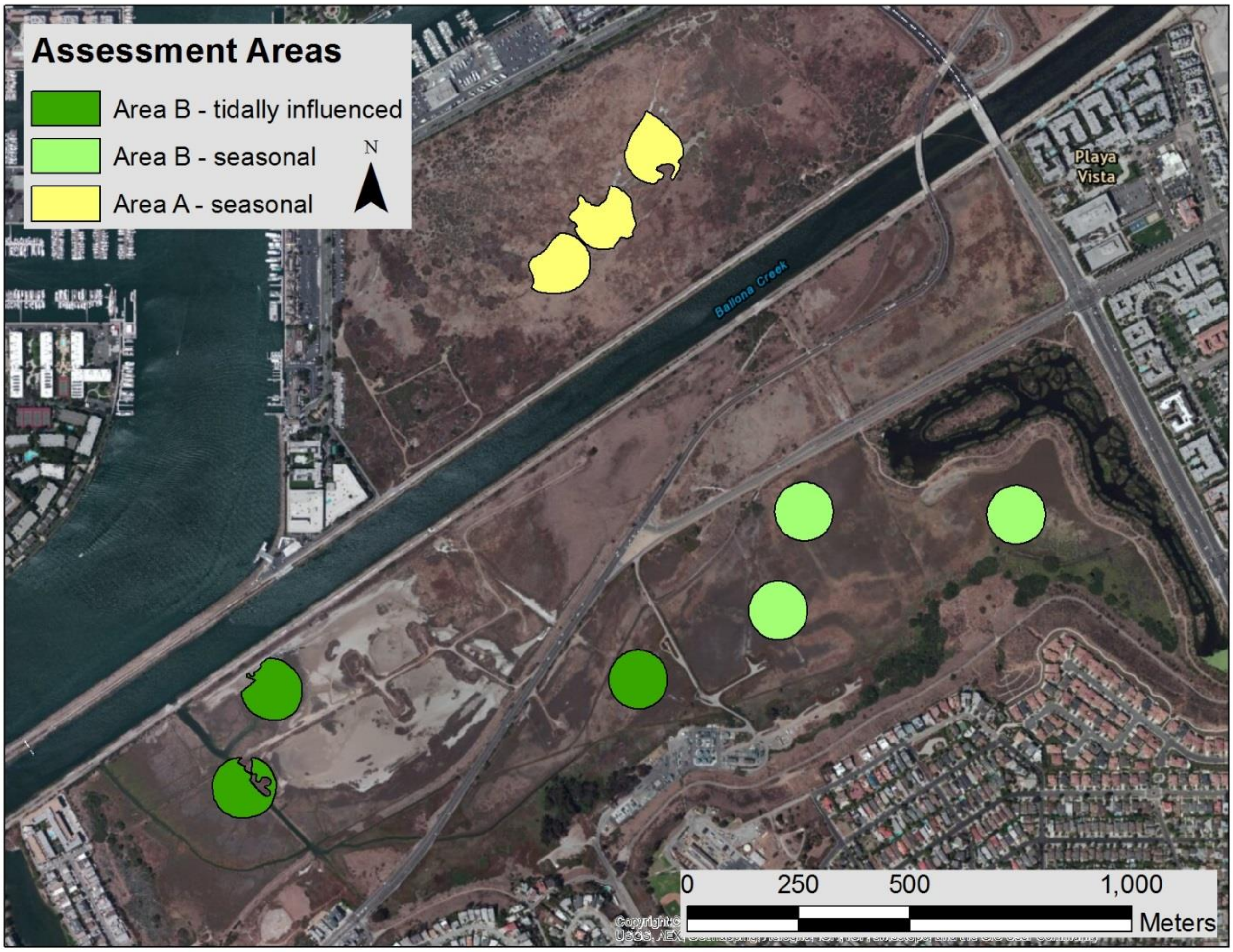

Figure 1. Map of survey Assessment Areas within the Ballona Wetlands Ecological Reserve.

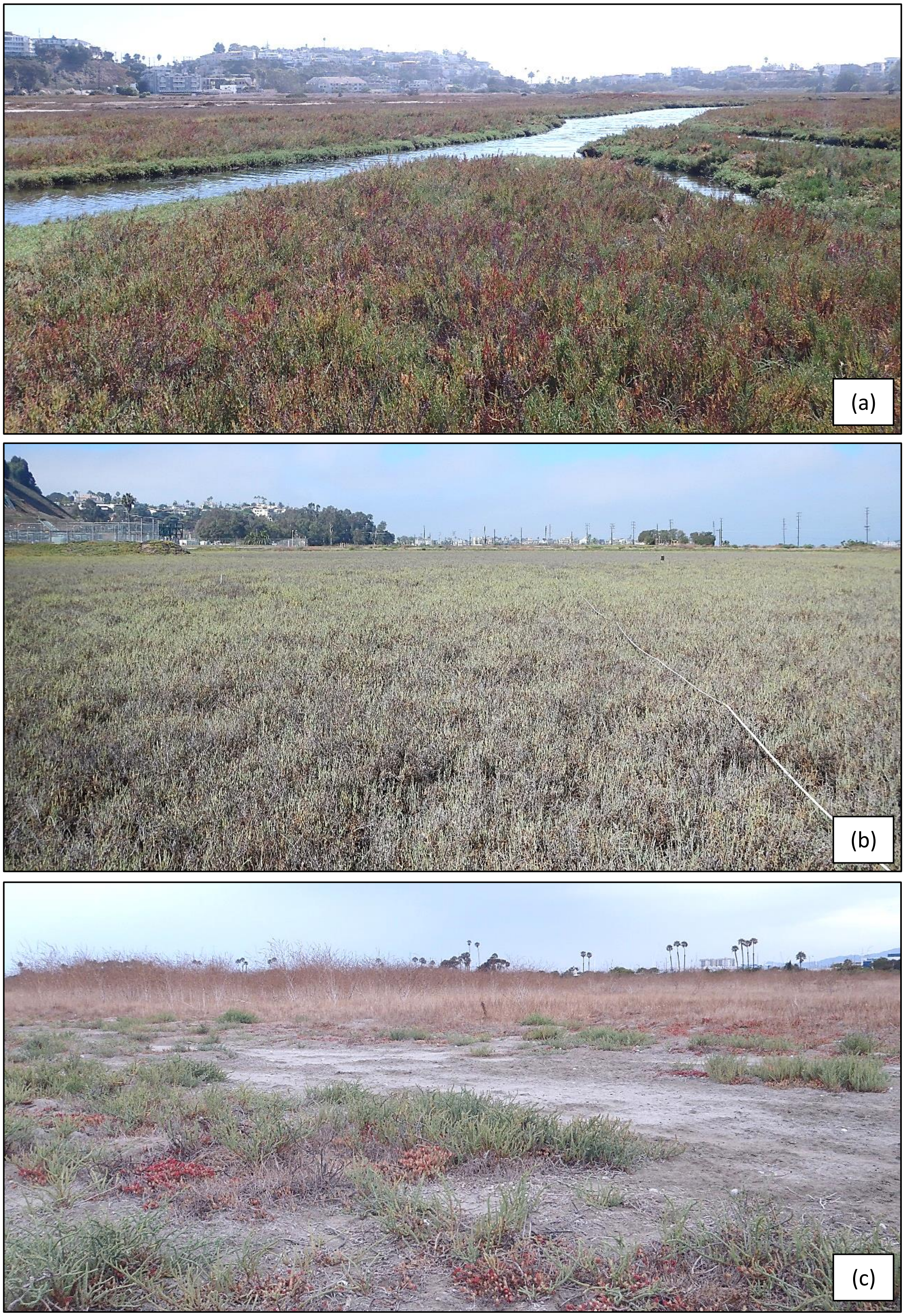

Figure 2. One representative photograph from the centroid of an AA at each wetland sub-area: (a) Area B – tidally influenced; (b) Area B – seasonal; (c) Area A – seasonal.

CRAM assessments were conducted from 16 August – 16 October 2012 and again from 7 August – 26 September 2014 following using both the CRAM "estuarine" and "depressional" modules (CWMW 2012a, CWMW 2012b). Office assessments were conducted using GIS (ArcGIS 10.1). While the seasonal wetland habitats were most appropriately classified as 'depressional wetlands', and the western Area B tidal channels were most appropriately classified as 'estuarine wetlands', both modules were conducted across all AAs for comparative evaluation purposes. Both modules contain the same overall evaluation attributes and metrics, with differing specific definitions. Field work for each AA was conducted in a single 2-3 hour time period during low tide, according to the procedures outlined in the CRAM User's Manual.

The CRAM metrics are organized into four main attributes: landscape and buffer context, hydrology, physical structure, and biotic structure for each type of wetlands (i.e. depressional and estuarine wetlands) with multiple metrics and sub-metric assessments (Table 2). The attributes are all averaged to quantify a final assessment score for each wetland module and AA analyzed.

Table 2. Summary table of CRAM attributes; descriptions modified from the CRAM User Manual (CWMW 2013).

Attribute	Metric	Sub-metric	Description	Assessment Location
Landscape and Buffer Context	Aquatic Area Abundance	---	Spatial association to adjacent areas with aquatic resources	Office
	Buffer	Percent of AA with Buffer	Relationship between the extent of buffer and the functions it provides	Office
		Average Buffer Width	Extent of buffer width assesses area of adjacent functions provided	Office
		Buffer Condition	Assessment of extent and quality of vegetation, soil condition, and human disturbance of adjacent areas	Field
Hydrology	Water Source	---	Water source directly affects the extent, duration, and frequency of hydrological dynamics	Office / Field
	Hydroperiod	---	Characteristic frequency and duration of inundation or saturation	Office / Field
	Hydrologic Connectivity	---	Ability of water to flow into or out of a wetland, or accommodate flood waters	Office / Field
Physical Structure	Structural Patch Richness	---	Number of different obvious physical surfaces or features that may provide habitat for species	Field
	Topographic Complexity	---	Micro- and macro-topographic relief and variety of elevations	Field
Biotic Structure	Plant Community Composition	Number of Plant Layers	Number of vegetation stratum indicated by a discreet canopy at a specific height	Field

Attribute	Metric	Sub-metric	Description	Assessment Location
Biotic Structure	Plant Community Composition	Number of Co-dominant Species	For each plant layer, the number of species represented by living vegetation	Field
		Percent Invasion	Number of invasive co-dominant species based on Cal-IPC status	Field
	Horizontal Interspersion	---	Variety and interspersion of different plant “zones”: monoculture or multi-species associations arranged along gradients	Field
	Vertical Biotic Structure	---	Interspersion and complexity of plant canopy layers and the space beneath	Field

Error Avoidance and Observer Effect

Due to the slightly subjective nature of some CRAM metric assessments, effort was made to maximize the accuracy of each assessment in accordance with the CRAM methodology. This effort included several strategies: (1) CRAM practitioners attended a training course prior to field implementation; (2) field teams consisted of multiple trained individuals to avoid observer bias; and (3) quality control checks were performed by the Quality Assurance Officer.

Analysis Methods

Basic summary statistics were calculated for the data based on individual Assessment Areas including averages, standard error, and one-way ANOVAs with a confidence level of $\alpha < 0.05$. CRAM scores occur on a 25-100 point scale, with 100 as the maximum possible score, indicating the highest possible wetland condition. Grand means were calculated by averaging AA scores by area and then averaging again at a site-level to compare across years.

Results

BWER CRAM condition scores varied by attribute, CRAM module, and year. Table 3 displays the overall grand mean CRAM scores and the scores for each attribute by module and year. Final scores using the estuarine module were similar between years, with 2012 results indicating a slightly higher final score (54.1 ± 3.4) than 2014 (53.5 ± 3.3). Similarly, the 2012 final score using the depressional module (60.7 ± 2.6) was slightly higher than the 2014 final score (58.1 ± 3.0), indicating a slight drop in condition using both modules over the two-year period. Scores for the landscape-buffer context and hydrology attributes were not different between years. These attributes are a measure of the surrounding landscape and dominant hydrologic characteristics which did not experience significant changes during this time period.

Table 3. Grand mean CRAM scores for each attribute and each module by year: (a) estuarine module results; (b) depressional module results.

Estuarine CRAM Module (a)					
Year	**Buffer and Landscape Context**	**Hydrology**	**Physical Structure**	**Biotic**	**Final Score**
2012	69.4 ± 4.0	37.0 ± 4.4	45.8 ± 4.7	64.2 ± 3.0	**54.1 ± 3.4**
2014	69.4 ± 4.0	37.0 ± 4.4	48.6 ± 5.3	59.0 ± 2.6	**53.5 ± 3.3**

Depressional CRAM Module (b)					
Year	**Buffer and Landscape Context**	**Hydrology**	**Physical Structure**	**Biotic**	**Final Score**
2012	69.4 ± 4.0	61.1 ± 2.8	45.8 ± 4.7	66.4 ± 2.8	**60.7 ± 2.6**
2014	69.4 ± 4.0	61.1 ± 2.8	47.2 ± 5.8	54.6 ± 3.3	**58.1 ± 3.0**

There were no significant differences overall by year ($F_{1, 34} = 0.260$; $p = 0.614$) or module ($F_{1, 34} = 3.441$; $p = 0.072$) for the final scores, although the relatively low p-value for the module difference was heavily weighted by a significant difference in the hydrology attribute between modules, ($F_{1, 34} = 45.244$; $p < 0.001$), due to the impacted and tidally-restricted nature of most of the Reserve.

Area-specific Results

There was a significant difference by wetland sub-area for average final score for both modules (estuarine: $F_{2, 15} = 28.111$, $p < 0.001$; depressional: $F_{2, 15} = 28.853$, $p < 0.001$), with Area A possessing the significantly lowest final score, followed by seasonal Area B; the highest scores occurred in the tidally influenced portion of Area B. The estuarine and depressional modules both reported similar area-specific results, except for the hydrology attribute (Table 4).

Table 4. Average CRAM scores for each attribute and each module by sub-area: (a) estuarine module results; (b) depressional module results.

Estuarine CRAM Module (a)					
Sub-Area	**Buffer and Landscape Context**	**Hydrology**	**Physical Structure**	**Biotic**	**Final Score**
A	54.2 ± 0	25.0 ± 0	39.6 ± 2.1	56.0 ± 2.5	**43.7 ± 0.7**
B-E	79.2 ± 0	33.3 ± 0	39.6 ± 2.1	62.0 ± 4.0	**53.5 ± 1.4**
B-W	75.0 ± 2.6	52.8 ± 3.5	62.5 ± 6.5	66.7 ± 2.8	**64.2 ± 3.0**

Depressional CRAM Module (b)					
Sub-Area	**Buffer and Landscape Context**	**Hydrology**	**Physical Structure**	**Biotic**	**Final Score**
A	54.2 ± 0	50.0 ± 0	39.6 ± 2.1	56.9 ± 5.0	**50.2 ± 0.9**
B-E	79.2 ± 0	66.7 ± 0	37.5 ± 3.2	58.3 ± 4.2	**60.4 ± 1.4**
B-W	75.0 ± 2.6	66.7 ± 0	62.5 ± 6.5	66.2 ± 3.5	**67.6 ± 2.3**

Statewide and Regional Comparisons

Figure 3 compares the averages of final CRAM scores for each sub-area of the BWER to California-statewide and regional (southern California) maximum and minimum score data for both estuarine and depressional CRAM modules (Table 5, Figure 3). Data were downloaded from the public CRAM EcoAtlas database on 29 January 2015: www.ecoatlas.org. For the estuarine module, the statewide and regional low CRAM scores were both 40 and are thus represented by the same color line. The maximum values are from healthy, reference wetlands.

Table 5. Statewide and regional, southern California, CRAM final score maximum / minimum data points (data downloaded from EcoAtlas; 29 January 2015). Data points are color-coded to match Figure 3.

Module	Statewide Maximum	Regional Maximum	Statewide Minimum	Regional Minimum
Estuarine CRAM	94	91	40	40
Depressional CRAM	91	77	30	34

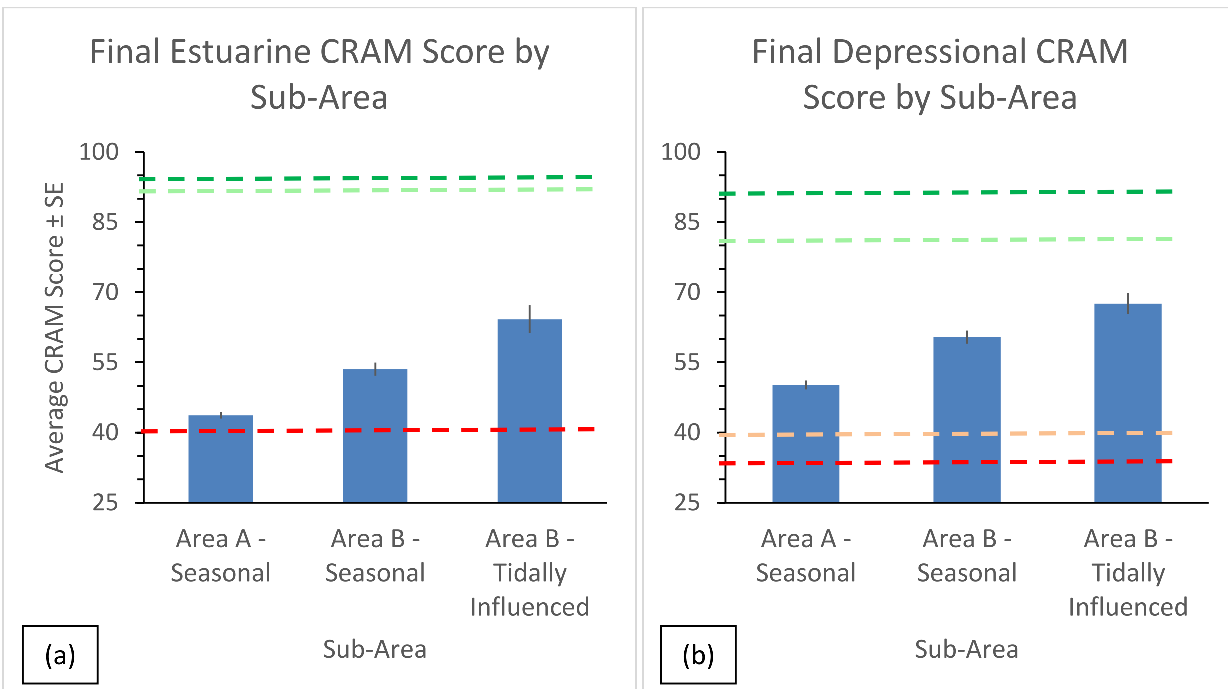

Figure 3. Average final CRAM score by sub-area and module with reference maximum (greens) and minimum (reds) score lines based on Table 5: (a) estuarine module; (b) depressional module.

Conclusions

Several clear patterns are evident based on the CRAM condition assessment data across two years. Firstly, while not statistically significant, final CRAM scores indicate that the wetland habitats at the Reserve from 2012 – 2014 were experiencing slowly deteriorating conditions. Declining CRAM scores can be primarily attributed to several sub-metrics, including a decrease in biotic structure characteristics and an influx of annual, non-native plants. As no significant management actions (e.g. restoration, tide gate modifications) occurred within the sampling period, the landscape-buffer and hydrological attributes remained the same.

Additionally, these data are the first comparative rapid condition assessments evaluating the wetland habitats across the site. Area A was significantly the most degraded sub-area on site, followed by seasonal Area B; the tidally influenced portion of Area B exhibited the highest condition scores. This was likely heavily influenced by the level of invasion in the plant community in Area A, as well as a lack of hydrological connection to an estuarine water source resulting from historic anthropogenic soil disturbances and the construction of water impoundment structures.

Lastly, comparing average Ballona Reserve CRAM scores to high- and low-scoring wetlands across the state further demonstrates the degraded current condition of the Reserve wetland habitats, especially based on the estuarine module assessments. While most coastal wetlands in California have been exposed to various degrees of impacts and exist in a semi-natural state, wetland habitats of the Reserve still had condition scores 30 – 50 points below state reference wetlands. Subsequently, Area A is among the most degraded wetlands in California with an estuarine module score only four points higher than the lowest condition wetland in the state. Given the major modifications and impacts to the Reserve over the last century, such as the concrete levees and fill placement, the results were not unexpected.

While it's often difficult to compare the condition of hydrologically-dissimilar wetland areas, the implementation of multiple CRAM module surveys support the sub-area condition assessments across wetland types (i.e. estuarine and depressional). Additionally, CRAM scores comparing modules exhibit similar trends, with slightly higher depressional module scores, driven by the hydrology attribute. The depressional module's hydrology attribute accounts for freshwater-driven sources, which are seasonally present at all sites; estuarine tidal hydrology is only present at one of three sub areas (i.e. Area B – tidal). However, as changes in scores across each sub-area are consistent for both module assessments, final CRAM scores still indicate significant differences by area regardless of which module is applied. Thus, the consistent conclusions across modules reinforce the findings that despite differences in dominant hydrology, Area A was significantly more degraded than seasonal Area B, and the tidally-influenced portion of Area B contained the highest condition wetlands on the Reserve.

These data serve as a baseline pre-restoration assessment of the condition of the site; they could be compared to post-restoration data in the future to evaluate the change in wetland condition based on management actions. Repeated surveys at the same AAs over a longer period of time will serve to evaluate if any of the specific metrics or attributes continue to decline over time.

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