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Project Name: California Rapid Assessment Method Statewide Study
San Francisco Estuary Institute, Richmond CA
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Task 5:
The effects of aquatic area abundance, buffer, and hydrology on depressional wetland condition based on CRAM

Introduction

CRAM assumes that the kinds and levels of ecosystem services that a wetland can sustain increase with the support of its surrounding landscape. This support is assessed as landscape connectivity using the Aquatic Area Abundance Metric, resistance to landscape stressors using the Buffer Metric, and naturalness of hydrological sources and processes using the Hydrology Attribute.

CRAM practitioners have especially questioned the usefulness of the Aquatic Area Abundance Metric for assessing the conditions of projects. It is the only CRAM Metric that is intended to assess connectivity between projects and their surrounding landscape. One concern is that project sponsors usually lack control over these conditions. Another concern is that the landscape surrounding the project may not support the abundance of aquatic areas necessary for high Condition Index scores, due to natural constraints, such as aridity or topographic steepness, or land use. These concerns have led to the consideration that the Aquatic Area Abundance Metric may be biased against projects. To a much lesser degree, there is a concern that the Buffer Metric and Hydrology Attribute might also be biased against projects, since their scores sometimes reflect conditions outside project boundaries. These considerations are explored by addressing the following questions.

1. Is Aquatic Area Abundance correlated to Wetland Condition?
2. How is Wetland Condition affected by Aquatic Area Abundance?
3. Does Aquatic Area Abundance differ between projects and non-project wetlands?
4. Does excluding the Aquatic Area Abundance Metric influence the Condition Index scores differently for projects and non-project wetlands?
5. Does excluding the Buffer Metric and Hydrology Attribute influence the Condition Index scores differently for projects and non-project wetlands?

Dataset

A project is defined as a purposeful change in topography, hydrology, or vegetation to create, restore, or enhance a depressional wetland. Compensatory mitigations are regarded as projects.

CRAM assessments for depressional wetlands were compiled from the statewide CRAM database (www.cramwetlands.org). Each assessment was classified as being for a project, a non-project wetland, or indeterminate, based on the field notes and case-specific reports. A few projects have been assessed multiple times. The first sets of scores for these projects were excluded from the dataset because they represented pre-project assessments. The other sets of scores for these projects were included as independent assessments. Indeterminate scores were excluded from the dataset. The final dataset includes 355 assessments for depressional wetlands ranging in size from about 0.005 to 591 ha.

Findings

Question 1: Is Aquatic Area Abundance correlated to Wetland Condition?

Null Hypothesis: There is no correlation between Aquatic Area Abundance and condition.

Summary of Findings**:** The null hypothesis is not rejected. There is no correlation between Aquatic Area Abundance and condition for depressional wetlands. Based on these findings, high and low condition scores are equally likely across the full range of Aquatic Area Abundance.

To fully address this question, Aquatic Area Abundance was regressed on two modifications of the Original Condition Index, one excluding the Buffer and Landscape Context Attribute (NoBL Index), and one also excluding the Hydrology Attribute (NoBL-NoH Index). There are three reasons for calculating the Index score in these two ways:

1. The Task 2 memorandum*, Relationship between Wetland Size and CRAM Condition Scores for Depressional Wetlands,* reports that Condition Index scores are weakly but positively correlated to scores for the Buffer and Landscape Context Attribute. To prevent autocorrelation when testing for a relationship between Aquatic Area Abundance and condition, the Condition Index was calculated excluding the Buffer and Landscape Context Attribute (NoBL Index).
2. The Task 4 memorandum*, CRAM Stress Index,* recommends moving the Hydrology Metrics from the Condition Index to the Stress Index. In order to be consistent with this recommendation, and to prevent autocorrelation (see reason 1 above) the test for correlation between Aquatic Area Abundance and Condition used a Condition Index that excludes the Hydrology Attribute as well as the Buffer and Landscape Context Attribute (NoBL-NoH Index).
3. Given that the recommendation from the Task 4 memorandum to remove the Hydrology Attribute from the Condition Index might not be implemented, the correlation between Aquatic Area Abundance and Condition was tested with and without the Hydrology Attribute (Figure 1).

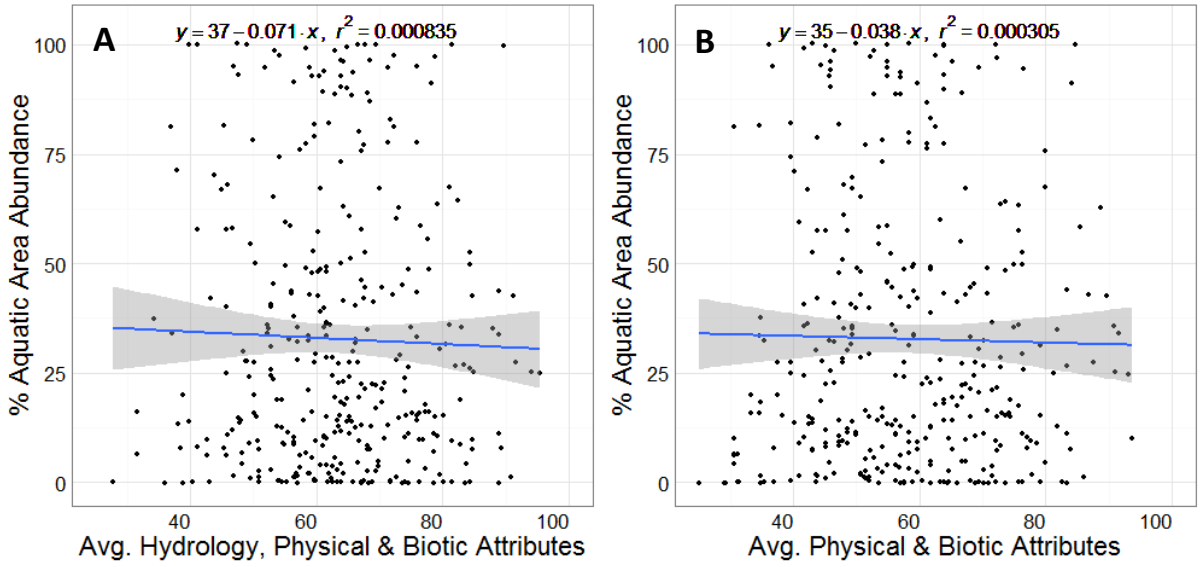

Figure 1. Aquatic Area Abundance plotted against wetland condition (A) excluding the Buffer and Landscape Context Attribute (NoBL Index), and (B) excluding the Hydrology Attribute as swell as the Buffer and Landscape Context Attribute (NoBL-NoH Index).

Wetlands with low scores for Aquatic Area Abundance are likely providing important functions unrelated to their ecological or hydrological connectivity. Expected functions include support for native vegetation and for native terrestrial and wetland wildlife with small home ranges, especially reptiles, amphibians, small mammals, and birds. They may also serve as breeding sites for amphibians that spend most of their lives in terrestrial habitats. Depressional wetlands that are more ecologically and hydrologically interconnected may provide additional services such as floodwater storage, groundwater recharge, and support for dispersal and migration of plants and animals.

Question 2: *How is Wetland Condition affected by Aquatic Area Abundance?*

Null Hypothesis: Aquatic Area Abundance has no effect on the Index score.

Summary of Findings: The null hypothesis is rejected. Excluding the Aquatic Area Abundance Metric can have a considerable positive or negative effect on the CRAM Index score for depressional wetlands. Any decision to include or exclude scores for this Metric from calculations of the Index score could significantly affect the comparability of past and future Index scores and their interpretation.

This question can be addressed by comparing the Aquatic Area Abundance score to the difference between Condition Index scores that are calculated with and without the Aquatic Area Abundance Metric. The Index that includes the scores for Aquatic Area Abundance is referred to as the Original Index. The version that excludes the scores for Aquatic Area Abundance is referred to as NoAAA Index.

The effect on the Condition Index score of excluding Aquatic Area Abundance can be visualized by plotting the difference between NoAAA Index scores and the Original Index scores against the Aquatic Area Abundance score (Figure 2). As expected, the effect changes as Aquatic Area Abundance increases. Excluding the Aquatic Area Abundance Metric when its score is high can *decrease* the Index score by up to 6 points; excluding the Metric when its score is low can *increase* the Index score by up to 9 points.

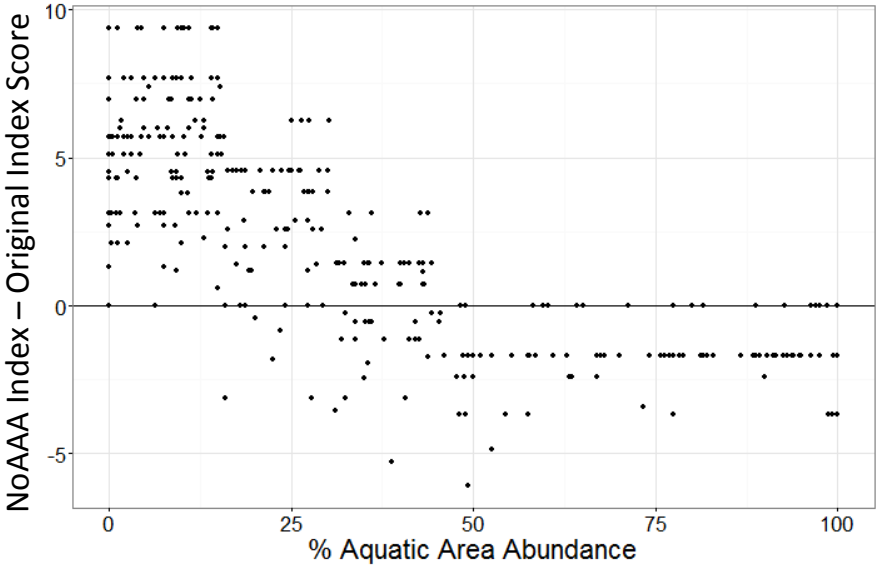

Figure 2. Aquatic Area Abundance plotted against the difference between NoAAA Index scores (excluding the Aquatic Area Abundance scores) and the Original Index scores.

Question3: *Does Aquatic Area Abundance differ between projects and non-project wetlands?*

Null Hypothesis: Aquatic Area Abundance is the same for projects and non-project wetlands.

Summary of Findings: The null hypothesis is rejected. The Aquatic Area Abundance is greater for projects than non-project wetlands (Figure 3).

While the range of percent Aquatic Area Abundance overlaps for project and non-project wetlands (Figure 3), an analysis of variance test indicates that project assessments have significantly higher amounts of aquatic area than non-project assessments ($p<0.001$). This may reflect a variety of factors. For example, there is an apparent tendency for projects to be sited near other aquatic areas, perhaps as water sources. Also, some of the larger projects included in this analysis are much larger than the CRAM AA, thus other wetland area within the project is included in the assessment of aquatic area abundance. Conversely, many of the non-project wetlands are located in landscapes that lack aquatic areas because of natural aridity or land use. This is true for many rural stockponds, urban or industrial water storage features, and water hazards on golf courses.

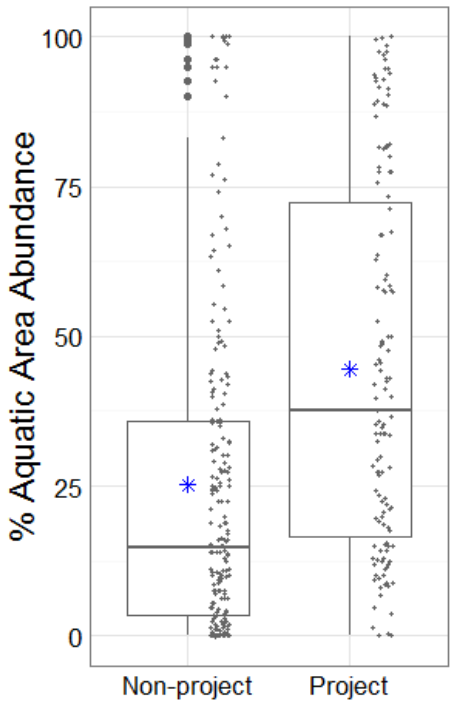

Figure 3. Box-and-whisker plots comparing Aquatic Area Abundance for project and non-project wetlands. The boxes are defined by the 25th and 75th quartiles of the data; the horizontal lines through the boxes represent the 50th percentile score. The means are represented by blue stars. The whiskers above and below each box indicate 1.5x the interquartile range, and the large black dots beyond the whiskers are outliers. Scatter plots of the project and non-project data are shown alongside their respective box-and-whisker plots.

Question 4: *Does excluding the Aquatic Area Abundance Metric influence the Condition Index scores differently for projects and non-project wetlands?*

Null Hypothesis: The influence of Aquatic Area Abundance on the CRAM Index score is the same for projects and non-project wetlands.

Summary of Findings: The null hypothesis is not rejected. Excluding Aquatic Area Abundance has the same influence on CRAM Index scores for projects and non-project wetlands.

This question was addressed by comparing projects and non-project wetlands based on the Original Condition Index and a modified Index excluding the Aquatic Area Abundance Metric (i.e., NoAAA Index). The NoAAA Index is slightly greater than the Original Index for projects and non-project wetlands alike (Figure 4). The range in scores is not affected.

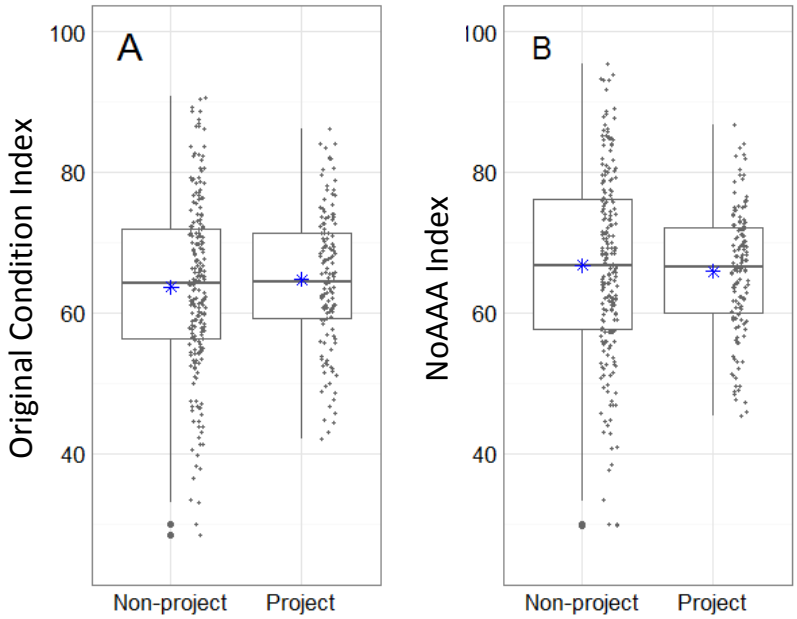

Figure 4. Box-and-whisker plots of CRAM Index scores for projects and non-project wetlands based on (A) the Original Index, and (B) the NoAAA Index that excludes scores for the Aquatic Area Abundance Metric.

Question 5: *Does excluding the Buffer Metric and Hydrology Attribute influence the Condition Index scores differently for projects and non-project wetlands?*

Null Hypothesis: CRAM assessments of buffer and hydrology affect condition assessments similarly for project and non-project wetlands.

Summary of Findings: The null hypothesis is not rejected. CRAM assessments of condition for project and non-project wetlands are similarly affected by buffer and hydrology scores.

In addition to the Aquatic Area Abundance Metric, CRAM also uses the Buffer Metric and the Hydrology Attribute to assess the setting and landscape context of depressional wetlands. This raises a question

about the relative influences of the Buffer Metric and Hydrology Attribute on the assessment of condition, and whether or not this influence is the same for project and non-project wetlands.

With regard to the Buffer Metric, project and non-project wetlands were compared based on the amount of buffer, calculated as the square root of the product of two Buffer Sub-metrics: Percent of AA with Buffer and Average Buffer Width. The Buffer Condition Sub-metric was excluded from this analysis because it is expected to have less influence on wetland condition than the amount of buffer. Neither summing nor averaging the scores for Percent of AA with Buffer and Average Buffer Width provides adequate differentiation between cases. For example, a wetland with scores of 3 and 12 for these Sub-metrics would have the same sum and average score as another wetland with scores of 9 and a 6, although the former wetland has almost no buffer and the latter has a substantial amount of buffer around more than half of the wetland. The square roots of the average scores are 6.0 and 7.3, respectfully, which is consistent with the CRAM premise that lots of narrow buffer is better than scant but wide buffer. By plotting the amount of buffer for projects and non-project wetlands, we find that the amount is especially similar (Figure 5).

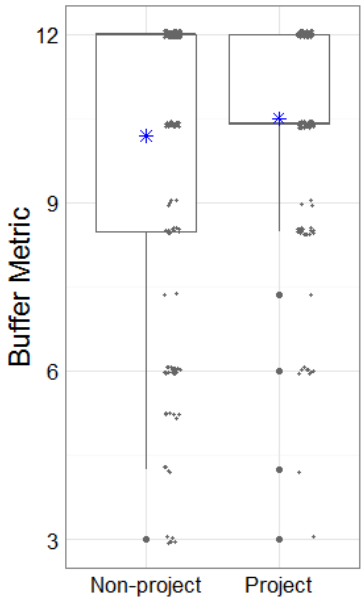

Figure 5. Box-and-whisker plots comparing the amount of Buffer for project and non-project wetlands.

The Aquatic Area Abundance Metric, Buffer Metric, and Hydrology Attribute were sequentially excluded from the Condition Index to further analyze their effects on assessments for project and non-project wetlands. Four versions of the Condition Index were calculated for this analysis.

- The Original Index includes all the Metric scores for each of the four CRAM Attributes.
- Index NoAAA excludes the scores for Aquatic Area Abundance (see Figure 4 above).
- Index NoBL (see Question 1 above) excludes the scores for Buffer as well as Aquatic Area Abundance (i.e., excludes the entire Buffer and Landscape Context Attribute).
- Index NoBL-NoH (see Question 1 above) excludes the Hydrology Attribute as well as the Buffer and Landscape Context Attribute.

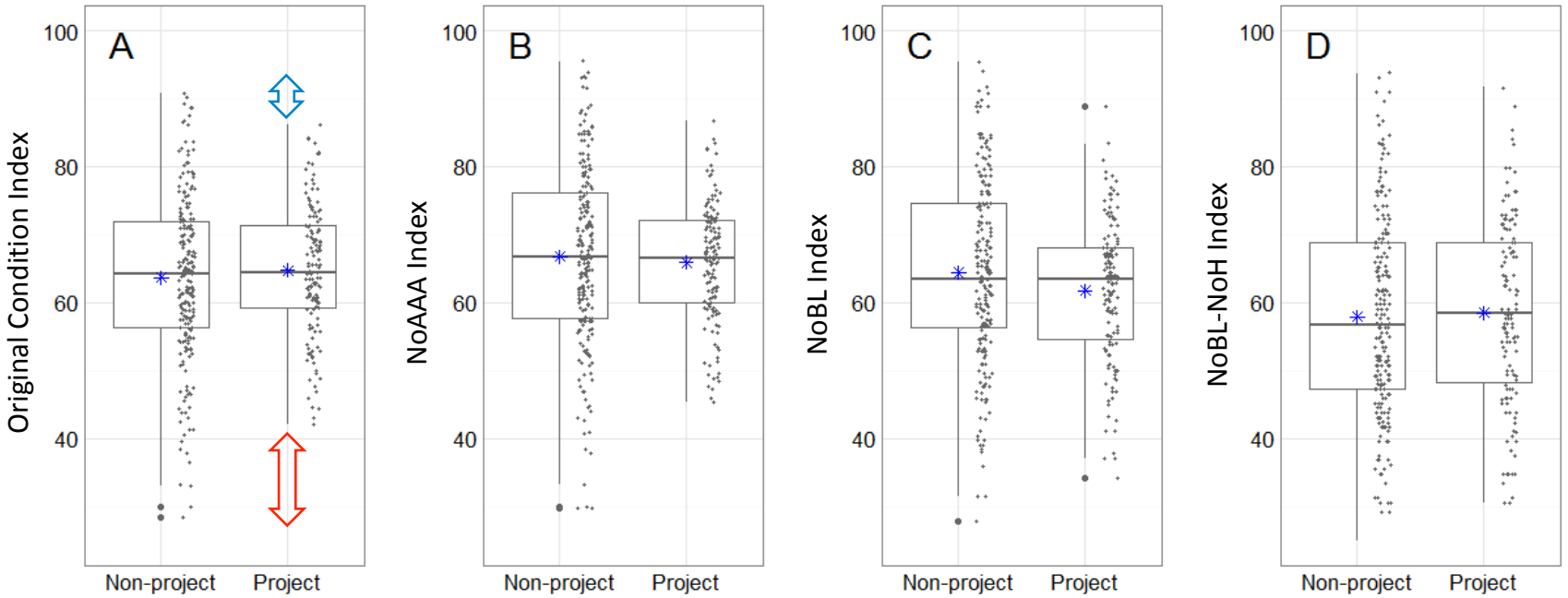

Figure 6. Box-and-whisker plots comparing condition for project and non-project wetlands based on (A) Original Condition Index, (B) NoAAA Index (i.e., excluding the Aquatic Area Abundance Metric), (C) NoBL Index (i.e., excluding the Buffer and Landscape Context Attribute), and (D) No-BL-NoH Index (excluding the Hydrology Attribute as well as the Buffer and Landscape Context Attribute).

For each of the four versions of the Condition Index (i.e., Original Index, NoAAA Index, NoBL Index, NoBL-NoH Index), there is no significant difference between average scores for project and non-project wetlands. The average scores for the three alternative versions of the Index (i.e., NoAAA Index, NoBL Index, and NoBL-NoH Index) are also no different than the average score for the Original Condition Index. These findings indicate that none of the Metrics or Attributes used to assess the setting of a wetland are biased for or against project or non-project depressional wetlands.

However, both the lowermost and uppermost portions of the range of Original Index scores are missing for projects (red and blue arrows in Figure 6A). This truncation of the range of Index scores is perhaps most evident when the Aquatic Area Abundance Metric is excluded from the calculation of condition (see 6B), reflecting the fact that projects tend to have higher scores for Aquatic Area Abundance than non-project wetlands (see Figure 3), although removing scores for this Metric from the Condition Index can both increase and decrease Index score (see findings for Question 2).

The truncation of the lowermost portion of the range in Index scores for projects might also indicate that projects are being designed and managed well enough to prevent very poor conditions that are sometimes evident for non-project wetlands.

This truncation of the uppermost portion of the range in Index scores for projects might suggest that projects are not designed or managed for their maximum natural complexity, or that most projects are still evolving and have yet to achieve their highest scores. The relationship between project age and condition relative to natural reference wetlands is further elucidated by Task 3, *Depressional Wetland Habitat Development Curves.*

Conclusions

This analysis of the effect of Aquatic Area Abundance on CRAM Index scores supports the following conclusions.

- There is no correlation between Aquatic Area Abundance and condition for depressional wetlands.
- However, excluding the Aquatic Area Abundance Metric from the CRAM Index can have a considerable positive or negative effect on the assessment of overall condition for depressional wetlands. Any decision to include or exclude this Metric from calculations of the Condition Index could significantly affect the comparability of past and future Index scores and their interpretation.
- Aquatic Area Abundance has the same influence on CRAM Index scores for projects and non-project wetlands. That is, the considerable effect that excluding the Aquatic Area Abundance score has on the Index score is similar for projects and non-project wetlands.
- The mean score for Aquatic Area Abundance tends to be greater for projects than non-project wetlands. This may be due to projects being sited near other aquatic areas.
- The sensitivity of the Index score to excluding the Buffer Metric and Hydrology Attribute is similar for projects and non-project wetlands.
- None of the CRAM Metrics or Attributes used to assess the setting of a wetland are biased for or against projects or non-project depressional wetlands.

Discussion

The Aquatic Area Abundance Metric has value for assessing the landscape connectivity of depressional wetlands. It is the only CRAM Metric to assess the dispersal of wetlands in the landscape or larger context. For this reason, the Metric is an important component of ambient wetland surveys. It may also be useful for siting projects to help assure their adequate connectivity.

The Aquatic Area Abundance Metric, Buffer Metric, and Hydrology Attribute have very little or no difference in effect on the assessment of overall condition for projects and non-project depressional wetlands. However, excluding these Metrics or Attributes for either projects or non-project wetlands, but not for both, would render their assessments incomparable.

The Aquatic Area Abundance Metric is more appropriate for assessing non-project wetlands and ambient wetland condition than for project assessments. This is because project sponsors usually lack authority to modify the landscapes around their projects, and many projects are located in landscapes that are naturally unable to support abundant aquatic areas. Furthermore, the Aquatic Area Abundance Metric adds variability to the Index score, which in turn reduces its power to compare projects or to assess changes in their condition over time.

Recommendations

The following recommendations are provided to the Level 2 Committee of the California Wetlands Monitoring Workgroup (CWMW) for its consideration.

1. The Aquatic Area Abundance Metric should be included in ambient surveys of wetland condition.
    a. The CRAM Index used for ambient surveys should be called the CRAM Ambient Condition Index.
    b. Unless other changes to CRAM are implemented (see Task 4, *CRAM Stress Index,* and the recommendations regarding buffer in Task 2), the Ambient Condition Index should be calculated based on the Buffer and Landscape Context Attribute, the Hydrology Attribute, the Physical Structure Attribute, and the Biological Structure Attribute.
    c. The ambient surveys should include projects and non-project wetlands.
    d. Projects should be considered as a stratum of ambient survey sample frames because they tend to have higher scores for Aquatic Area Abundance.
    e. The eCRAM database should enable queries of Ambient Condition Index scores.
2. The CRAM Ambient Condition Index should be used to site projects.
    a. To help implement the watershed approach to project planning, and to help assure that projects have adequate connectivity, candidate project sites should be compared using the Ambient Condition Index.
    b. The eCRAM database should enable queries of project site evaluations.

3. The Aquatic Area Abundance Metric should be excluded from the assessment of projects intended to evaluate their performance.

   a. The CRAM Index used for project assessment should be called the CRAM Project Condition Index.

   b. For project assessments, unless other changes to CRAM are implemented (see Task 4, *CRAM Stress Index,* and recommendations in Task 2), the Project Condition Index should be calculated based on the Buffer Metric, the Hydrology Attribute, the Physical Structure Attribute, and the Biological Structure Attribute, excluding the Aquatic Area Abundance Metric.

   c. The eCRAM database should be elaborated to enable queries of Project Condition Index scores.

4. Project assessments based on the Project Condition Index should be augmented with a second companion assessment based on the Ambient Condition Index.

   a. The companion Ambient Condition Index score can be calculated based on the Metric scores for the Project Condition Index plus the Aquatic Area Abundance score.

   b. The purpose of the companion Ambient Condition Index score is to build the dataset necessary to understanding the influence of landscape connectivity on project performance.