CRAM Review
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1. After reviewing the Topics in this request, please comment on the recommended appropriate and inappropriate uses of CRAM listed in Table 1. (CRAM Executive Summary, Ch. 1.3; Technical Bulletin Sec. 3B-C)

TABLE 1:

Recommended Appropriate Uses of CRAM

a. Ambient assessment of wetland condition.
b. Monitoring of ecological reserves, mitigation banks, wildlife refuges or similar management units. Evaluation of wetland Beneficial Uses.
c. Evaluation of pre-project conditions at potential impact sites.
d. Evaluation of impacts associated with unauthorized (enforcement) actions.
e. Evaluation of pre-project conditions at potential mitigation or restoration sites.
f. Assessment of performance/success of mitigation or restoration sites.
g. Assessment of compliance of mitigation sites with required targets or performance criteria.
h. Comparison of proposed alternatives for regulatory or restoration planning purposes.

Generally Inappropriate Uses of CRAM

a. Jurisdictional determinations.
b. Focused species or threatened and endangered species monitoring.
c. Evaluation of specific management questions that call for Level 3 monitoring.
d. Evaluation of compliance with water quality objectives.
e. Assessment of mechanisms or processes of wetland function (diagnostic evaluation of wetland function).
f. Assessment of wetland values. It has been well documented that wetlands provide a variety of values that are beneficial to people, such as floodflow attenuation, aesthetics, and contaminant sequestration. CRAM is designed to evaluate the ecological condition of a wetland in terms of its ability to support characteristic plants and animals. Human use values cannot be appropriately assessed using CRAM.
g. Use of CRAM metric descriptors as stand-alone project design templates. While the narrative descriptions of best attainable conditions for the CRAM metrics can be used as general guidelines for overall project designs, they do not account for site-specific constraints and opportunities or design objectives. Because CRAM has been calibrated against statewide conditions, it is not appropriate to design a specific project based on the descriptions contained within each metric.

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: The only use of CRAM that is debatable is the monitoring of mitigation banks. Some studies are questioning the use of tools developed on naturally-occurring sites for application at mitigation sites, due to a number of factors including unique landscape factors associated with mitigation sites, the similarity of a constructed ecosystem with the operating rules of a natural one, etc. A limited test of CRAM on mitigation versus natural sites is required before widespread or regulatory use.

2. The U.S. Environmental Protection Agency has developed a three-level approach for wetland assessment. The design provides that each level

builds on the previous one, and adds more specific information. Level 1 data is usually generated from aerial photos and maps for the purposes of inventory and planning; Level 2 data is collected in the field using rapid assessment methods; Level 3 includes data of a specific type to assess site specific concerns or validate methods or conclusions. CRAM is designed to be a Level 2 assessment tool to evaluate the overall condition of wetlands and to assess impacts of human activities that stress the local wetland ecology. (CRAM Executive Summary, Ch. 1.2)

The term "surface waters" is used repeatedly in Chapter 1; it would seem that "wetlands" would be a more appropriate term.

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: The description of Level 1 assessment in the CRAM Executive Summary incorrectly summarizes language contained in US EPA 2006, as well as other references that describe the basis of this work (Wardrop et al., 2007: Brooks et al. 2004,; Brooks et al., 2006). US EPA 2006, Table 1, defines Level 1 Landscape Assessments as, "Use GIS and remote sensing to gain a landscape view of watershed and wetland condition. Typical assessment indicators include wetland coverage (NWI), land use and land cover". The CRAM description completely utilizes only the inventory portion of this description. Landscape Assessments are intended to be a first cut at a condition assessment of the wetland, and an inventory alone does not satisfy the intent of a Level 1 assessment. Many authors have contributed methods that utilize landscape characteristics and metrics as a first cut at condition assessment (examples include Wardrop et al., 2007; Hychka et al., 2007; Wellar et al., 2007). Only if a Landscape Assessment provides a condition assessment can the following be true: "each level builds on the previous one, and adds more information". The CRAM method, as stated, deviates significantly from this concept of interconnectedness between levels of assessment with refinement from one level to the one "above" it.

3. CRAM's wetland classification system is reliable for use throughout California (CRAM Ch. 1.5 & 3.2.2; Technical Bulletin, Sec. 3.A)

Note: Collins et al., 2008, does not contain a section 3.3

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: The question is oddly worded, but let me state the assumptions under which I am answering:
I cannot comment on whether or not all possible wetland types in the state are covered by the classification, nor do I have the extensive field experience in California to determine whether it is reliable. Based on the extensive fieldwork done in support of CRAM's

development, I believe that the above statement can be supported to the largest possible extent. However, I would raise a different question concerning whether the classification is appropriate for use in conjunction with the rapid assessment of wetland condition. There can be situations where wetland types are present in a mosaic, and this mosaic functions in a different way, by virtue of its complexity, than the sum of its parts. For example, the mid-Atlantic region of the U.S. often contains wetland systems, along headwater streams, that have riverine, slope, and depressional elements/subsystems at small spatial scales that collectively result in a system called a headwater complex (the complex can occur at spatial scales as small as 0.5 acres). The different elements occur proximate to one another, making delineation between specific elements arbitrary. In addition, one must ask if each were assessed separately, would the combined answer be the same as if the whole mosaic were assessed? For example, consider the following system: a headwater stream occurring in a narrow valley between the base of opposing slopes. A depressional wetland may occur in the valley at the base of a slope, along with other slope wetlands, that grade into the riverine wetland generally present along the stream. Now assume that there is a stressor, perhaps a culvert discharge, that directly affects only the depressional wetland. Theoretically, CRAM will only account for the presence of this stressor on one wetland (the depression), and not in the adjoining wetlands, although the stressor affects the entire mosaic of wetlands, since they are hydrologically connected. Will the collection of CRAM scores for these individual wetlands be comparable to a CRAM score that would be developed based on a mosaic wetland class? I don't know the answer, but my experience has been that it is important to test for inconsistencies in lumping or splitting wetland classes in rapid assessment techniques. During development of HGM functional assessment models for Pennsylvania, we did indeed develop separate models for depressions, slopes, and floodplains, and a mosaic class termed headwater complexes. We found that assessment results for headwater complexes were more stable and consistent than utilizes the suite of scores provided by the individual assessments applied to the subsystem elements. While the recommendations concerning AA features and sizes provide guidance on "splitting", they do not seem to address when "lumping" is appropriate. Fennessy et al., 2004 states: "The goal of classification is to reduce variability within a class and enable more sensitivity in detecting differences between least- impacted and impaired wetlands." The question is whether this is best achieved, in some cases, by a lumped or mosaic class.

4. Sources of stress or pressure affecting the condition or state of wetlands are identified in CRAM. This design facilitates management *responses* to prevent or mitigate undesirable effects. CRAM assumes that the "pressure-state-response" (PSR) model applies to wetland assessment and monitoring and that this framework may be used in CRAM to evaluate the state, or condition, of wetlands (CRAM Ch. 2.2.1).

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: The P-S-R model is a useful, adaptive management construct, and its use in the technical background documentation of CRAM is well-appreciated.

However, if you adhering to this concept strictly, and consider its application to the CRAM method itself, the inclusion of buffer and landscape context in CRAM metrics is inconsistent. They can be considered "pressure" measures, not "state" ones, and have been shown time and time again to be related to a number of condition indicators. At best, their inclusion in the overall score is circular. I would assess whether the CRAM gives the same result both with and without their inclusion. It is admirable that this issue is raised in Section 2.3.1, but quantitative assessment of the effect of the metric's inclusion/exclusion, or a sensitivity analysis, would be illuminating.

5. CRAM assumes that ecological conditions can be evaluated based on a fixed set of observable indicators, and that conditions respond to variation in natural and anthropogenic stress in a predictable manner. (CRAM Ch. 2.2.2 - 2.2.3)

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: This statement is full of sub-phrases incorporating undeclared nuance, the most obvious being, "in a predictable manner". While the statement above is sound, its embodiment in CRAM is what is critical, not the statement itself. Its embodiment cannot be assessed without a detailed review of the data itself, i.e., was predictable assumed to be a linear relationship between stress and any given indicator, or were other relationship types considered? In addition, the following statement is incorrect:

> CRAM metrics were built on this basic assumption according to the following three criteria common to most wetland rapid assessment methods (Fennessy et al. 2004):
>
> > *the method should assess existing conditions*(see Section 2.1 above), without regard for past, planned, or anticipated future conditions;
> > *the method should be truly rapid*, meaning that it requires two people no more than
> > one half day of fieldwork plus one half day of subsequent data analysis to complete; and
> > *the method is a site assessment* based on field conditions and does not depend largely on inference from Level 1 data, existing reports, opinions of site managers, etc.

The three criteria were not used to select the individual metrics which constitute the construction of CRAM, they are used to screen which metrics can be obtained according the constraints of a rapid method, i.e., they define the pool of potential metrics, not the final list of those which are appropriate indicators that respond to stress in a predictable manner.

6. In CRAM, wetland condition is defined as the ability of a wetland to maintain its complexity and capacity for self-organization with respect to species composition, physio-chemical characteristics, and functional processes, relative to healthy wetlands of the same type. CRAM assumes that wetland condition is based on an evaluation of wetland

location, form and structure. (CRAM, Ch. 2.2.3, Appendix III – Glossary)

This statement is unclear and not commonly utilized in current literature.

Additional comments: Self-organization is a concept often discussed in the complex adaptive systems literature, and its use as a foundational concept here is ill-advised. While complexity could be clearly described with respect to the three factors listed in the definition, the same cannot be said of self-organization. My suggestion is to either drop the concept from the definition, or include a narrative describing clearly how the concept is utilized in CRAM. I would offer the observation that none of the metrics in CRAM, or their scoring, utilizes the concept of self-organization; e.g., which metric or its valuation, currently in CRAM, delineates a wetland with a capacity for self-organization from one that does not have such capacity?

7. As part of the CRAM assessment, a checklist is provided that characterizes stressors as to their likely effect on wetland condition. It is assumed that the stressor checklist can be used by researchers and managers to explore possible relationships between condition and stress, and to identify actions to counter stressor effects. (CRAM, Ch. 2.2.1.5).

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: The question is unclear, and the references are incorrect (e.g., there is no Section 2.2.1.5). Assuming that the statement refers to material that is described in Sections 2.2 and Section 5.1, my comment concerns the presence of buffer characteristics as a metric in CRAM, and the list of buffer and landscape attributes in the Stressor Checklist. Buffer characteristics have been shown to be valuable diagnostics in explaining disparities between wetland condition and landscape attributes (Wardrop et al., 2007b). Like the presence of invasive plants, which can be argued as either a metric of a stressor, a sensitivity analysis of CRAM concerning these metrics should be investigated. If they are found to have a significant role in the eventual CRAM score, it would suggest circularity in the reasoning and approach.

8. CRAM accepts the primary assumption that the condition of a wetland is determined by interactions among internal and external hydrologic, biologic (biotic), and physical (abiotic) processes, as presented by Brinson,(15, 1993) and others (e.g., 16. Barbour, 1995). CRAM is based on a series of assumptions about how wetland processes interact through space and over time. First, CRAM assumes that the condition of a wetland is mainly determined by the quantities and qualities of water and sediment (both mineral and organic) that are either processed on-site or that are exchanged between the site and its immediate surroundings. Second, the supplies of water and sediment are

ultimately controlled by climate, geology, and land use. Third, geology and climate govern natural disturbance, whereas land use accounts for anthropogenic stress. Fourth, biota tend to mediate the effects of climate, geology, and land use on the quantity and quality of water and sediment. Fifth, stress usually originates outside the wetland, in the surrounding landscape or encompassing watershed. Sixth, buffers around the wetland can intercept and otherwise mediate stress . *(*CRAM, Ch. 2.2,3 *).*

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: Two minor revisions could be made to the text. Firstly, the language following the statement, "CRAM is based on a series of assumptions about how wetland processes interact through space and over time", deals only with the interaction of processes in space; no mention is made of any temporal interactions. Either a discussion of temporal interactions needs to be added, or the phrase simplified to indicate that only spatial factors are considered. Secondly, disturbance needs to be added to the statement concerning the sixth assumption, in order to be consistent with Figure 2.2.

9. Metrics are measurable components of the four wetland attributes recognized by CRAM: Buffer and landscape context, hydrology, physical structure, and biotic structure. The metrics used in CRAM are ecologically meaningful, field-based measures that record the potential range of conditions in a wetland's hydrology, physical structure, biotic structure, and adjacent landscape, and are formulated to have a response to variations in stress that is distinguishable from natural variation. (CRAM, Ch. 2.3.1 and 2.1).

This statement is judged to be based upon sound scientific knowledge, methods, and practices for the four wetland attributes recognized by CRAM; it does not judge whether the four recognized attributes are the most appropriate of all possible attributes.

Additional comments: the text that reads, "and are formulated to have a response to variations in stress that is distinguishable from natural variation" implies that the metrics were manipulated to have the desired relationship to estimates of stress. In many IBI techniques, a criteria for metric inclusion is that it has a **predictable** response to stress that is distinguishable from natural variation, i.e., the system is responding according to a conceptual ecological model.

10. CRAM has "modules" for each major wetland type. A module is developed in a nine step process organized into three phases: basic design, calibration, and validation. This developmental framework results in a valid Level 2 assessment method.(CRAM, Ch. 2.3).

This statement cannot be assessed without accompanying definitions of design,

calibration, and validation. No definitions are given, just the processes used in CRAM to address them.

Additional comments: The following references should be consulted by the authors, and a definition of each term included in the glossary:
Mitro M.G. 2001. Ecological model testing: verification, validation, or neither? *Bulletin of the Ecological Society of America*, 82:235-236.
Oreskes N, Shrader-Frechette K, Belitz K. Feb 1994. Verification, validation, and confirmation of numerical models in the earth sciences. *Science*, 263:641-646.
Rykiel, E.J., Jr. 1996. Testing ecological models: the meaning of validation. *Ecological Modeling*, 90:229-244.

For example, Rykiel (1996) defines calibration as "*the estimation and adjustment of model parameters and constants to improve the agreement between model output and a data set.*" The steps listed under calibration in the CRAM manual would not fit this definition.

11. Calibration is a process whereby iterative adjustments to the CRAM wetland classification system and metrics are made through multiple field tests. Through repeated field evaluations, the descriptions of the range of potential conditions are adjusted in relation to each other. These exercises are repeated until the calibrations for all metrics work together to provide results that are replicable by any observers in any similar wetland. (CRAM Ch. 2.3.2)

This statement cannot be assessed without an accompanying definition of calibration (see above comment to Issue 10). The objectives of the calibration phase, as described in Section 2.3.2, do not meet most available definitions of calibration.

Additional comments: Section 2.3.2. states:

> The calibration phase was used to determine if the draft wetland classification scheme, the attributes, the metrics, and the narrative descriptions of alternative states were (1) clear and understandable; (2) comprehensive and appropriate; (3) sensitive to obvious variations in condition; (4) able to produce similar scores for areas subject to similar levels of the same kinds of stress; and (5) tended to foster repeatable results among different practitioners. The calibration phase was also used to test and select methods of calculating, scaling, and weighting scores for metrics, attributes, and AAs.

If we utilize the Rykiel's definition of calibration as "*the estimation and adjustment of model parameters and constants to improve the agreement between model output and a data set*", it is clear that the steps listed above would not fit this definition. Calibration should entail the adjustment of the metrics to Level 3 information, not an adjustment to metrics to make them either more stable between field personnel (a QA/QC issue), or to make sites comparable according to Best Professional Judgement. Another method of calibration would be to adjust the metrics so that the results are at least anchored at the opposing ends of the condition spectrum, i.e., that extreme values of the metrics represent the extreme ends of the range of condition.

12. CRAM's condition-based rapid assessments can be expected to reliably discriminate between wetlands of moderately different condition classes, after appropriate data collection, QA, calibration and validation of a sufficient body of data. (CRAM, Ch. 2.3.2; Technical Bulletin Sec. 3.J)

This statement cannot be assessed without accompanying definitions of design, calibration, validation, and sufficient data.

Additional comments: If the individual portions of the rapid assessment cannot be assessed for their scientific credibility in their definition or use, neither can the cumulative result.

13. Procedures are in place to refine CRAM metrics through calibration studies to improve discrimination between wetlands exhibiting moderate differences in condition. (CRAM, Ch. 2.3.3; 25).

This statement cannot be assessed without an accompanying definition of calibration (see above comments to Issues 10, 11, and 12).

Additional comments: This statement is the same as that present in Stein et. Al, 2009, which states the following (context provided to make the following point):

> In this paper, we present the results of validation of the California Rapid Assessment Method (CRAM; Collins et al. 2006) in riverine and estuarine wetlands. We define ''validation'' as the process of documenting relationships between CRAM results and independent measures of condition in order to establish CRAM's defensibility as a meaningful and repeatable measure of wetland condition. The overall validation process includes several steps designed to meet the following objectives: 1) assure that the method is producing meaningful results based on a comparison between CRAM scores and independent measures of condition (evaluation), 2) make adjustments to the method, where needed, to improve the ability of the CRAM to discern differences in wetland condition (calibration), and 3) minimize observer bias by assessing repeatability between independent assessment teams and modifying metrics that lead to inconsistencies (standardization).

In the above, calibration is defined as one step in the validation process. If this definition of calibration s used, the issue statement can be judged as consistent with sound science. However, in the CRAM manual, calibration is an undefined separate step of the process from validation. In addition, the calibration as described does not address the USACE issue. Many attempts at reconciling condition assessment scores (as the dependent variable) with some measure of stress (as the independent variable) demonstrate a large disparity or lack of correspondence in the middle region of condition or stress. This may be due to a fundamentally different basis of ecosystem response than the one assumed (e.g., alternative stable states or the presence of thresholds in one variable or another), a controlling variable that has not been measured as a part of the assessment, or a poorly conceived expression of stress. It is not clear what is encompassed, or intended, by "procedures are in place to improve discrimination".

14. The stated within-team and between-team precision of CRAM of plus or minus 10% for attribute scores and overall site scores is acceptable for Level 2 conditional assessments of wetlands. (CRAM, Ch. 2.3.2; Technical Bulletin, Sec. 4.B).

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: I would expect that the USACE review has assessed the implication of this statement when utilizing CRAM in management and/or regulatory contexts, and such would be outside of the scope of this review. However, one approach that would be helpful in this regard would be the comparison of the 95% confidence interval of the CRAM score for a probabilistic-based survey of wetlands to this precision standard.

15. The maximum CRAM score for a wetland type represents the best achievable condition for that wetland type in California. (CRAM, Executive Summary; Ch. 3.5, 3.8, Technical Bulletin Sec. 3.J.).

This statement cannot be assessed without an accompanying description of how the original pool of sites for CRAM development was selected.

Additional comments: It is unclear how the original pool of candidate sites was selected. In general, pools of candidate sites that are selected as per a probabilistic survey are a better source of potential reference sites than those that are not, due to the removal of any bias about what constitutes a "good" site. For example, the best achievable condition will be interpreted by an individual as only the best site that he/she has personally visited; if the pool of candidate sites is probabilistically-based, one can put an estimate on the confidence of having at least one reference site in the pool.

16. Validation is defined as "…the process of documenting relationships between CRAM results and independent measures of condition in order to establish [CRAM's] defensibility as a meaningful and repeatable measure of wetland condition." (23). Overall performance of CRAM is validated by evaluating the relationship of metric scores and attribute scores to Level 3 data of key indicators of selected wetland services (e.g., natural values, water quality) (CRAM, Ch. 2.3.3)

This statement is judged to be based upon sound scientific knowledge, methods, and

practices.

Additional comments: This statement is easily agreed to, by virtue of manuscripts published in peer-reviewed literature (Stein et al., 2009).

17. CRAM scores are not invalidated by natural stochastic changes inherent in all natural systems. (CRAM, Ch. 2.2.2- 2.2.3)

This statement cannot be assessed as to scientific soundness, because it is depends upon the construction of CRAM itself.

Additional comments: If invalidate is, "to weaken or destroy the cogency of", then the protection of CRAM from the invalidating impacts of natural stochastic changes would require a sampling of the same wetland sites before and after such events, and comparing the resulting CRAM scores. At that point, metrics which exhibited instability to such events could be removed from the assessment. Without demonstration of such, I cannot assure the soundness of the issue statement, as given.

18. CRAM scores do not provide measures of human value or importance.

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: The attributes, metrics, and scoring utilized in CRAM do not provide any such measures.

19. CRAM scores will be used to adjust metrics as needed to remove any systematic bias against particular kinds of wetlands, or their natural settings. (CRAM Ch. 1.5, 3.2.2.1;Technical Bulletin Sec. 3A)

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: The methodologies to achieve this certainly exist, but attendance to them in future CRAM endeavors cannot be assumed.

20. The selection of CRAM reference sites for all conditions of wetlands is based on "best professional judgment" of regional teams. Selected reference sites exhibit a wide range of condition, from poor to best achievable condition (Technical Bulletin, Sec. 4.C).

The selection of CRAM reference sites for all conditions of wetlands by "best professional judgment" does not represent sound scientific knowledge, methods, and practices.

Additional comments: The basis of "poor" and "best' condition should be a survey that can express, with a given measure of confidence, the probability that such has been found. In general, pools of candidate sites that are selected as per a probabilistic survey are a better source of potential reference sites than those that are not, due to the removal of any bias about what constitutes a "good" or "bad" site. For example, the best achievable condition will be interpreted by an individual as only the best site that he/she has personally visited; if the pool of candidate sites is probabilistically-based, one can put an estimate on the confidence of having at least one reference site in the pool.

21. "Best Achievable Condition" reference sites are used to define the highest standard for the type of wetland being assessed. This reference standard becomes the point against which the range of wetland conditions can be judged from highest to lowest, and thus becomes the basis of individual CRAM metric scores. (CRAM, Ch. 3.8.1) Therefore, any two scores for the same type of wetland can be compared to each other because they are based on the same statewide standard (Technical Bulletin, Sec. 3.J).

"Best Achievable Condition" may vary by surrounding landcover types for any wetland type; under such conditions, the above statement cannot meet sound scientific standards.

Additional comments: Many studies have indicated that the "Best Achievable Condition" may vary according to surrounding land cover (Wardrop et al., 2007; Hruby, 30). Surrounding land cover may alter the very processes by which structures, and thus functions, are expressed. Thus, some comparison of CRAM scores for wetlands of the same type, but in varying land cover surroundings, would have to be provided to be able to make the last statement in the above issue.

22. The same scores for different wetlands of the same type do probably represent the same overall condition and functional capacity (CRAM, Ch. 3.8.1; Technical Bulletin Sec. 2, 3B, 3J).

The same scores for different wetlands of the same type do probably represent the same overall condition, but the same cannot be said for functional capacity.

Additional comments: CRAM is, according to all the provided materials, a method of condition assessment. However, it is lacking metrics and attributes that explicitly address key variables of the recognized biogeochemical functions of wetlands (Table 2.3), such as cover estimates for carbon pool estimation, soil redox characteristics or indicators, and soil organic carbon. Therefore, functional capacity is not directly assessed, and is done in an extremely limited manner.

23. Predictions of future conditions of wetlands may be possible through statistical analysis of CRAM reference site data and other CRAM data. (CRAM, Ch. 3.8.1).

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: The methodologies to achieve this certainly exist, but attendance to them in future CRAM endeavors cannot be assumed. To develop future trajectories, some analysis of "Best Achievable Condition" according to surrounding land cover would be necessitated (see discussion under Issue 21).

24. CRAM Quality Assurance/Quality Control (QA/QC) procedures are consistent with sound scientific data management practices. Methods specified are sufficient to assure consistency in the statewide collection of data over time. (CRAM Ch. 3.8.2)

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: The QA/QC procedures are sound and well-documented.

25. In regards to Step 2 above: Further refinement and subdivision of CRAM's wetland classes could take place over time based on wider data collection and analysis. Following CRAM's developmental procedures, meaningful conditional assessment scores for these new wetland classes can continue to be obtained (CRAM, Ch. 2.3.3; Technical Bulletin Sec. 3.A).

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: Further refinement is always possible with the addition of new data. However, I am more concerned about the lack of consideration of "lumping" classes than I the availability of data to sub-divide. Please see the response to Issue #3.

26. In regards to Step 4 above: AA's, as defined through criteria listed in Chapter 3 of the CRAM Manual, are a valid sample type and size for determining wetland condition (CRAM, Ch. 3.5, Technical Bulletin Sec. 5).

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: This is perhaps the best-written and conceived portion of the manual, and its comprehensiveness and use of examples is well-appreciated. The following factor provides a solid foundation and check on the methodology: "The size-frequency distribution of wetlands for each wetland type (a Level 1 analysis) was also considered when the recommendations for AA sizes were being developed."

27. In regards to Step 4 above: The ambient assessment sampling and the project assessment sampling methods for CRAM may both be expected to provide valid, repeatable results (CRAM, Ch. 3.5.3, Appendix I).

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: The critical concepts common to both approaches (Sample Universe and Sample Frame) are well-founded, logical, and clearly presented.

28. In regards to Step 7 above: CRAM metric scoring, as described in Chapter 4 of the CRAM manual, is based choosing the most appropriate narrative description of the state or condition of the metric being observed in the field, ranging from low to high ecological service. CRAM yields an overall AA score based on the individual scores of the attributes and their metrics (CRAM, Ch. 3.8.1).

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: The manual provides clear and easy-to-use narrative scoring criteria. However, a broader question is begging to be asked, and is not included in the topics to be reviewed. CRAM is an ecological model, similar to hydrogeomorphic functional assessment models. In developing a typical HGM guidebook, the following steps are followed prior to the scoring, calibration, and validation steps:

- Identification of controlling variables in the process of interest
- Construction of the conceptual model
- Selection of indicators
- Selection of measurement techniques

Uncertainty and potential error is present in each of these steps. For example, the wrong controlling variables could be identified, the variables in the functional assessment model might be combined in an inappropriate way, good indicators are not available, or measurement techniques are inherently variable. Documentation of these steps is not included in CRAM in any explicit way. For example, the mathematical combination of submetrics in the raw attribute score for Buffer and Landscape Context implies a certain understanding of the wetland ecosystem:

$$\left[\text{Buffer Condition} \times \left(\text{\% AA with Buffer} \times \text{Average Buffer}\right)^{1/2}\right]^{1/2} + \text{Landscape Connectivity}$$

The basis of this model is not discussed or documented. Without this foundational information, the appropriateness of the compositional metrics and the resulting attribute scores cannot be assessed.

29. CRAM reliably evaluates the condition of estuarine and riverine

wetlands in California.

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: This statement is easily agreed to, by virtue of manuscripts published in peer-reviewed literature (Stein et al., 2009). The article includes an excellent description of the actions taken as a result of the validation process (Table 7), as well as an extensive description of the weight-of-evidence approach and its appropriateness in CRAM development and refinement.

30. In cases where the physical findings indicating the top of the stream bank where the stream flow would enter the active flood plain (bankfull indicators) are obscured or unreliable due to channel disturbance, CRAM adequately addresses the uncertainty of using bankfull width by applying a sensitivity test when determining the metric score in the hydrologic connectivity section (29).

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: The approach appears eminently reasonable, although some sort of reference for the approach would increase its defensibility.

31. CRAM can be expected to reliably evaluate the condition of depressional wetlands, assuming continued development according to CRAM's developmental process.

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: The above statement is true if the developmental process described in the CRAM Manual is supported with the type of validation work presented for the estuarine and riverine models in Stein et al., 2009.

32. The development of CRAM for these four wetland types has not progressed as far as those listed above. If the same developmental process is applied to these four types, then a similar outcome is anticipated resulting in CRAM for these types. (CRAM, Ch. 1, 2)

This statement is judged to be based upon sound scientific knowledge, methods, and practices.

Additional comments: The above statement is true if the developmental process described in the CRAM Manual is supported with the type of validation work presented for the estuarine and riverine models in Stein et al., 2009.