California Rapid Assessment Method (CRAM) **February 17, 2010**

External Peer Review by Gerald J. Niemi

General Comments

I have read through all the materials provided to me for a review of the CRAM procedures. The primary task requested was to review these documents and address a series of 32 isues regarding the CRAM methodology. In addition, the request was broad so if additional issues were noted, I was free to identify any additional concerns.

Wetland rapid assessment methods have been around for a considerable period of time as identified in the review by Fennessy et al. (2007). There is practical need for wetland rapid assessment methods, especially in consideration of the large number of wetlands that need to be evaluated and the cost to complete these evaluations and assessments in a timely but defendable manner. Wetland rapid assessment methods logically are considered a Level 2 assessment as defined by EPA that includes some field evaluation, but not Level 3 that would include more detailed field data collection and evaluation. There is no question that rapid assessment methods are necessary, but they must be based on quality science and evaluated thoroughly before being implemented.

My comments will be partly based on my experience with wetlands in the upper Midwestern US, including all of the US Great Lakes. A substantial amount of the research that I have been involved with in this area has bearing on CRAM and potentially some considerations for revisions or future changes. Even though this may be construed as excessive self-citations, the project I directed and funded through a US EPA STAR grant (EPA/R-8286750) consisted of 27 co-principal investigators from 10 different institutions, including the US EPA Mid-Continent Ecology Division. The EPA grant (EPA/R-8286750), plus an additional EPA grant to my colleague, Dr. Lucinda Johnson (EPA/R-828777), and my National Aeronautics and Space Administration grant (NAG5-11262-Sup 5), represented over $7 Million in funding all focused on Great Lakes wetlands research (Niemi et al. 2007, Wolter et al. 205, 2006). In my comments below, I have cited representative articles that would provide additional considerations for improvement in some aspects of CRAM. Of course, most of these were not published when CRAM was being developed. I trust that there will be periodic revisions and improvements to the CRAM.

RESPONSE TO ISSUES TO BE REVIEWED

Responses below correspond to the 32 comments requested by the external review.

1. Responses to Table 1. In general, these are reasonable, but they do not necessarily stand alone without some additional detailed knowledge of CRAM and its overall intent.

a. Appropriate uses – Table 1.b – this statement is awkwardly worded. An appropriate use might include the evaluation of wetland beneficial uses within ecological reserves, mitigation banks, etc.

b. In general, I suggest many of the "appropriate uses" could be expanded upon in this table. For instance, it is not clear what "unauthorized (enforcement) actions" or what "required targets or performance criteria" represent. Perhaps a bit more detail like f and g under inappropriate uses would improve this description.

2. I agree – the EPA documents and supporting literature identify the appropriate use of CRAM as a level 2 process in wetland evaluation.

3. This is always subject to change and on-going consideration, but the classification seems very reasonable and justifiable for use in CRAM.

4. The concept of pressure-state-response (PSR) model is relatively well accepted by ecologists and is being applied in numerous places in various forms across the globe. Moreover, the cycle of the adaptive management approach is equally well-accepted as a framework for evaluation, planning, action and monitoring. The PSR model can be defended as a general guideline as long as one avoids the implication to the philosophical arguments of cause-and-effect. The key concern is whether these steps are actually fully followed and implemented by management agencies. This concern applies to the implementation of CRAM in California in light of monetary resource issues, in particular, but also commitment on the part of management agencies over the long term.

5. The assumption that ecological condition can be evaluated based on observable indicators is a very reasonable assumption. Tests on whether ecological condition can be predicted in response to variation in natural and anthropogenic stress have been elusive, but some examples exist. McDonald and I reviewed the use of ecological indicators (Niemi and McDonald 2004) and clearly this is the primary assumption and use of ecological indicators. In addition, indicators are used as an early-warning signal of ecological problems and as barometers for trends in ecological resources. There is a substantial literature to support these assumptions.

6. The definition of wetland condition is reasonable. I am not going to wordsmith the document, but the concepts of history and ecological processes should be incorporated into complexity and the capacity for self-organization.

7. I could not find reference to this in Ch. 2.2.1.5 unless I was looking in the wrong document. It is unclear. There is a "Guidelines to Complete Stressor Checklists" in CRAM 5.0.2, Chapter 5. As a checklist, these are reasonable but I do have some concern with the limited area of the assessment, especially 50 m. I realize that the "Buffer and Landscape Context Attributes" include assessments up to 500 m. There are substantial ways that the influence of the surrounding landscape of a wetland can be improved (see Hollenhorst et al. 2007). For instance, wetlands and wetland biota can be influenced by direct stress to the wetland, adjacent disturbances (e.g.., 0-500m), and well beyond 500 m for disturbances that directly affect the contributing area of the watershed of the wetland. I would foresee a better linkage between level 1 and level 2 assessments. Level 1

assessments with good geographic information systems (GIS) analysis (e.g., using aerial photography) could provide information that is simply verified by the level 2 CRAM. Note that there is a substantial amount of publically-available, spatial information that should be available to environmental regulators in the state of California (e.g., see variable lists in Danz et al. 2005, 2007) that could be used to better assess stress within the watersheds of the respective wetlands. For instance, one variable not included is human population density, we found this to be an important variable in the Great Lakes (Brazner et al. 2007a,b). With California's high human population, this is an important stress variable and is available at a reasonable spatial resolution. This will likely be even better with the next US census. Moreover, these data could then be used to better quantify the gradient of disturbance among the wetlands included in the validation (see below). In summary, the checklist is a reasonable start in the CRAM, but I suggest that future improvements could be made in this portion of the assessment and should eventually be included.

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EXPLANATORY LETTER TO NIEMI RE STATEMENT 7
Dear Dr. Bowes:

We have received the comments received from Dr. Niemi. We are appreciate that the reviewer's comments and ideas are presented in such a clear, comprehwensive and useful form.

Regarding Item 7, the Reviewer stated that, "I could not find reference to this in Ch. 2.2.1.5 unless I was looking in the wrong document." The following information is provided to guide the reviewer to the appropriate citations.

Item 7 in Attachment 2 was referring to Ch. 2.2.1 of the CRAM Manual, and Chapter 5 of the CRAM Manual. The annotation apparently did not clearly indicate that citation. The following citations from the CRAM Manual may assist the reviewer in any further deliberation on this topic:

→The general concept and uses of the Stressor Checklist are discussed in the Executive Summary of the CRAM Manual.

→Chapter 2.2.1 provides the theoretical basis of the use of the Checklist ("A separate stressor checklist is then used to note which, if any, stressors appear to be exerting *pressure* affecting condition. It is assumed that managers with knowledge of pressures and states will exact more effective *responses*."). Figure 2.2 conceptually illustrates the spatial hierarchy of stressors, buffers, and wetland condition (" Most stressors originate outside the wetland. The buffer exists between the wetland and the sources of stress, and serves to mediate the stress").

→Chapter 3 provides some guidance, and Chapter 5 provides detailed guidance, on recording observations of stressors.

If we can be of further assistance, please let us know.

Cliff Harvey
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March 4, 2010

Gerald J. Niemi
University of Minnesota

RE: CRAM Additional Review Response

Item 7. I have re-read the correct wording that was provided for this item and I have re-examined the documents that were referred to in the corrected version. I do believe that the theoretical basis, the stressor checklist, and the detail provided on the stressor list are reasonable. However, my previous response is still appropriate. I was primarily trying to emphasize that there have been advancements made in linking watershed stressors to local impacts using geographic information systems and the many publically available data bases (e.g., land use/cover, point sources, etc.). This could ultimately strengthen the relationship between the level 1 and 2 assessments.
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8. The assumptions are all fine and supportable via the scientific literature. Effective implementation of these assumptions is the difficult part.

9. The separation of response to stress and distinguishing this from natural variation requires a long term data set to examine natural variation and responses to specific human-caused events. It is, however, a reasonable assumption if the field-based measurements of wetland quality are related to a broad gradient that defines natural, high quality wetlands from those that have been degraded by human activity. The application of CRAM to a gradient of wetland conditions is a reasonable assumption in this context.

10. I have serious concerns regarding the verification and validation phase of the CRAM procedure. One place where these results are reported is in Sutula et al. (2006). For instance they state "*To verify CRAM, the three Regional Teams selected 118 wetlands representing high quality and low quality conditions for each of the wetland classes. The a priori classification of condition was based on consensus of the experts following their review of pertinent site-specific reports and field visits. Verification was conducted through the Regional Teams, and the regional results were complied into one verification dataset."* However, they state *"This provided **preliminary** assurances that the draft metrics were able to distinguish among wetlands of varying condition."* They further go on to state - *"In both calibration and validation, the concept is to determine whether RAM metric, attribute, and overall index scores are good predictors of wetland condition, as measured against the results of more intensive measures of wetland condition."* **However, they go on to identify cost as a prohibitive factor that these**

intensive measures were not really completed nor was a statistically-designed sampling process included.

This paper was then followed up by a paper by Stein et al. (2009) which strived *to "present a case study of the validation of the riverine and estuarine modules of the California Rapid Assessment Method (CRAM)."* This paper presents a substantial amount of information to validate the CRAM procedure including data on avian diversity, benthic macroinvertebrate indices, and plant community composition. These are all important components of wetland ecosystems and provide an important step toward validation. I applaud the authors for publishing these data in the peer-reviewed literature and in an appropriate journal. My concerns are related to the following issues and the potential for broad application of CRAM. However, note I am not criticizing the paper per se – I am glad it was published but my major question is whether it is adequate as the primary basis for accepting CRAM across the broad state of California for these two wetland types?

These issues are the following. 1) The validation was confined to the riverine and estuarine classes, plus they noted that depressional wetlands, vernal pools, seeps and springs, and lake and lagoon fringe wetlands will occur in the future. 2) The total sample size was 95 riverine sites (54 with macroinvertebrate data and 41 with bird data) and 38 estuarine sites (all with vegetation data only). How does this compare to the number of wetlands of these two types in California? Also these biotic data represent a small subset of the biotic community and none of them include information about ecological processes. 3) Many of the relationships are not very convincing – e.g., see Fig 1.c; Fig. 2b or 2c. There are definitely a number of outliers in these figures. What if some of these wetlands were identified as of poor quality, but actually contained a few important wetland-dependent bird species? Wetland-dependent species should be analyzed separately as should species that are endangered, threatened, or special concern (Peterson and Niemi 2007). An analysis of those wetlands that did not "fit" the pattern is important to examine further. Overall bird species richness is not a good metric to use. It is too general – at minimum the analysis should have been completed for wetland-dependent species. It is not clear what role the individuals gathering MAPS data were involved in the interpretation of these bird data? Also it is unfortunate that amphibians were not included in the analysis, their distribution and use of the wetlands are easy to monitor. 4) Finally, I do appreciate the "*Final Thoughts"* in this article. It is clear that the authors recognize the limitations of the methodology and it is likely cost that has prohibited them from gathering the appropriate comprehensive data to fully validate CRAM. In summary, I do not think the procedure has received adequate validation. Validation should require the gathering of data unique to the CRAM process and should include a wide spectrum of the wetland characteristics including benthos, birds and plants, but also amphibians and fish as well as water quality. Several professional statisticians should also be consulted to receive their opinion on the adequacy of the validation process and interpretation of the results.

Ideally, given the importance and breadth to which CRAM will be applied in California, a solid field-based and statistically valid sampling regime should have been completed to

validate the CRAM procedure. The use of data that happened to be available for a subset of wetlands is not adequate as a validation process.

11. Many of the same issues identified in response 10 above are relevant here as well. The same level 3 data (e.g., MAPS, EMAP) were used for the calibration.

12. It is unclear to me the extent to which CRAM can discriminate "*between wetlands of moderately different condition classes.*" I do not see appropriate data within the material provided to assess this ability to discriminate. I am concerned that there is not an independent "gradient" that was derived to identify those wetlands (whether riverine, estuarine, or depressional) that are of good or bad condition.

13. It is good that procedures are in place to refine CRAM metrics through calibration studies. I would agree with the comments of Klimas that it can be difficult to discriminate among wetlands of moderately different condition – though the term "moderate" could be operationally defined. This level of uncertainly could also be statistically analyzed with appropriate field data and the calibration process (e.g., repeated measurements by the same individual and other individuals) could be incorporated into the analysis.

14. The 10 % for attribute scores seems like a reasonable level of within-team and between-team precision; however, this level of variation needs to be considered within the context of the precision upon which the program wants to identify "moderate" differences in condition classes. The higher the level of variation allowed in attribute scores results in less precision to discriminate among condition in wetlands. Again, consultation with a professional statistician is essential to adequately address this question.

15. This is completely logical.

16. I have made extensive comments on the issue of validation in response 10. The basic problem is the lack of an "independent" gradient of stressors to the wetland ecosystems. Independent evaluation as used here primarily relies on data gathered on responses on birds, benthos, and plants by MAPS, EMAP, etc. This is fine for some of the validation, but the analysis as described above is not extensive enough. In addition, I suggest that an independent gradient of the stressors to the wetlands need to be better developed. If best achievable condition is defined as indicated in Issue 15 *("least levels of anthropogenic stress"*), then this represents a reference condition. I agree with this interpretation and I contend it is possible to partially quantify this reference condition and the proportion of stress across a gradient of good to poor condition (Danz et al. 2005, 2007; Host et al. 2005).

17. This is a difficult and perhaps intractable problem. My response is similar to what I stated in response to Issue 9 above. CRAM scores are not necessarily invalidated by natural stochastic changes, but common sense or good professional judgment is required in a subjective type assessment like CRAM.
18. I agree and support this statement.

19. As stated in Issues 10 and 16, I do not agree that validation has been established. The method has inherent biases based on structure and selected biota. The CRAM does include training, plus a selection of a diversity of personnel to complete evaluations is essential to minimize these biases.
20. At this point in the development of CRAM, "*best available judgment"* is perhaps the best that can be used, but refinement and improvement by incorporation of quantifiable stress information is possible with modern GIS and remote sensing technology (Host et al. 2005, Wolter et al. 2006, Danz et al. 2007).
21. Similar response as above to Issue 16.
22. I agree and support this statement.
23. If as stated in Issue 17 that "*land use accounts for anthropogenic stress"* then future conditions must rely on land use change as a basis for predicting future condition of a wetland. I agree that this line of reasoning is reasonable but I have not seen a good linkage between land use and wetland condition in this CRAM process nor have the appropriate studies been completed to substantiate this linkage over time. The CRAM process has the potential to do this over the long-term as long as the appropriate land use/land cover data layers are included (e.g., see Wolter et al. 2006). Additional information on point sources, human population density, invasive species, and other relevant information should be incorporated. I agree with most of the points made by Klimas.
24. The version of QA/QC in my packet is dated 3 May 2005 (Collins et al. – Insert 25 of Binder 3 of 3) and it is labeled Draft. It is a draft. There is some detail on a variety of issues, but it is incomplete and needs substantially more information on how QA/QC will be evaluated and how the resulting data will be statistically analyzed for uncertainty in the various methods.
25. The continued refinement of wetland classes over time is a healthy approach; especially as new information is obtained. I certainly support this perspective.
26. Wetland delineation is not my area of expertise, but the procedures look reasonable. However, note my comment under Issue 7 – I think the buffer and landscape context are too small. Among the best concepts we have learned over the past twenty years in ecology is the importance of landscapes and watersheds on receiving bodies such as wetlands, lakes, and streams. GIS has given us the capabilities of incorporating analyses hardly dreamed about even 30 years ago.
27. This seems reasonable – though same concerns as in Issue 7 and 26. Also, the sample and project assessments need to be incorporated into QA/QC procedures.
28. The basis for these measurement categories is well-founded in the literature. An important refinement possibility for the future would be to analyze the covariation among these categories. For instance, it might be possible to simplify the method later if it is found that some of the quantitative measures being gathered are highly correlated and therefore redundant. We gathered and analyzed over 200 independent stress variables in wetlands of the Great Lakes. We found that there was substantial correlation among the stress variables and they could be reduced to a much smaller number yet retain a substantial portion of the variation (see Danz et al. 2005, 2007). This can simplify the process in subsequent years in these wetland assessments. Stein et al. (2009) did this type of analysis and more of it is encouraged.

29. In consideration of the value of wetland ecosystems, I do not think this material provides conclusive evidence that CRAM can be reliably used to evaluate condition of estuarine and riverine wetlands in California. Wetland ecosystems provide enormous environmental benefits to humans (flood control, nutrient processing, etc.) and to biota. The ***precautionary principle*** should be used. Given the questions I have raised and preliminary nature for much of the work, especially validation, further development is necessary. I would also be concerned that if the method is applied now, then further development and validation would not occur.
30. No comment. This issue is not within my level of expertise. I suggest that it needs to be evaluated by a hydrologist.
31. I cannot support its use on the basis of my answer in Issue 29. Considerable developmental, evaluation, validation, and QA/QC issues remain.
32. The CRAM methodology is applicable to all of these wetland types, but all of the precautions and concerns that I have identified apply here as well.

Conclusions

The scientific basis of rapid assessment methods is reasonably well-developed. I have major concerns with the extent to which CRAM has been validated and I would strongly encourage the development of stronger, independent analysis of a human stress gradient. There is a draft document that was produced for the USEPA Office of Water in 2005 that developed this concept of a Biological Condition Gradient further, but I am not sure of its status. However, many of the peer-reviewed articles that I have cited have shown that it is possible to quantify this gradient with available stressor information (Danz et al. 2005, 2007) and interpret these data in the context of wetland biota (Brazner et al. 2007a, b). It is even possible to consider samples of the wetland biota to estimate the ecological condition of wetlands (e.g., see Howe et al. 2007). For instance, it is entirely reasonable to assume that the organisms living in these wetlands can indicate their overall condition, especially since they are living in the prevailing wetland conditions.

If we consider the monetary value of wetlands which is something we have ignored for too long, the consequences of making mistakes in wetland evaluation is very high. Wetlands provide many important functions (flood control, nutrient and other contaminant processing and removal, habitat for game and non-game species; nurseries for fisheries, recreational opportunities), so the protection of their integrity and appropriate assessments are essential. This need was clearly identified by Collins et al. (2005, 2008) within this packet of material. Coordinated efforts with Oregon and Washington for the entire US Pacific Coast should also be considered, especially since financial budgets are presumed to very tight.

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