DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:

CECW-CP

AUG 13 2008

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Policy Guidance on Certification of Ecosystem Output Models

1. References:

a. EC 1105-2-407: Planning Models Improvement Program: Model Certification (CECW-CP, 31 May 2005)

b. Interim Guidance for Planning Centers of Expertise (PCX) to Proceed with Model Certification (7 September 2006)

c. Protocols for Certification of Planning Models (July 2007)

d. Policy Guidance on Authorization and Budget Evaluation Criteria for Aquatic Ecosystem (ECO) Restoration Projects, March 2007

e. ECO-PCX White Paper: Recommendations to Headquarters, U.S. Army Corps of Engineers on Certification of Ecosystem Output Models (May 2008)

f. Report of the Planning Models Improvement Task Force (September 2003)

2. Requirements for certifying and documenting the quality of planning models have been issued in EC 1105-2-407 (reference 1a) and remain in effect. This memorandum establishes additional policy and procedures regarding the certification requirements for ecosystem output models used in all planning activities. These additions and clarifications are based in large part on recommendations from the Ecosystem Planning Center of Expertise (ECO-PCX) White Paper (reference 1e) and are presented with respect to each of the 18 recommendations in that document. The White Paper has been extensively coordinated among the Major Subordinate Commands (MSCs) and with HQUSACE and its recommendations are adopted with the annotations that follow.

3. Recommendation 1 regarding the importance, use and review of conceptual models is adopted.

4. Recommendation 2 regarding the approval of a list of standard methodological approaches is adopted. Note that study teams are by no means restricted to using the methodological approaches listed, but project development teams (PDT's) should coordinate as early as possible with the ECO-PCX and the rest of the vertical team if other approaches are being considered to assure corporate agreement of the study direction, and to identify appropriate support to the PDT in the method's development, validation, application and documentation.

5. Recommendation 3 regarding the approval of US Fish and Wildlife Services (USFWS) Habitat Suitability Index (HSI) models is adopted, recognizing that any associated computational models or software must be verified for system quality, and that the USFWS HSI models must be used in a risk and uncertainty analytic framework consistent with ER 1105-2-100.

6. Recommendation 4, regarding existing ecosystem output models that are documented and tested to the level required by EC 1105-2-407 is adopted, and also applies to any proprietary models (although these are not specifically mentioned in the White Paper). All such models will be evaluated for compliance with Corps policy which will include, but is not limited to: the ability to distinguish between aquatic and upland restoration outputs; the inclusion of variables that are not consistent with ecosystem restoration policy (recreation value, property values, cultural or historic value, educational value, etc.); the extent to which risk and uncertainty can be treated in the analysis; and the extent to which analytic results can fulfill the necessary authorization and budget evaluation criteria (reference 1d).

7. Recommendations 5 and 6 specify details of technical review conducted by the ECO-PCX and are adopted.

8. Recommendations 7 through 10 specify a number of initiatives to improve the tools for evaluating ecosystem outputs associated with planning activities. Recommendation 11 recognizes the need to further develop guidance for the application of professional judgment in assessing ecosystem outputs. (Note: the term "Best Professional Judgment" has a specialized usage within EPA in a regulatory context, and should not be adopted by the Corps in its ecosystem restoration program to avoid confusion with this existing practice). Recommendation 12 identifies a number of current topics that should be more fully investigated by the ECO-PCX, and Recommendation 13 addresses the need for support and training specific to ecosystem output models to enhance USACE capability.

These and other initiatives to improve and disseminate best practices throughout the community of practice are central to the ECO-PCX mission and are strongly supported.

9. Recommendations 14 and 15 address strategies for the PCX to more effectively execute and prioritize ecosystem output model assessments and certifications. A major implication of the policy changes enacted in this memo is that many ecosystem output models (those not expected to be used on multiple studies) will be assessed and documented through technical review rather than through a separate model certification process. This means that technical review will necessarily become much more intensive since the basic requirements of the Certification Protocols (reference 1c) requiring documentation of technical and system quality must still be met. Certification will be pursued for USACE ecosystem output models that are expected to be used in multiple studies. Models developed by others will assessed consistent with Recommendation 4, above. Workload prioritization, while not a matter of policy, is of prime importance given the large number of ecosystem output models currently engaged. The ECO-PCX is encouraged to continue utilizing strategies to execute this workload effectively. Finally, as a point of clarification, this guidance applies only to ecosystem output models, not to "ecosystem services or economics" models as mentioned in the Background and Discussion of Section IX.

10. Recommendations 16 and 17 address conditions under which the assessment of ecosystem output models will be managed by USACE or by an eligible external organization. These recommendations are adopted as follows: for ecosystem output models used in studies that require Independent External Peer Review (IEPR), the model assessment will be coordinated by the ECO-PCX but managed outside the Corps as part of the IEPR process; for models used in studies that do not require IEPR, the model assessment may be managed within USACE by the ECO-PCX, recognizing that review teams may include members drawn from outside the Corps. Additionally, for ecosystem output models submitted for Certification, the process will be managed outside the Corps except in cases where an alternate process is recommended by the ECO-PCX and approved by CECW-P in accordance with the procedures in reference 2 b.

11. Recommendation 18 cites the importance of having proposed approaches to ecosystem output modeling and review addressed in the study Review Plan as well as the Feasibility Scoping Meeting, and is adopted. The importance of early coordination with the ECO-PCX and vertical team cannot be overstated.

12. The policies and procedures in this memorandum are effective immediately. They will be incorporated into ECO-PCX standard operating procedures, and the policy components will ultimately be incorporated into permanent Corps guidance along with EC 1105-2-407.

FOR THE COMMANDER:

Encl

STEVEN L. STOCKTON, P.E.
Director of Civil Works

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REPLY TO
ATTENTION OF:

CEMVD-PD-N

2 May 2008

MEMORAMDUM FOR HQUSACE (CECW-P), WASH DC 20314-1000

SUBJECT: Recommendations on Certification of Ecosystem Output Planning Models

1. The Ecosystem Restoration Planning Center of Expertise (ECO-PCX) is working to successfully manage the workload for certification of models used in ecosystem restoration and mitigation projects. The workload for review and certification of the ecosystem restoration planning models is daunting. The ECO-PCX has reviewed Peer Review Plans for nearly 100 projects, the overwhelming majority of which use a planning model or models that are specific to the project. The ECO-PCX has already been requested to review more than 30 ecosystem restoration planning models.

2. Although EC 1105-2-407 "Planning Models Improvement Program: Model Certification" and "Protocols for Certification of Planning Models" (2007) provide detail on the model certification process and model criteria, the Ecosystem Restoration Planning Center of Expertise (ECO-PCX) identified the need to develop more specific recommendations for the certification of ecosystem output models. A workgroup was established to develop draft recommendations which were coordinated with the Planning Advisory Board and the MSC Environmental Chiefs. The recommendations are described in the enclosed White Paper, "Recommendations to Headquarters on Certification of Ecosystem Output Models" (encl 1).

3. The recommendations strive to clarify requirements and acknowledge the rigorous review that has already been conducted for specific models. The recommendations also propose to manage the model workload by requiring rigorous model assessment on regional models and those used on projects requiring External Peer Review (EPR) and provide guidance for ITR teams' review of model quality for projects not requiring EPR.

CEMVD-PD-N 2 May 2008
SUBJECT: Recommendations on Certification of Ecosystem Output Planning Models

4. Please review the enclosed recommendations and consider incorporating the recommendations into revisions to EC 1105-2-407 or updates to ER 1005-2-100. Implementation of the enclosed recommendations is the key to successfully managing the model certification workload while minimizing project delays. The ECO-PCX requests permission to begin implementing these recommendations immediately.

1 Encl

RAYFORD E. WILBANKS
Director, National Ecosystem Planning Center of Expertise

CF:
CENAD-PSD-P (Vietri)
CESAD-PDS (Paynes)
CELRD-PDS-P (Moyer, Zimmerman)
CESWD-PDS-P (Duman)
CENWD-PDD (Fredericks, Hudson, Ponganis)
CESPD-PDS (Charlton)
CEPOD-PDC (Hihara-Endo, Iwamura)
CECW-PB (Sherman)
CECW-PC (Coloismo, Carlson, Matusiak)
CECW-CP (Kitch)

WHITE PAPER
ECO-PCX Recommendations to Headquarters on
Certification of Ecosystem Output Models

I. Introduction.

The Corps Planning Models Improvement Program (PMIP) was established to review, improve and validate analytical tools and models for Corps Civil Works business programs. The PMIP resulted in development of Engineering Circular (EC) 1105-2-407, Planning Models Improvement Program: Model Certification in May 2005. The EC requires use of certified models for all planning activities. It tasks the Planning Centers of Expertise to evaluate the technical soundness of all planning models based on theory and computational correctness. Although Protocols for Certification of Planning Models[1], finalized in July 2007, provide more detail on the model certification process and model criteria, the Ecosystem Restoration Planning Center of Expertise (ECO-PCX) identified the need to develop more specific recommendations for the certification of ecosystem output models. A workgroup was established to develop recommendations. Workgroup members include the following: Pete Dodgion (Huntington District), Scott Estergard (LA District), Craig Fischenich (ERDC-EL), Matt Mallard (Vicksburg District), Angie Sowers (Baltimore District), Jodi Staebell (Rock Island District), Tisa Webb (ERDC-EL), Brian Zettle (Mobile District).

The purpose of this white paper is to make recommendations to provide additional guidance on the process for certification of planning models used for ecosystem restoration (ER) and mitigation.

II. Definitions

Model Assessment – Review of a planning model by Corps and/or external resources and an assessment of the technical and system quality and usability of the model in accordance with EC 1005-2-407 and Protocols for Certification of Planning Models. The review team should not have been involved in model development. Assessment should include information on the basis of concern, significance of concerns and should suggest ways to resolve concerns.

Rigorous Model Assessment – Review of a planning model as described above using individuals external to the Corps.

[1] US Army Corps of Engineers. 2007. Protocols for Certification of Planning Models, Planning Models Improvement Program.

III. Recommendation Summary

1. Conceptual Models. Conceptual models should be developed for all ER projects, but will be reviewed as part of the normal ITR process and do not require certification.

2. Ecosystem Output Methodologies. The ECO-PCX should approve the following ecosystem output methodologies for use in ecosystem restoration planning and mitigation planning. The ECO-PCX will need to certify or approve for use each regionally modified version of these methodologies and individual models and guidebooks used in application of these methods..

- Habitat Evaluation Procedures (HEP),
- Hydrogeomorphic (HGM) Approach to Assessing Wetland Functions.
- Index of Biotic Integrity (IBI)
- Macroinvertebrate IBI (MIBI)
- Floristic Quality Assessment (FQA)
- Qualitative Habitat Evaluation Index (QHEI)

3. USFWS Habitat Suitability Index Models. The ECO-PCX should approve the Habitat. Suitability Indices listed in Appendix A that were developed and published by the US Fish and Wildlife Services.

4. Existing Quality Models. The ECO-PCX should certify or approve for use, without additional review, quality models that have been documented to have sufficient technical and system quality in accordance with the protocols (Protocols for Certification of Planning Models under the Planning Models Improvement Program, July 2007).

5. Model Application. ECO-PCX should describe the responsibilities of the ITR team for review of appropriate application and use of ecosystem output models and include this information in the ITR review guide that is under development.

6. Model Application. Once a model has been certified or approved for use, minor modifications will not require additional model review. The determination of whether modifications are minor or major will be made jointly by the ECO-PCX, vertical team and PDT.

7. Software: The ECO-PCX should encourage use of software applications to conduct evaluations to minimize errors.

8. Software. The ECO-PCX should encourage ERDC and others to complete software that may be useful in conducting ecosystem restoration quantification. ECO-PCX should review these models and certify/approve for use when appropriate.

9. Spreadsheet Errors. The ECO-PCX should prepare and disseminate an information paper describing the issue with spreadsheet errors and describing best practices for development of spreadsheet models to minimize errors.

10. Software and Spreadsheet Testing. The ECO-PCX should identify internal or external sources for conducting model testing and debugging and these sources should be provided to model developers or PDT. PDT or model developer should be required to show proof that the formulas within programs or spreadsheets have been tested and debugged.

11. Best Professional Judgment (BPJ). The ECO-PCX should support development of guidelines on how to document BPJ and develop guidelines for review of BPJ application by ITR teams. It is understood that this may be a deliverable proposed in the new Environmental Benefits Analysis Research Program.

12. Lessons Learned. The ECO-PCX should prepare and distribute issue papers on the following topics related to ecosystem output evaluation. Summaries of issue papers and links to papers should be submitted to Planning Ahead.

- Use of Relative Value Indices or Weighting
- Spreadsheet error rates and the significance to ecosystem output evaluation
- Best practices in development and debugging spreadsheets
- Development and use of Conceptual Models

13. Model Support. The ECO-PCX should provide support teams and training to assist PDTs in development of ecosystem planning models.

14. Model Categories. The ECO-PCX should pursue the above or an alternative means to categorize model types and identify possible variations in associated model protocols or in prioritization based upon that classification.

15. Workload Prioritization. The ECO-PCX should prioritize model certification efforts, focusing certification efforts models used on projects with high output and with the highest implementation costs.

16. Workload Prioritization. Projects that do not require External Peer Review should have a model assessment of the planning ***models*** to assess technical and system quality using review criteria provided by the ECO-PCX, early in the study process.

17. Workload Prioritization. Models with regional application will require model certification. Projects that don't require EPR and that are using a regional model will have a model assessment as described in the above recommendation until the regional model is reviewed and certified.

18. Workload Prioritization. Approach to modeling and model review will be proposed in the Peer Review Plan and discussed at the Feasibility Scoping Meeting. For projects that have proceeded past the FSM, it is the responsibility of the Districts to contact the ECO-PCX as soon as possible to discuss model review requirements.

IV. Certification Scope.

1. *Conceptual Models.* The Protocols outlined in the July 2007 document include conceptual models among the examples of models and analytical tools requiring certification. A conceptual model is a tentative description of a system or sub-system that serves as a basis for intellectual organization and represents the modeler's current understanding of the relevant system processes and characteristics[2]. Conceptual models provide a basis for establishing the Future-Without-Project condition and the benefits of proposed alternatives; as such, they should be developed and documented for every ER project. Although they play an important role in ecosystem restoration planning and should be carefully reviewed, conceptual models do not lend themselves to certification as envisioned in the EC. They are qualitative in nature and neither right nor wrong, but can be gauged as to their appropriateness for a given application. In most circumstances, conceptual models cannot be directly verified.

Recommendation 1. Conceptual models should be reviewed as part of the normal ITR process.

2 *Ecosystem Output Methodologies.* There are a number of ecosystem output methodologies in wide use. Some of the methods are based on US Fish and Wildlife Service Habitat Evaluation Procedures (HEP) [3] [4] accounting framework which quantify the product of habitat quality and quantity. Other methodologies are based on regional habitat assessment or biological indicators. The following methodologies are well established and have been adequately peer reviewed:

- Habitat Evaluation Procedures (HEP)
- Hydrogeomorphic (HGM) Approach to Assessing Wetland Functions[5]
- Index of Biotic Integrity (IBI)[6] [7]
- Macroinvertebrate IBI (MIBI)[8]
- Floristic Quality Assessment (FQA) [9] [10] [11]

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[2] Fischenich, C. 2008. "The Application of Conceptual Models to Ecosystem Restoration," ERDC/EBA TN-08-1, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

[3] U.S. Fish and Wildlife Service 1980. Habitat as a Basis for Environmental Assessment. ESM 101. Division of Ecological Services,. Dept. of the Interior. Washington, D.C.

[4] U.S. Fish and Wildlife Service. 1980. Habitat Evaluation Procedures (HEP). ESM 102. Division of Ecological Services,. Dept. of the Interior. Washington, D.C.

[5] Smith, R.D., A. Amman, C. Bartoldus, and M. Brinson. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices. Technical Note WG-EV-2.2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

[6] Karr, J.R. 1981. Assessment of biotic integrity using fish communities. Fisheries 6:21-27

[7] Karr, J.R. K.D. Fausch, P.L. Angermeier, P.R. Yant, and I.J. Schlosser, 1986. Assessment of biological integrity in running water: a method and its rationale. Illinois Natural History Survey Special Publication, Number 5, Champaign, Illinois.

[8] Karr, J.R. and B.L. Kerans. 1992. Components of biological integrity; their definition and use in development of an invertebrate IBI. Pages 1-16 in W.S. Davis and T.P. Simon editors. Proceedings of the 1991 Midwest Pollution Control Biologists Meeting,. U.S. Environmental Protection Agency, Chicago, Illinois. EPA-905/R-92/003

[9] Wilhelm, G.S. 1977. Ecological assessment of open land areas in Kane County, Illinois. Kane County Urban Development Division. Geneva, Illinois.

- Qualitative Habitat Evaluation Index (QHEI)[12]

Recommendation 2. The ECO-PCX should approve the ecosystem output methodologies listed above for use in ecosystem restoration planning and mitigation planning. The ECO-PCX will need to certify or approve for use each regionally modified version of these methodologies and individual models and guidebooks used in application of these methods. Examples of individual models include the following: Habitat Suitability Index models not included in the list below, HGM regional guidebooks, State of Georgia IBI Protocols; State of Wisconsin Co-efficient of Conservatism List (for FQA), and modifications of QHEI to different regions.

3. *USFWS Habitat Suitability Index Models.* The US Fish and Wildlife Service developed approximately 150 Habitat Suitability Index (HSI) in the Habitat Suitability Index Model Series. The HSI models are used with Habitat Evaluation Procedures and are applicable to planning Corps ecosystem restoration projects and to Corps mitigation planning. According to the USGS website,

> "The models in this series reference numerous literature sources in an effort to consolidate scientific information on species-habitat relationships. Models are included that provide a numerical index of habitat suitability on a 0.0 to 1.0 scale, based on the assumption that there is a positive relationship between the index and habitat carrying capacity .... The models vary in generality and precision, due in part to the amount of available quantitative habitat information and the frequent qualitative nature of existing information. When possible, models are included that are derived from site-specific population and habitat data."

The models were developed in accordance with Standards for the Development of Habitat Suitability Index Models for Use in the Habitat Evaluation Procedures [13].

The HSI Model documentation explains the model's structure and assumptions. The documentation provides insights necessary to modify the model when appropriate, and facilitates revision of the model to meet individual study constraints. The models serve as a basis for decision-making and increased understanding of habitat relationships because they specify hypothesis of habitat relationships that can be tested and improved.

The models were developed in compliance with USFWS standards. Rigorous scientific review and model testing and validation were conducted prior to publication. The review by USFWS has addressed the technical and computational correctness of the HSI models.

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[10] Swink, F. and G. Wilhelm. 1979. Plants of the Chicago region. Revised and expanded edition with keys. The Morton Arboretum,, Lisle, Illinois

[11] Swink, F. and G. Wilhelm. Plants of the Chicago region. 4th edition. Indiana Academy of Science, Indianapolis, Indiana

[12] Rankin, E.T. (1989). "The qualitative habitat evaluation index [QHEI]: rationale, methods, and application," Ohio EPA, Division of Water Quality Planning and Assessment, Columbus, Ohio

[13] U.S. Fish and Wildlife Service. 1980. Standards for the Development of Habitat Suitability Index Models. ESM 103. Division of Ecological Services,. Dept. of the Interior. Washington, D.C.

Many of these models have been in use for over 20 years. While these models are based on validated and accepted theory, simply selecting an approved model is not sufficient. The ITR team must evaluate whether the application of the model is appropriate.

Recommendation 3: The ECO-PCX should approve, without additional review, the Habitat Suitability Indices listed in Appendix A that were developed and published by the US Fish and Wildlife Services.

4. *Existing Quality models.* Corps planning studies frequently use quality models that have been developed by the Corps, other Federal agencies, non-Federal government entities, NGOs or academic institutions. Examples of quality models include State of Wisconsin Coefficient of Conservatism Plant List for Floristic Quality Assessment, the Georgia Piedmont Index of Biotic Integrity, and the Arizona Riverine Hydrogeomorphic Model. The technical quality, system quality, and usability of these models vary.

Many of these quality models have been developed with a rigorous of scientific input and peer review. Documentation of the technical quality, system quality, and usability of the models should be provided to the ECO-PCX as outlined in Table 2 of the Protocols for Certification of Planning Models under the Planning Models Improvement Program. Sufficient detail should be provided to assure the ECO-PCX that the technical and system quality of the model are acceptable. Documentation may require the PDT to contact the model developer to collect information for Table 2. Review of all models for compliance with Corps policy will be required.

Recommendation 4. The ECO-PCX should certify or approve for use, with review that is limited to compliance with Corps policy, quality models that have been documented to have rigorous technical and system quality in accordance with the protocols (Protocols for Certification of Planning Models under the Planning Models Improvement Program, July 2007). If documentation does not adequately demonstrate technical and system quality, the ECO-PCX should undertake a more detailed review of the model prior to making the determination on certification or approval of the model.

V. Model Application.

Discussion: A clear distinction is needed between model verity and the quality of application. Good models may be misapplied, and a review of the model alone cannot protect against improper use. Some aspects of modeling and analysis may be better suited to review through the Independent Technical Review (ITR) process than through the certification process. There is no guidance which identifies the responsibilities of the ITR team with regard to models. There is an opportunity to identify ITR tasks during development of the ECO-PCX review guide.

The ECO-PCX should focus on the scientific and technical aspects of a model that is submitted for certification. Appropriate application and use of a model by a project is the responsibility of the project team and ITR team.

Recommendation 5: The ITR is responsible for reviewing application of certified or approved planning models. ECO-PCX should describe the responsibilities of the ITR team for review of application of ecosystem output models. These responsibilities should be included in the review guide that is under development.

Recommendation 6: Once a model has been certified or approved for use, minor modifications will not require additional model review. The determination of whether modifications are minor or major will be made jointly by the ECO-PCX, vertical team and PDT.

VI. Software

Background. Project Delivery Teams use computer programs and software to conduct numerical computations for ecosystem output models. Some models use compiled source code, while others use spreadsheets. These tools frequently contain numerous formulas and conduct multiple computations. Published studies have documented high percentages of spreadsheet errors[14]. Raymond Panko summarized studies by others which found errors in 94% of the 88 spreadsheets audited in 7 studies[15]. Research has been conducted on how to test and debug spreadsheets to minimize spreadsheet errors[16].

As part of model certification, the ECO-PCX needs to ensure that programming was done correctly. The Protocols for Certification of Planning Models require documentation of system quality that includes proof that the programming was done correctly and description of the process used to test and validate the model. Each formula in the program should be tested separately, and if possible the model should be calibrated and verified. Additional requirements are included in Table 2 of the protocol. For some models, the software tool is a computer program written specifically for the ecosystem output evaluation. For models using spreadsheets, the software tool is the spreadsheet.

Discussion: Software for conducting ecosystem output evaluation that might reduce errors is not readily available. The USFWS developed DOS-based software to conduct habitat evaluations, but no longer supports this software. ERDC has developed a MS Windows-based software, Habitat Evaluation and Assessment Tool (HEAT), to enter HSI and HGM Regional Guidebooks and conduct HEP and HGM evaluations. However, the testing and documentation of this software is not yet complete and is not available for widespread use. USGS is also developing a prototype MS Windows-based software, called Habitat Workshop, to conduct habitat evaluations.

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[14] Kruck, S.E. and Steven D. Sheetz. 2001. Spreadsheet Accuracy Theory. Journal of Information Systems Education 12 (2001): 93 - 108.

[15] Panko, R.R. 2005. What We Know About Spreadsheet Errors. White Paper. University of Hawaii, Honolulu, HI. weblink

[16] Powell, S.G., K.R. Baker and B Lawson. 2007. An Auditing Protocol for Spreadsheet Models. Tuck School of Business, Dartmouth College, Hanover, New Hampshire. http://mba.tuck.dartmouth.edu/spreadsheet/product_pubs_files/Auditing.doc (accessed November 2007)

Recommendation 7. ECO-PCX should encourage use of thoroughly tested and reviewed software applications to conduct evaluations in order to minimize computational errors. Examples of such software include EXHEP, CE-QUAL-W2, and EFM[17].

Recommendation 8. ECO-PCX should encourage ERDC and others to complete software that may be useful in conducting ecosystem restoration quantification. ECO-PCX should review these models and certify/approve for use when appropriate.

Recommendation 9. ECO-PCX should prepare and disseminate an information paper describing the issue with spreadsheet errors and describing best practices for development of spreadsheet models to minimize errors.

Recommendation 10. ECO-PCX should identify internal or external sources for conducting model testing and debugging and the ECO-PCX should support the use of this expertise in model development. PDT or model developer will be required to show proof that the formulas within programs or spreadsheets have been tested and debugged.

VII. Use of Best Professional Judgment

Background and Discussion: Most ecosystem output models rely to some degree on Best Professional Judgment (BPJ). Development of some models involves capturing the Best Professional Judgment of experts. Other models rely on BPJ in application of models and prediction of future with and without project conditions. There are no guidelines on how to document use of BPJ in ecosystem output evaluation. Reports do not document the application of BPJ in a way that can be reviewed by an Independent Technical Review Team.

Recommendation 11: The ECO-PCX should support development of guidelines on how to document BPJ and develop guidelines for review of BPJ application by ITR teams. It is understood that this is a deliverable proposed in the new Environmental Benefits Analysis Research Program. The ECO-PCX should work with ERDC on the development of this product.

VIII. Lessons Learned

Background and Discussion: Policies related to ecosystem restoration continue to evolve. Lessons learned on evolving ecosystem output model issues need to be shared with the ecosystem restoration community. Sharing of these lessons learned would inform PDTs of emerging issues.

[17] SWWRP Toolbox: https://swwrp.usace.army.mil/portal/alias__swwrp/lang__en-US/tabID__3705/DesktopDefault.aspx (accessed April 2008)

Recommendation 12: ECO-PCX should prepare and distribute issue papers on the following topics related to ecosystem output evaluation. Summaries of issue papers and links to papers should be submitted to Planning Ahead and posted on the Planning Community of Practice SharePoint Website[18].

- Use of Relative Value Indices or Weighting
- Spreadsheet error rates and the significance to ecosystem output evaluation
- Best practices in development and debugging spreadsheets
- Development and use of Conceptual Models
- Application of Risk and Uncertainty in ecosystem planning models
- Co-application of engineering and planning models

Recommendation 13: The ECO-PCX should provide support teams and training to assist PDTs in development of ecosystem planning models. USACE resources need to be made available to support this effort.

IX. Model Categorization.

Background and Discussion: The range of models that can be applied to ecosystem restoration projects is vast. Potentially included are models that assess habitat, population dynamics, physical processes, ecosystem services, economics, and so on. The models may be stochastic or deterministic, spatially explicit or non-spatial, statistical- or process-based, continuous or discrete.

Regardless of the type of model, it is necessary for the proponent to demonstrate and document the model's 1) technical verity and theoretical soundness, 2) computational accuracy, 3) compliance with Corps' policies, and 4) appropriate application. Appropriate application (#4) can be judged only on a case-by-case basis, so would normally be addressed as part of the Independent Technical Review process. Requirements 1, 2 and 3 could be addressed on a case-by-case basis as well, or could be accomplished once and the model thereby "Certified" for other future projects. Certified models would not be exempt from requirement 4, so the appropriateness of application must be assessed for each project.

Three classes of models are proposed to help inform decisions regarding the need for or benefit from Certification:

- Class 1: These are models that are developed to meet the needs of a specific project and are unlikely to be used in the same form for other ecosystem restoration projects.

- Class 2: These are existing models that are (or may be) used for multiple ecosystem restoration projects, and have already been subjected to a rigorous peer review of the underpinning theory or computational accuracy, typically through some review process external to the Corps.

[18] https://kme.usace.army.mil/CoPs/CivilWorksPlanning-Policy/default.aspx (accessed April 2008)

- Class 3: These are existing or new models that are (or may be) used for multiple ecosystem restoration projects, and have not previously been subjected to a rigorous peer review of the underpinning theory or computational accuracy.

For Class 1 models, there is no advantage to certification. However, demonstration and documentation of the model validity is necessary, and generally requires the same steps as required for certification. Some reduction in effort relative to full Certification can be expected because the model need not require demonstrable application to situations other than the specific project to which it is applied.

For Class 2 models, certification is advantageous in that the necessary reviews can be accomplished one time, although the model may be applied in numerous instances. Because some level of validation may already exist for Class 2 models, the level of effort required for certification may be reduced substantially from that required for Class 3 models. The certification requirements will depend upon the degree to which the provided documentation substantiates the theoretical soundness and computational accuracy of the model. Generally speaking, review processes employed by other agencies, peer review publication, and demonstration of application as an industry standard can substitute for the theoretical soundness and/or technical accuracy requirements, but a separate assessment of conformance to Corps policies would be required.

For Class 3 models, certification is recommended as a means of avoiding duplication of review effort. Models require certification only one time. Thereafter, proponents can note that they are using a fully certified model and the review will focus on the appropriate application of that model without regard for theoretical soundness, computational accuracy, or policy conformance (as these will have been previously certified).

Recommendation 14: The ECO-PCX should pursue the above or an alternative means to categorize model types and identify possible variations in associated model protocols or in prioritization based upon that classification.

X. Workload Prioritization.
Based on preliminary information, it appears that most PDTs are using models developed specifically for an individual project. The ECO-PCX has received Peer Review Plans for over 80 ecosystem restoration projects; therefore, there are potentially over 80 ecosystem planning models to be certified or approved for use. The ability of any PCX to certify so many models in a timely manner is questionable. The ECO-PCX cannot work on certification for all these projects at once. A system to prioritize workload is needed.

A number of prioritization strategies could be considered. Three possible strategies are described below. For any of the prioritization strategies, the ECO-PCX and HQ need to agree on how to address models that are not reviewed immediately. Basic model quality

items should be identified for review by ITR teams. One specific item to address is how to ensure spreadsheet accuracy.

1. Prioritize based on implementation costs.
Projects would be sorted by implementation costs and model certification efforts would be conducted on projects with the highest costs. Milestones such as FSM, AFB and CWRB would be taken into account in prioritization. For lower cost projects, some level of model review would be conducted by the ITR team with guidance provided by the ECO-PCX. Following review of models for high cost projects, model review would be conducted on lower costs projects that have not yet had CWRB.

2. Conduct "pilot model review" and apply lessons learned.
A variety of projects would be selected and model review would be conducted on these select projects. Projects would be selected to represent a variety of model types and magnitude of construction costs. Review of these initial select models would take 6-12 months. Lessons learned would be prepared for the pilot model review and applied to future efforts. Following the pilot review, model review would be conducted on models based on other prioritization strategies. The Corps would need to determine how to address projects that have CWRB scheduled during the pilot model review period.

3. Prioritize based on regional application.
Projects would be sorted based on the regional applicability of models. Models with regional application would be reviewed first. For models without regional application, some level of model review would be conducted by the ITR team with guidance provided by the ECO-PCX. Following completion of review of regional projects, review of more local models would be conducted.

4. Prioritized based on the concept of "low-hanging fruit":

Consider level of outputs, cost, timing, complexity of model, and relative project performance. Projects with the following characteristics would be on the fast track to certification is: high outputs/low cost; low project cost; short term; small; easy. Projects with the opposite characteristics would be on the slow track to certification: low outputs/high cost; high project cost; long term; large; complex.

Recommendation 15: The ECO-PCX should prioritize model certification efforts on "low-hanging fruit concept".

Recommendation 16: Projects that do not require External Peer Review should have a model assessment to assess technical and system quality using review criteria provided by the ECO-PCX. The *Model Assessment* should occur early in the study process. The findings of the Model Assessment will be provided to the ECO-PCX and vertical team as part of project review to document the technical and system quality of the model.

Recommendation 17: Models with regional application will require model certification. Projects that don't require EPR and that are using a regional model will have robust

Model Assessment as described in the above recommendation until the regional model is reviewed and certified.

Recommendation 18: Approach to modeling and model review will be proposed in the Peer Review Plan and discussed at the Feasibility Scoping Meeting. For projects that have proceeded past the FSM, it is the responsibility of the Districts to contact the ECO-PCX as soon as possible to discuss model review requirements (Appendix B). Send request to Rayford Wilbanks with copies to Susan Smith, David Vigh, and Jodi Staebell.

XI. Conclusion

The recommendations in this White Paper were vetted with the MSC Planning Chiefs and MSC Environmental Chiefs.. The recommendations should be outlined in a CECW memorandum as interim guidance until EC 1105-2-407 is revised or model certification requirements are incorporated into ER 1105-2-100. The memorandum should be distributed prior to the start of the Planning Community of Practice Conference on May 20, 2008.

Appendix A
U.S. Fish and Wildlife Service Published Habitat Suitability Models
Approved for Use

Alewife and Blueback Herring
American Alligator
American Black Duck
American Coot
American Eider (breeding)
American Oyster, Gulf of Mexico
American Shad
American Woodcock (wintering)
Arctic Grayling Riverine Populations
Arizona Guild and Layers of Habitat Models
Atlantic Croaker
Baird's Sparrow
Bald Eagle
Barred Owl
Bass,
- Largemouth
- Smallmouth
- Spotted
- Striped Inland
- Striped, Coastal
- White
Bear, Black (Upper Great Lakes Region)
Beaver
Belted Kingfisher
Bigmouth Buffalo
Black Bear
Black-Bellied Whistling Duck
Black Brant
Black Bullhead
Black-Capped Chickadee
Black Crappie
Black Duck (Wintering)
Black-Shouldered Kite
Black-Tailed Prairie Dog
Blackbird,
- Red-winged
- Yellow -headed
Blacknose Dace
Blue Grouse
Blue-Winged Teal
Bluegill
Bobcat
Bobwhite, Northern
Brewer's Sparrow
Brook Trout
Brown Pelican (eastern)
Brown Thrasher
Brown Trout
Brown/White Shrimp, Northern Gulf of Mexico
Buffalo,
- Bigmouth
- Smallmouth
Bullfrog
Cactus Wren
Canvasback (breeding habitat)
Carp, Common
Catfish,
- Channel
- Flathead
Chickadee, Black-Capped
Chinook Salmon
Chum Salmon
Clam,
- Hard
- Littleneck
Clapper Rail
Coho Salmon
Common Carp
Common Shiner
Cottontail, Eastern
Creek Chub
Croaker, Juvenile Atlantic
Cutthroat Trout
Deer, White Tail
Diamondback Terrapin (nesting) Atlantic Coast
Downy Woodpecker
Drum, Red (larval and juvenile)
Duck,
- Black Duck
- Black-Bellied Whistling Duck
- Mallard
- Mottled Duck
- Wood Duck
Eastern Brown Pelican
Eastern Cottontail
Eastern Meadowlark
Eastern Wild Turkey
English Sole (juvenile)
Fallfish (927 KB)
Ferruginous Hawk
Field Sparrow
Fisher
Flathead Catfish
Flounder, Southern and Gulf
Forster's Tern
Fox Squirrel
Gadwall
Gizzard Shad
Goose,
- Greater White-fronted (wintering)
- Lesser snow
Gray Partridge

Gray Squirrel
Great Blue Heron
Great Egret
Greater Prairie Chicken
Greater Sandhill Crane
Greater White-Fronted Goose (wintering)
Green Sunfish
Grouse,
- Blue
- Rufffed Grouse
- Sharp-Tailed Grouse
Gulf of Mexico American Oyster
Gulf Menhaden
Gull, Laughing
Hairy Woodpecker
Hard Clam
Heron, Great Blue
Ibis, White
Inland Silverside
Inland Stocks of Striped Bass
Juvenile Atlantic Croaker
Juvenile English Sole
Juvenile Spot
Kingfisher, Belted
Lake Trout (Exclusive of the Great Lakes)
Largemouth Bass
Lark Bunting
Larval and Juvenile Red Drum
Laughing Gull
Least Tern
Lesser Scaup (breeding)
Lesser Scaup (wintering)
Lesser Snow Goose (wintering)
Lewis' Woodpecker
Littleneck Clam
Longnose Dace
Longnose Sucker
Mallard (Winter Habitat, Lower Mississippi Valley)
Marsh Wren
Marten
Meadowlark, Eastern
Mink
Moose, Lake Superior Region
Mottled Duck
Muskellunge
Muskrat
Newt, Red-Spotted
Northern Bobwhite
Northern Gulf of Mexico Brown Shrimp and White Shrimp
Northern Pike
Northern Pintail (Gulf Coast wintering)
Osprey
Owl,
- Barred
- Spotted
Oyster, Gulf of Mexico
Paddlefish
Pelican, Eastern brown
Perch, Yellow
Pileated Woodpecker
Pine Warbler
Pink Salmon
Pink Shrimp
Pintail, Northern (Gulf Coast wintering)
Plains Sharp-Tailed Grouse
Pronghorn
Quail (Northern bobwhite)
Rabbit, Swamp
Rainbow Trout
Red Drum (larval and juvenile)
Red King Crab
Red-Spotted Newt
Red-Winged Blackbird
Redbreast Sunfish
Redear Sunfish
Redhead (wintering)
Roseatte Spoonbill
Ruffed Grouse
Salmon,
- Chinook
- Coho
- Chum
- Pink
Scaup, Lesser (wintering)
Scaup, Lesser (breeding)
Shad,
- American
- Gizzard
Sharp-Tailed Grouse
Shelter-Belt Community
Shortnose Sturgeon
Shrimp,
- Brown/white
- Pink
Slider Turtle
Slough Darter
Smallmouth Bass
Smallmouth Buffalo
Snapping Turtle
Snowshoe Hare
Southern and Gulf Flounders
Southern Red-Backed Vole (Western United States)
Southern Kingfish
Sparrow,
- Baird's
- Brewer's
- Field
Spotted Bass
Spotted Owl
Spotted Seatrout
Squirrel,
- Gray
- Fox
Striped Bass, Inland
Striped Bass, Coastal

Sucker,
- Longnose
- White
Sunfish,
- Green
- Redbreast
- Redear
Swamp rabbit
Tern,
- Forster's
- Least
Thrasher, Brown
Trout,
- Brook
- Brown
- Cutthroat
- Lake
- Rainbow
- Spotted Seatrout
Turtle,
- Slider Turtle
- Snapping Turtle
Turkey
Veery
Vole, Southern Red-Backed
Walleye
Warbler,
- Pine
- Yellow
Warmouth
Western Grebe
White Bass
White Crappie
White Ibis
White Sucker
White-Fronted Goose (wintering)
White-Tailed Deer in the Gulf of Mexico & South Atlantic Coastal Plains
Williamson's Sapsucker
Wood Duck
Woodpecker,
- Downy
- Hairy
- Lewis'
- Pileated
- Williamson's Sapsucker
Wren, Marsh
Yellow Perch
Yellow Warbler
Yellow-Headed Blackbird

Appendix B
Proposed Certification Process for Ecological Planning Models
and Related Analytical Tools

Sequence of Steps for Certification/Approval of Existing Models (no previous ECOPCX involvement)

1. **PROPONENT:** Prepare model documentation per Table 2 of *Protocols for Certification of Planning Models*, including Background, Technical Quality, System Quality, and Usability. The documentation will identify the modeling approach used (e.g. index, mechanistic, etc.) and describe any special considerations to supplement the guidance in the protocols. The documentation will include descriptions of verification, field testing, or validation procedures. If model review will require significant labor, equipment, travel, or contract expense, then identify potential funding sources, develop a schedule, and submit both to the ECOPCX.

2. **ECOPCX:** Determine appropriate review level, and prepare certification review plan. In most cases this should include both internal and external peer reviewers selected based upon widely recognized expertise relative to the proposed model.

3. **ECOPCX:** Assemble certification review team. This team shall include a combination of internal or external peer reviewers appropriate to the character and complexity of the model or analytical tool, including functional area experts, planners/formulators, and/or software experts.

4. **PROPONENT:** Revise/update model and model documentation based upon results of peer review. Resubmit to ECOPCX for re-review and possible certification.

5. **ECOPCX:** Make a determination on recommendation of model certification approval or additional work required.