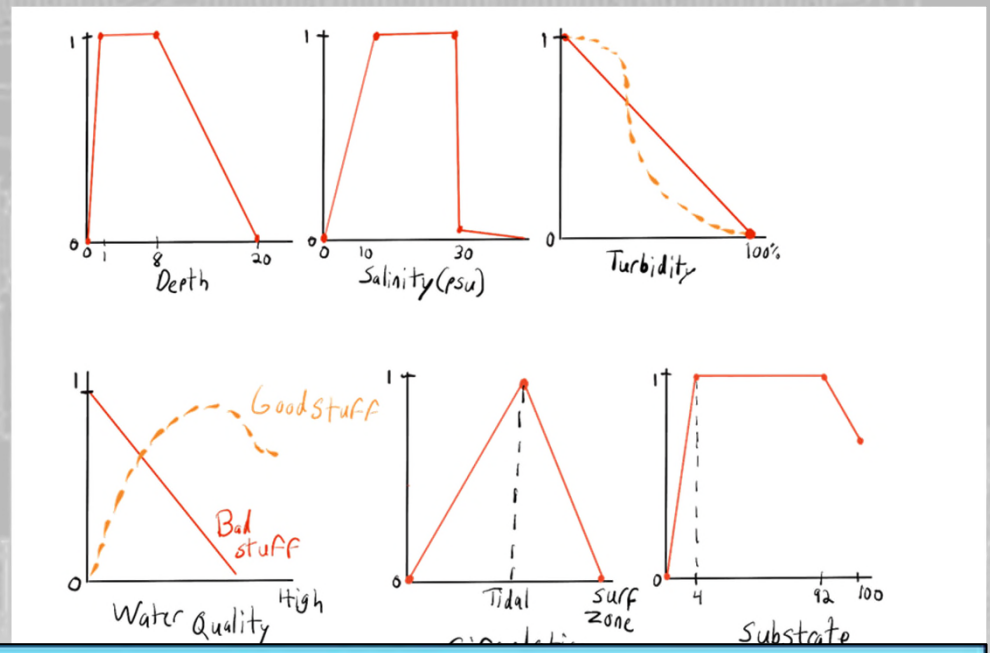
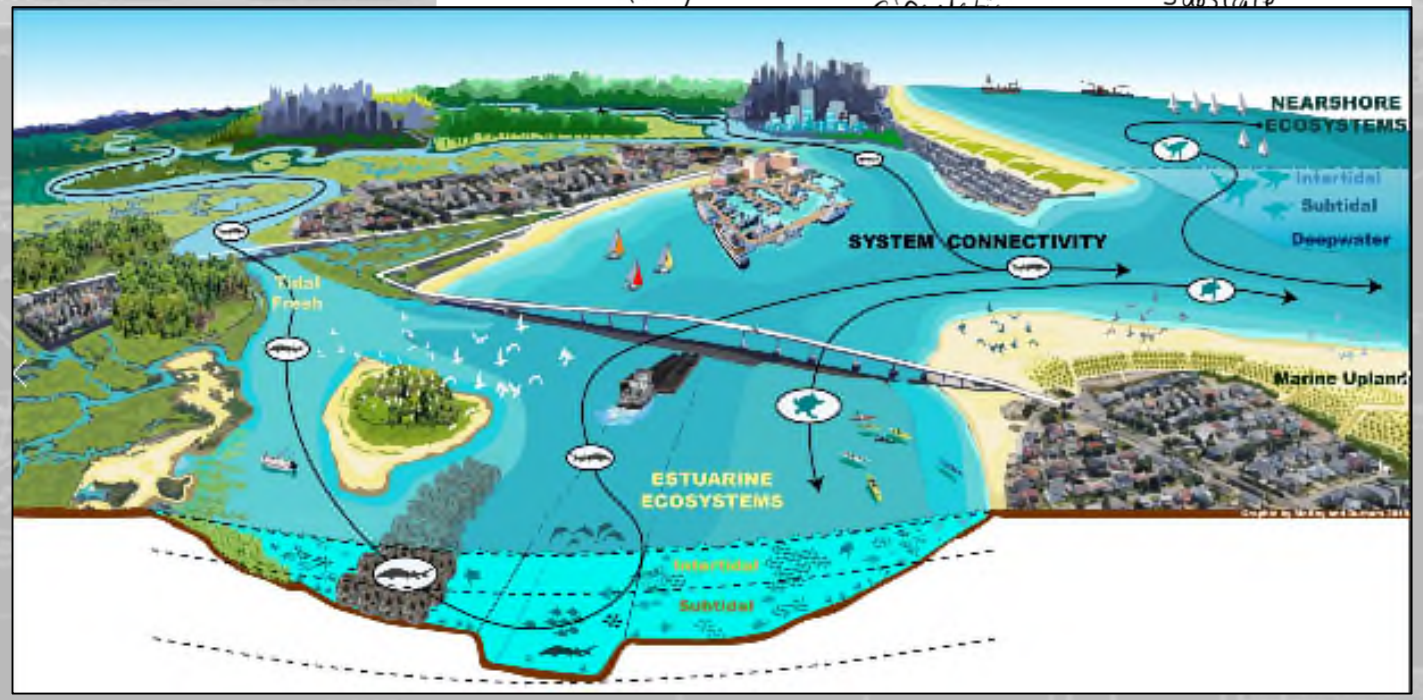
ECOLOGICAL MODELS, REVIEW, AND CERTIFICATION

Nate Richards
USACE Rock Island District
Ecosystem Restoration PCX

09 July 2020





US Army Corps of Engineers®

LRD	LRB	LRC	LRE	LRH	LRL	LRN
LRP	MVD	MVP	MVR	MVS	MVM	MVK
MVN	NAD	NAB	NAE	NAN	NAO	NAP
NWD	NWP	NWS	NWW	NWO	NWK	POD
POA	POH	SAD	SAJ	SAM	SAS	SAW
SAC	SPD	SPL	SPN	SPA	SPK	SWD
SWF	SWG	SWT	SWL	RE	E&C	PM
OD	PCOP	Policy	IWR	OWPR	RIT	ERDC

Click on the Annotation option on the left side of your screen and then use the Pencil Tool or checkmark to mark your response.

WHAT WAS YOUR CERTIFICATION EXPERIENCE?

Better Than Expected	As Expected	Worse Than Expected

Click on the Annotation option on the left side of your screen and then use the Pencil Tool or checkmark to mark your response.

OVERVIEW

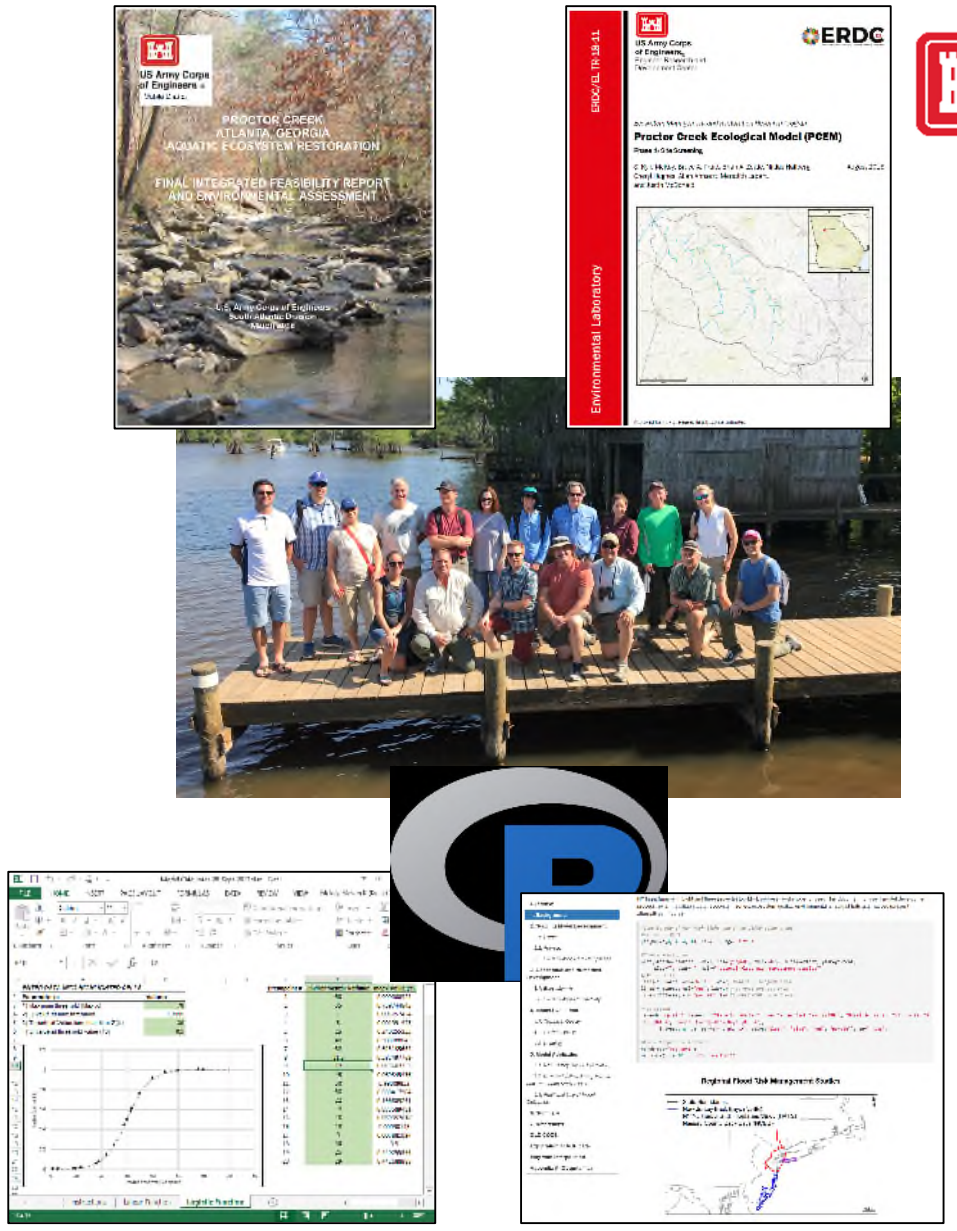
Ecological planning models

- Representation of a system for a purpose

Model Review and Certification

- Technical
- System
- Usability
- Policy

Good modeling practices, coordination, and review



ECOLOGICAL PLANNING MODELS

Engineer Circular 1105-2-412: Assuring Quality of Planning Models, 31 Mar 2011.

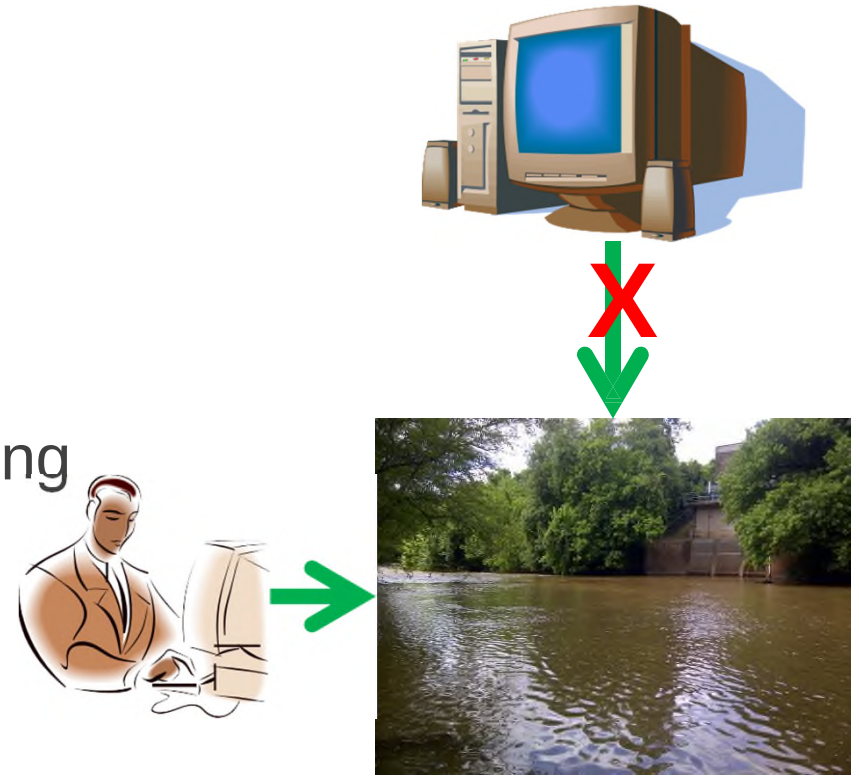
Planning Bulletin 2013-02: Assuring Quality of Planning Models (EC 1105-2-412), 31 March 2013.

WHAT IS AN ECOLOGICAL "MODEL"?

Academic definition: "abstractions of reality"

Model certification definitions (EC-1105-2-412):

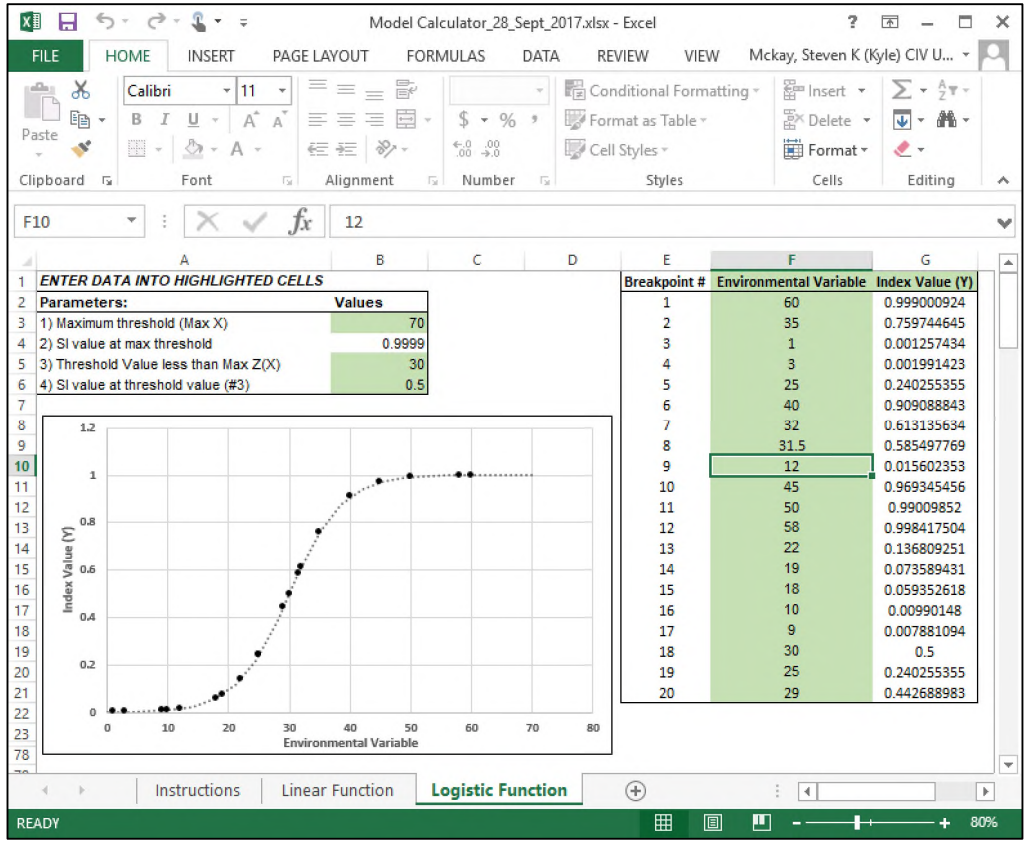
- "a representation of a system for a purpose"
- "a way to represent a system for the purposes of reproducing, simplifying, analyzing, or understanding it"



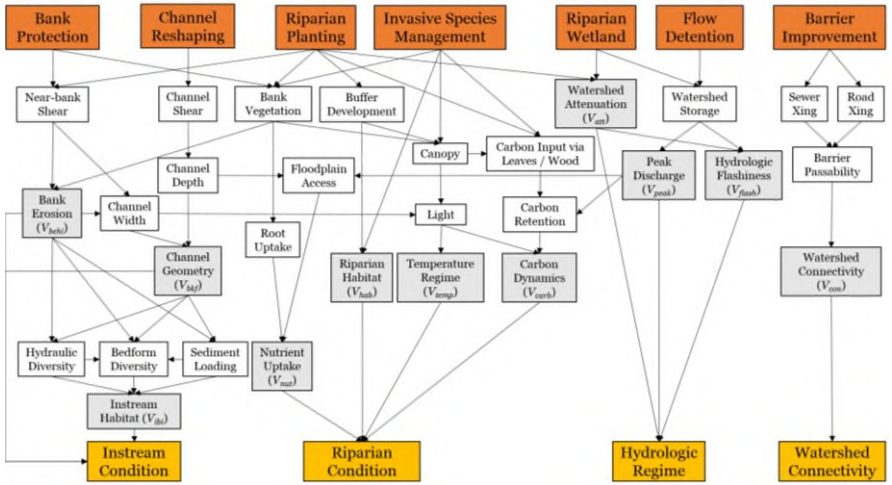
Planning Model:

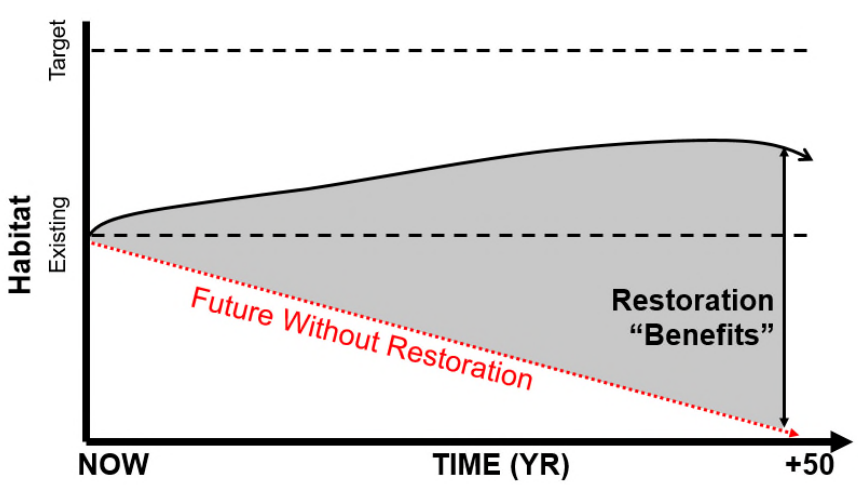
- "any models and analytical tools used to define water resources…"
- Not engineering models

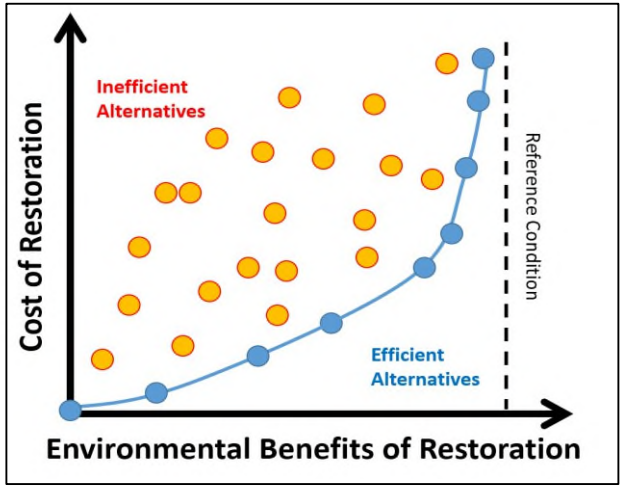
AN ECOLOGICAL MODEL IS USED TO REPRESENT A SYSTEM FOR A PURPOSE



WE USE MODELS TO UNDERSTAND COMPLEXITY, FORECAST SCENARIOS, AND INFORM DECISIONS.





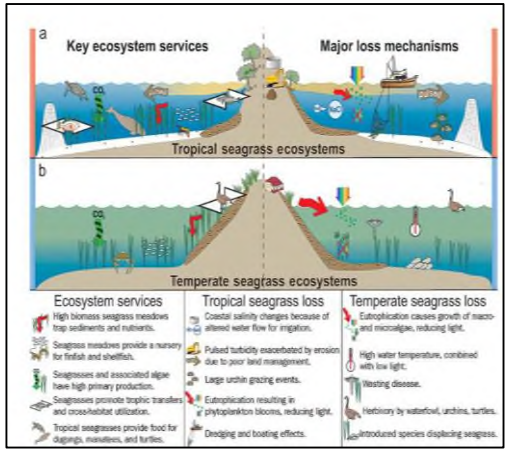


DIVERSE ECOLOGICAL MODELING TOOLS

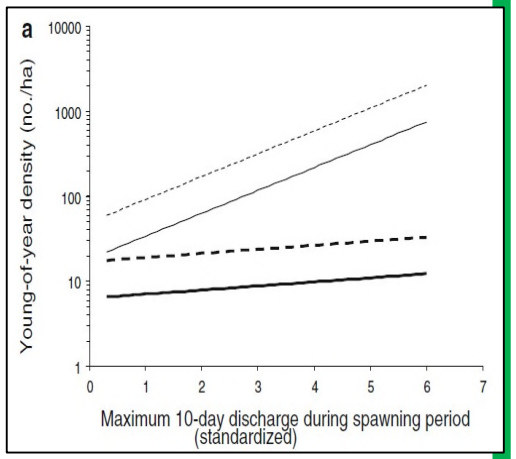
Approach

Outcome

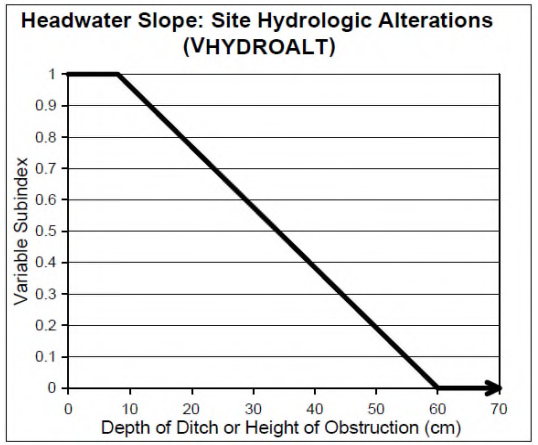
Conceptual



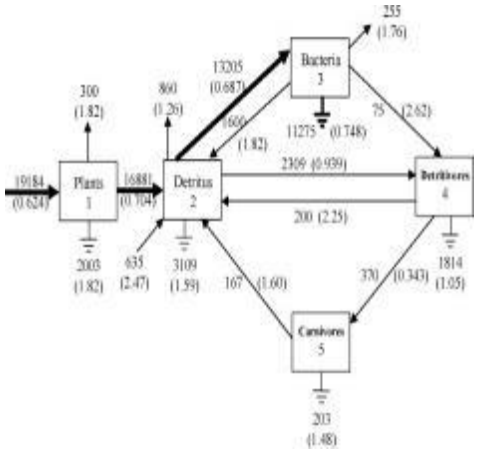
Statistical



Index-based



Mass Balance



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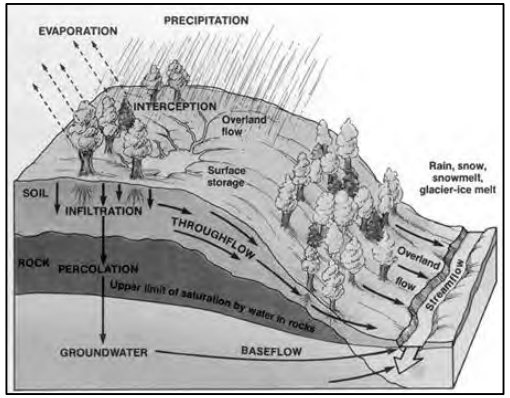
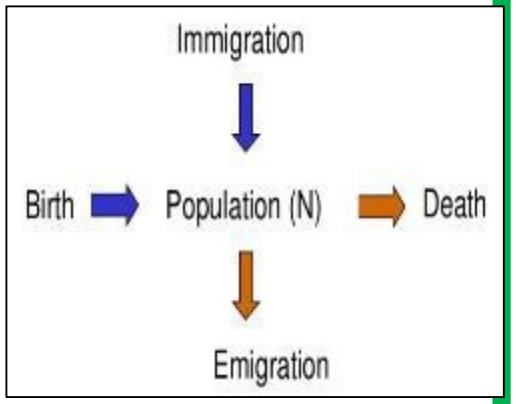
Physical

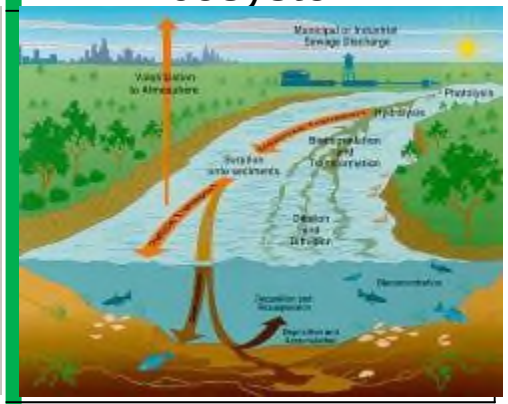


Population



Habitat

Ecosystem



...

MODEL'S CAN'T BE APPLIED UNTIL PROVEN "ACCURATE"

TRUE

FALSE

Click on the Annotation option on the left side of your screen and then use the Pencil Tool or checkmark to mark your response.

MODEL REVIEW AND CERTIFICATION

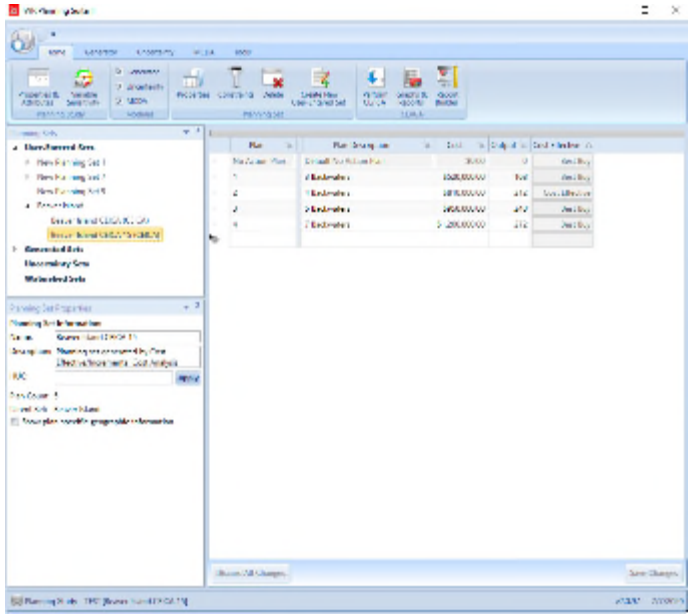
US Army Corps of Engineers. Assuring Quality of Planning Models - Model Certification/Approval Process: Standard Operating Procedures, Feb 2012.

Memorandum to Directors of National Planning Centers of Expertise – Subject: Modification of the Model Certification Process and Delegation of Model Approval for Use, 04 Dec 2017.

KEY TERMS

Certification

Models developed by the Corps.



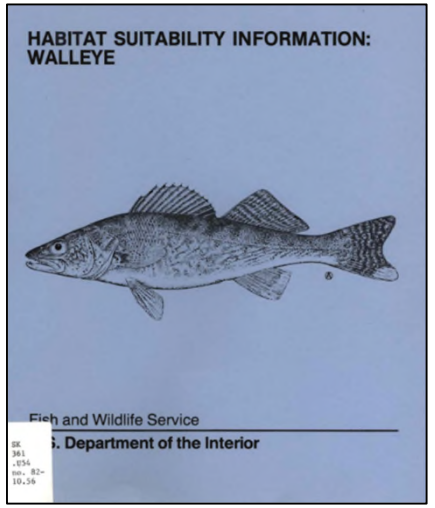
Approval

Models not developed by the Corps, or
Single-use or study specific models

Watershed-Scale Upstream Connectivity Toolkit (WUCT)

S. Kyle McKay

September 19, 2018



Scales:

Single-Use
Regional
National

USACE MODEL CERTIFICATION

Four key elements

- Technical quality
- System quality
- Usability
- Policy

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, D.C. 20314-1000

CECW-CP

EC 1105-2-412

Circular
No. 1105-2-412

31 March 2011

EXPIRES 31 March 2013

Planning

ASSURING QUALITY OF PLANNING MODELS

1. Purpose. This circular establishes the process and the requirements for assuring the quality of planning models.

2. Applicability. This circular applies to all USACE elements, Major Subordinate Commands (MSCs), and district commands having Civil Works responsibility. This guidance applies to planning models as defined in Paragraph 5 of this Circular.

3. References.

a. The Information Quality Act, Public Law No. 106-554.

b. Engineer Regulation 1105-2-100, Planning Guidance Notebook, April 2000.

c. Engineering and Construction Bulletin 2007-6: Model Certification Issues for Engineering Software in Planning Studies.

d. U.S. Army Corps of Engineers, Report of the Planning Models Improvement Task Force, September 2003.

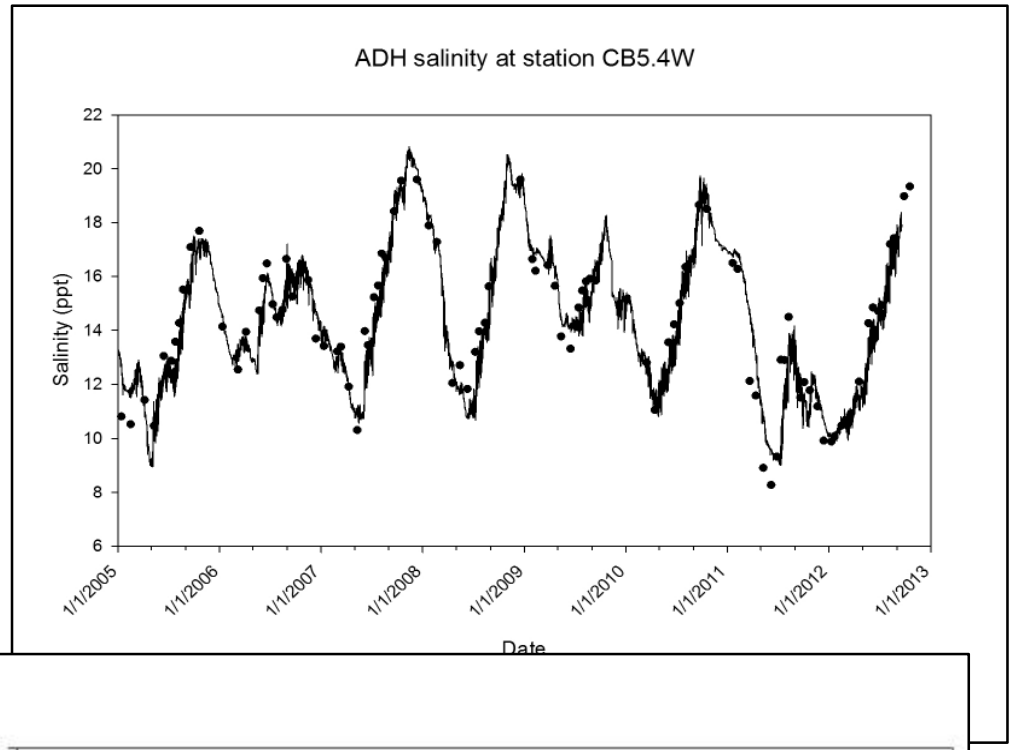
e. Office of Management and Budget, Final Information Quality Bulletin for Peer Review, Federal Register Vol. 70, No. 10, January 14, 2005, pp 2664-2677.

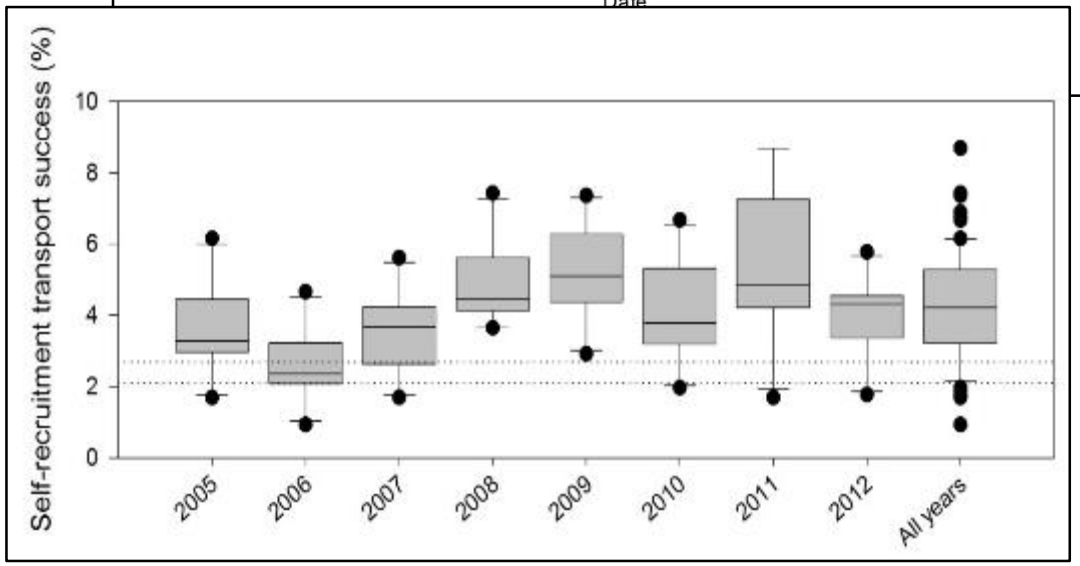
4. Background.

a. The Corps of Engineers Planning Models Improvement Program (PMIP) was established in 2003 to assess the state of planning models in the Corps and to make recommendations to assure that high quality methods and tools are available to enable informed decisions on investments in the Nation's water resources infrastructure and natural environment. The main objective of the PMIP is to carry out "a process to review, improve and validate analytical tools and models for U.S. Army Corps of Engineers (USACE) Civil Works business programs." In carrying out this initiative, a PMIP Task Force was established to examine planning model issues, assess the state of planning models in the Corps, and develop recommendations on improvements to planning models and related analytical tools. The PMIP Task Force collected the views of Corps leaders and recognized technical experts, and conducted investigations and

TECHNICAL QUALITY

- Structure
- Functional form
- Does the model correspond well to data from a real system?
- Sensitivity and uncertainty
- Documentation!!



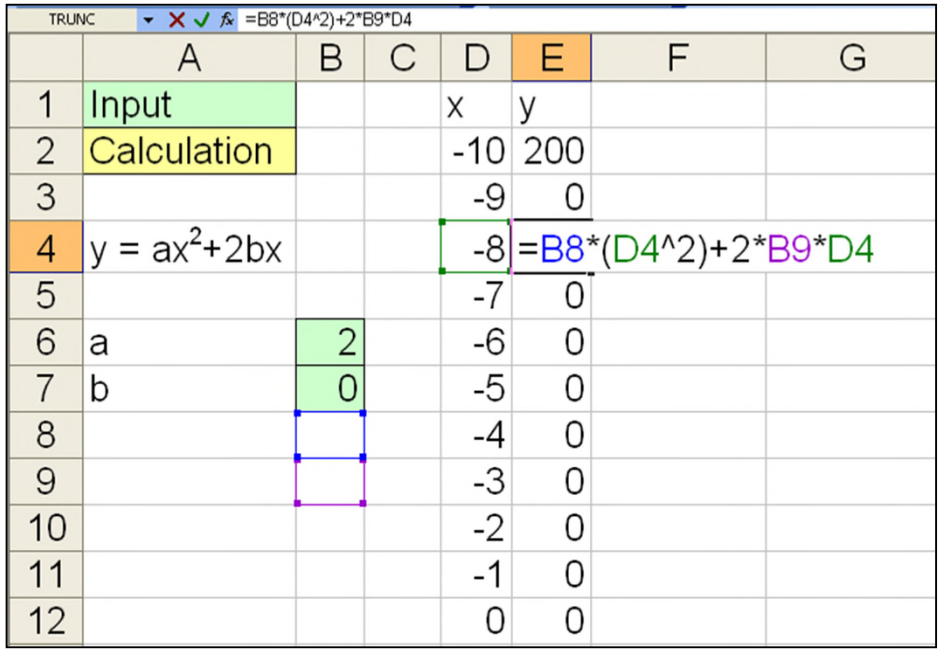


SYSTEM QUALITY

Quality Assurance:

Avoiding modeling errors

- Good modeling practices
- Interim code checking
- Math and logic checks



Quality Control:

Detecting errors via formal testing

- Test plans
- Can you break the model?

Table 1. Model test plan for a hypothetical habitat suitability model coded in R.

Component	Test	Expected Value	Outcome
SI_{cover}	Inputs for expected values (0, 25, 50, 75, 100)	0.0, 0.25, 0.50, 0.75, 1.0	Pass
SI_{cover}	Out of range inputs (-50, -1, 101, 150)	Error message	Pass
SI_{age}	Inputs for expected values (1,0)	1.0, 0.5	Pass
SI_{age}	Out of range inputs (5, -1)	Error message	Pass
SI_{age}	Incorrect format inputs (“Yes”, “No”)	Error message	Pass
HSI_{total}	Pairs of expected input values (SI_{cover}, SI_{age}): (1,1), (0,1), (1,0), (0.5,0.5), (1,0.5), (0,0.5), (0.01,1)	1, 0, 0, 0.5 0.71, 0, 0.01	Pass
HSI_{total}	Pairs of out of range inputs (SI_{cover}, SI_{age}): (-1,1), (1,-1), (1,2), (0,“Yes”), (1,“No”)	Error message	Pass

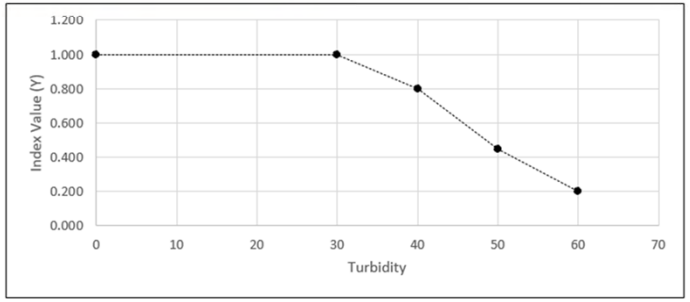
USABILITY

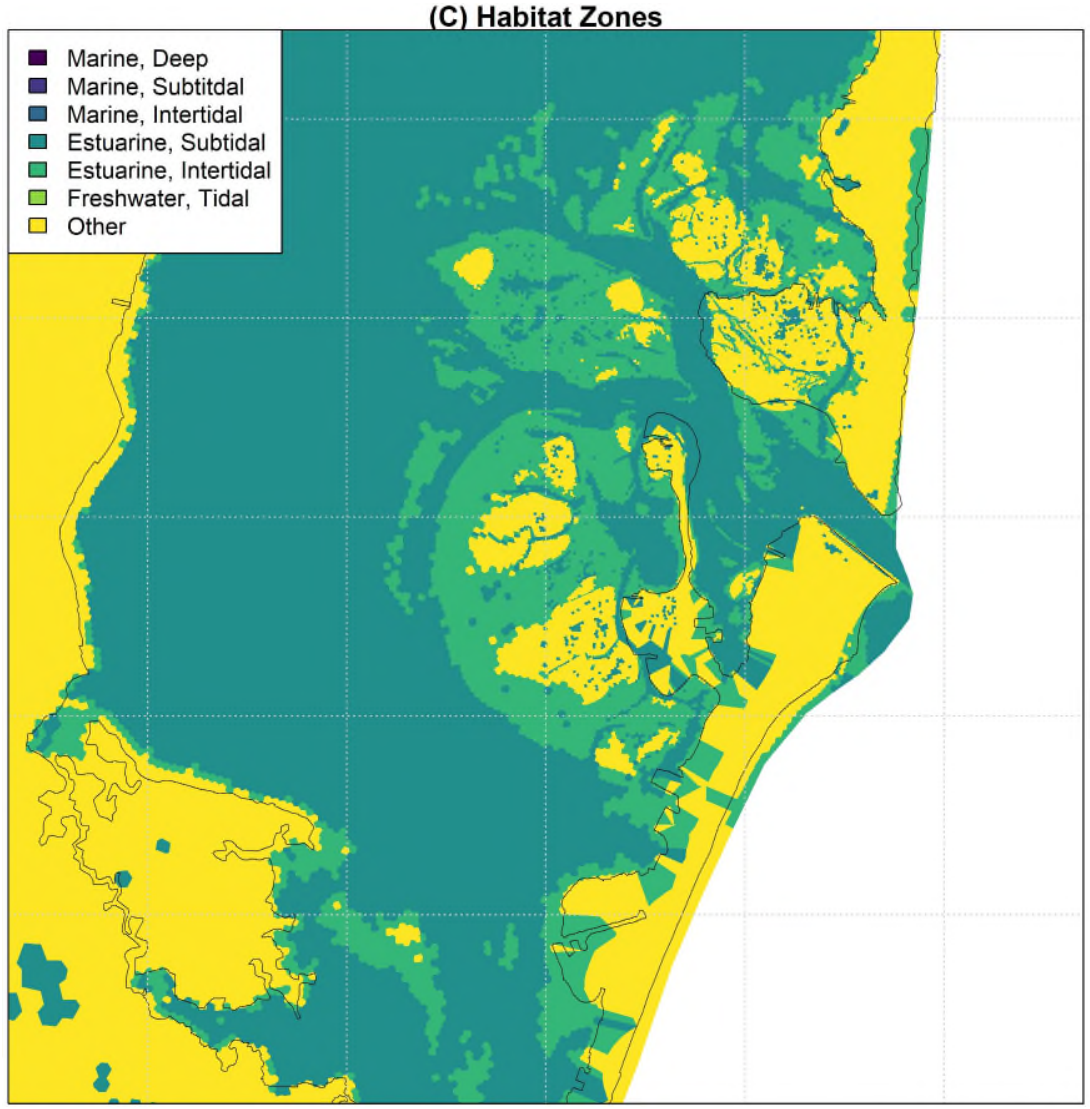
Not just a user interface

- User Guide
- Availability of input
- Training
- Repeatability
- Transparency

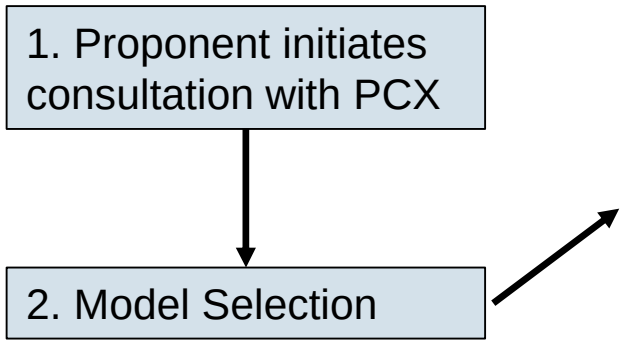
ENTER DATA INTO HIGHLIGHTED CELLS		
Breakpoint #	Turbidity	Index Value (Y)
1	0	1.000
2	30	1.000
3	40	0.800
4	50	0.450
5	60	0.2
6		
7		
8		
9		
10		

Values	Intercept	Slope	Equation
0 -30	1.00	0.0000	Y= 1 + (0 * Turbidity)
30 -40	1.60	-0.0200	Y= 1.6 + (-0.02 * Turbidity)
40 -50	2.20	-0.0350	Y= 2.2 + (-0.035 * Turbidity)
50 -60	1.70	-0.0250	Y= 1.7 + (-0.025 * Turbidity)
60 -	0.00	0.0033	Y= 0 + (0.0033 * Turbidity)
-			
-			
-			
-			
-			





WHAT IS THE PROCESS?



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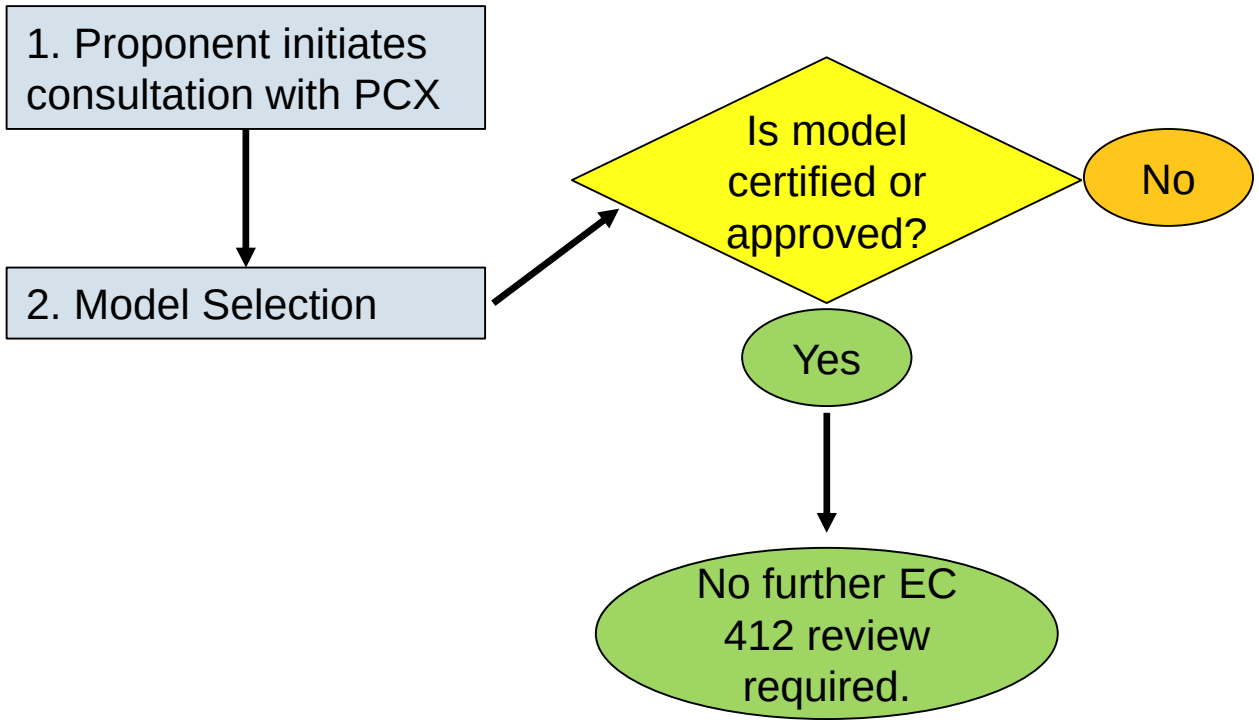
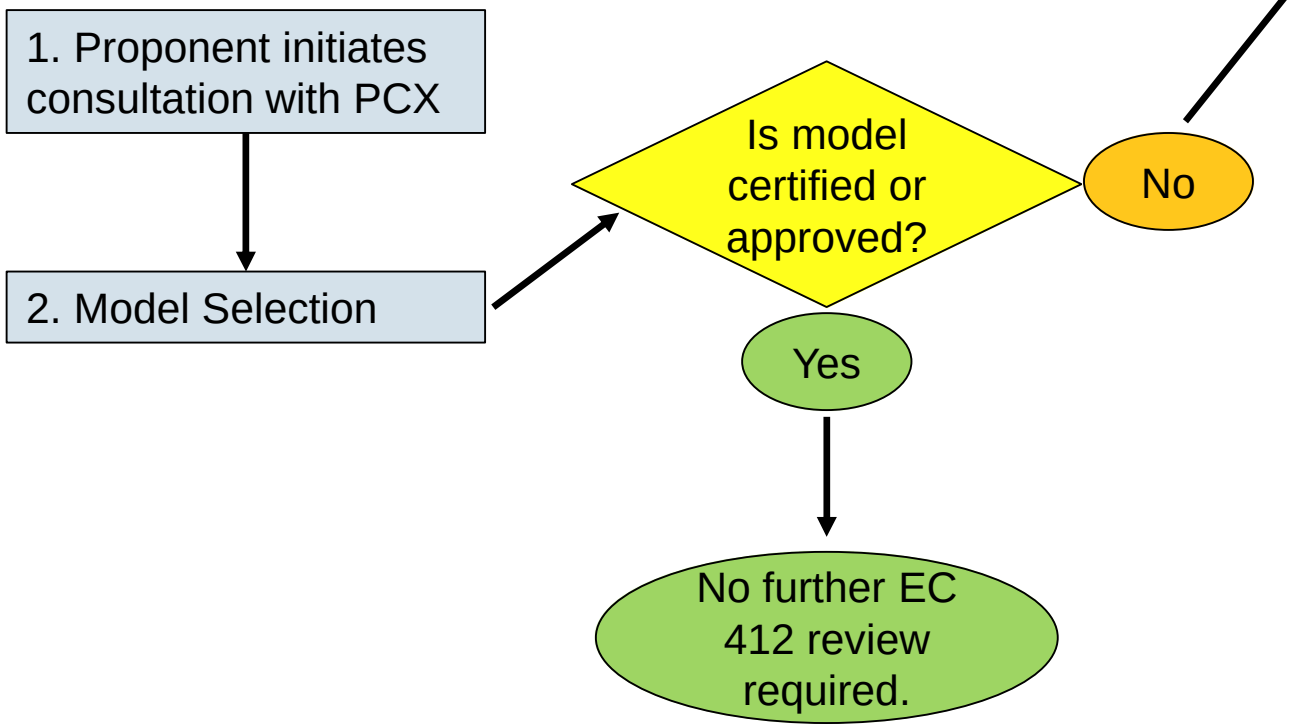


WHAT IS THE PROCESS?



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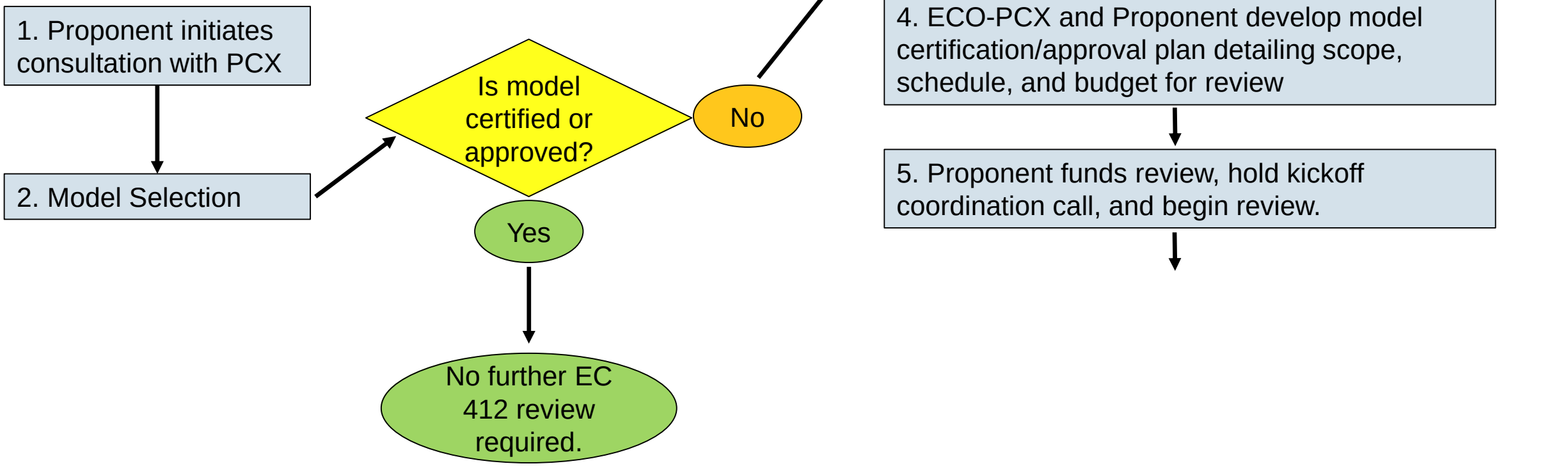

WHAT IS THE PROCESS?

1. Proponent initiates consultation with PCX

2. Model Selection

Is model certified or approved?

No

3. Proponent provides model documentation.

4. ECO-PCX and Proponent develop model certification/approval plan detailing scope, schedule, and budget for review

5. Proponent funds review, hold kickoff coordination call, and begin review.

6. Proponent addresses comments and revises model accordingly.

Yes

No further EC 412 review required.

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7. PCX prepares model recommendation package – memo, documentation, user guide, and application platform

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6. Proponent addresses comments and revises model accordingly.

7. PCX prepares model recommendation package – memo, documentation, user guide, and application platform

8. Operating Director submits to Technical Director for Certification/Approval

Final approval/certification memo sent to PDT. Model uploaded to ecological model library.

Yes

No further EC 412 review required.

*Ecological Model Library @ https://ecolibrary.planusace.us/#/home

MODEL REVIEW IS A BURDEN.

Generally agree

Generally disagree

Click on the Annotation option on the left side of your screen and then use the Pencil Tool or checkmark to mark your response.

URBAN LEGENDS

1. Model review and certification is expensive.

URBAN LEGENDS

1. Model review and certification is expensive.

The majority of the reviews we complete are $15-20k total.

URBAN LEGENDS

2. Model review takes a long time.

URBAN LEGENDS

2. Model review takes a long time.

Average duration is 4-7 months.

URBAN LEGENDS

3. Model certification pays little benefit.

URBAN LEGENDS

3. Model certification pays little benefit.

In 2018, review teams found 300+ technical, system, usability, or policy issues.

URBAN LEGENDS

4. Model development & certification can’t be accomplished within 3x3.

URBAN LEGENDS

4. Model development & certification can't be accomplished within 3x3.

Not true.

DOS AND DON'TS

Do coordinate with the ECO-PCX as early as possible. Think review plan.
Don't wait until your TSP to start model review.

Do consider the usefulness of unapproved models in your model selection.
Don't let the certification process constrain your planning.

Do have your mitigation planning models certified.
Don't think it is only for ecosystem restoration benefit models.

Did You Know?

The shortest time required for certification was about 3 weeks!

The ECO-PCX tracks an average of 7-10 models at any given time.

The IWR Ecological Model Library houses over 250 ecological models covering 48 states.

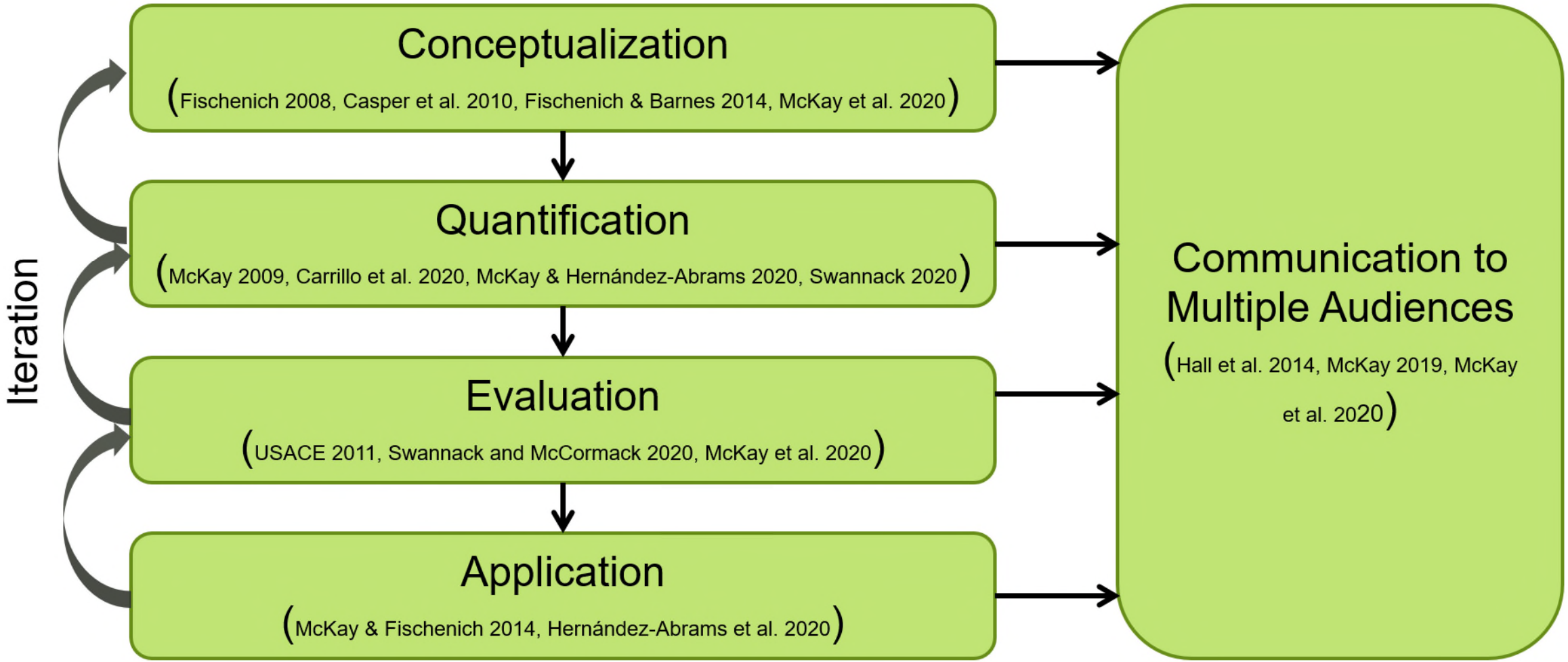
GOOD MODEL DEVELOPMENT AND REVIEW PRACTICES

Ecosystem Management and Restoration Research Program (EMRRP)
Kyle McKay – ERDC EL
Todd Swannack – ERDC EL

McKay S.K., Richards N., and Swannack T. 2019. Aligning ecological model development with restoration project planning. ERDC EMRRP-SR-89. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

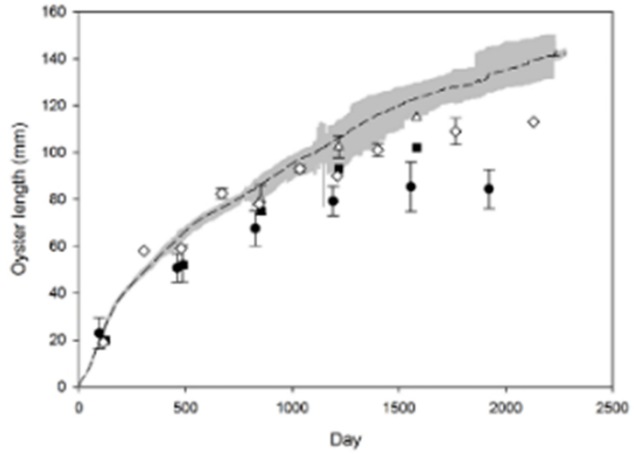
Ecological Model Development Process

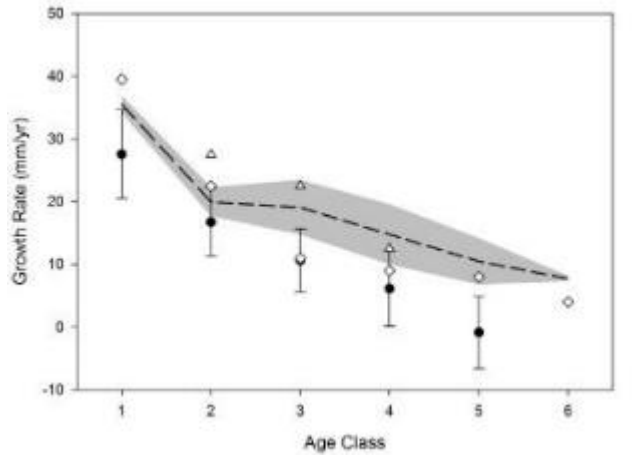
(Grant and Swannack 2008, Swannack et al. 2012, Herman et al. 2019, McKay et al. 2019)



EVALUATION AND DOCUMENTATION IS CRITICAL TO THE SUCCESS OF GETTING A MODEL CERTIFIED.

- Process of rigorously assessing model components
- Ensures scientific defensibility and transparency
  - What are its limits and weaknesses?
  - Is it re-creatable?
- Biggest issue is failure to document evaluation





COMPLETE MODEL DOCUMENTATION LEADS TO CERTIFICATION

Guidelines for Development of Good Model Documentation

- Background/Introduction Material
  - **General context**: What context does the reader need to know about (national effort, ecosystem on decline, industry developing, agency priority, etc.)?
  - **Problem statement**: What problem are you trying to solve? Why are you developing a model? Are there pertinent project details? Is there a target species, guild, or ecosystem? Are there broader project objectives the reader needs to know about?
  - **Model Purpose**: Objectives for developing the model: inform design? Screen alternatives Assess / forecast environmental benefits? Predict the future? Cumulative effects or single site? Objectives for accuracy (pattern v. relative comparison v. accurate prediction)?
  - **Model summary**: Insert brief description of the model (type, quant/qual, input-output structure, modeling platform).
  - **Intent of document**: This document is intended to provide documentation of the model's technical details, use, and relevant information for USACE model certification (EC 1105-2 412, PB 2013-02). Is this a user's guide?
- Model Development Process
  - **Process followed**: This sections addresses HOW the model was developed. Was a common process followed (e.g., conceptualization, quantification, evaluation, and application; Grant and Swannack 2008, Swannack et al. 2012, Starfield, others)? If not, wh steps were taken to develop models, minimize errors, minimize bias, or avoid problems? What quality assurance measure were taken? Workshop series, working groups on PDT, individual researcher, etc. Who was involved (USACE only, external, expertise)? Review model to date? Iterative development? Prior versions? Insert sentence about any constraints on model development (e.g., time, funding, data). Was the model developed

→

MODEL PURPOSE

Due to the lack of existing models, the District made the decision to develop a new model that would adequately represent the key MMR habitat variables adversely affected by river training structure construction. The Middle Mississippi River (MMR) Sturgeon Chub Model is intended to help quantify the effects of river training structure construction or modification on the quality of Sturgeon Chub (*Macrhybopsis gelida*) habitat. Similarly, it would be used to evaluate the effectiveness of potential mitigation actions to improve or restore this specific type of MMR MCB habitat. The model also could be used to evaluate other project actions that impact key variables in main channel border habitat of the MMR.

MODEL SUMMARY

The Sturgeon Chub Model consists of HSI curves for the habitat variables depth, velocity, substrate, and structured/unstructured habitat. These represent key variables in determining sturgeon chub habitat that also are most directly influenced by the construction or modification of river training structures. HSI curves are based on available literature and MMR, Lower Missouri River, and Lower Mississippi River Sturgeon Chub capture data presently available. Other datasets from the Missouri River Basin were used for comparison and confirmation of HSI curves. HSI curve equations

Photo from USFWS on-line source

Preliminary Model Testing

Initial testing of the model with river training structure construction/removal scenarios has been performed to verify effectiveness and limitations. The model generally performs as expected. With a limited number of variables and equal weighting, the model is responsive to predicted changes associated with placement or removal of river training structures.

Important Considerations: A critical consideration for use of this model is the river discharge at which the model is run for a given area. For example, within any given area of MCB habitat, river depth and velocity can change greatly based on river discharge. Those two variables constitute half of the model and dramatically affect the output. Areas that may provide high quality MCB habitat at high discharge may be completely dry and function as terrestrial habitat at low discharge. Model users will need to consider how to address differences in river stage and how to account for drastically different conditions. For example, model users may desire to run the model multiple times to understand how habitat quality changes for an area over a range of discharges. Alternatively, the model user may select a single flow level to model, using the output as a representation of habitat under certain conditions or assumptions. It will be up to the model user to identify the best approach to the situation, and understand and explain the assumptions and limitations.

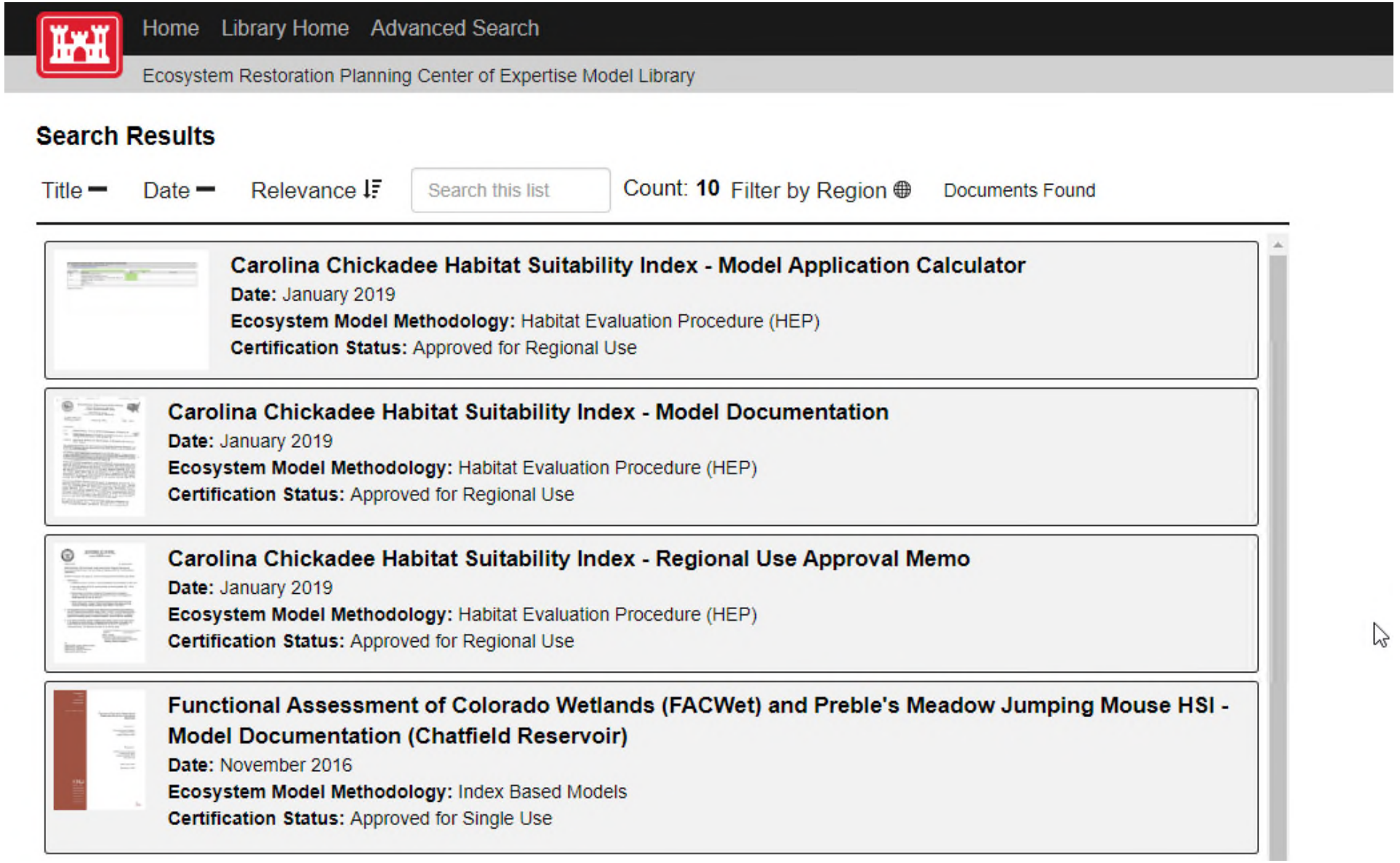
Another consideration is that substrate is temporal and can vary depending on the hydrograph and the flow for which samples are taken. Field data has shown that different substrates can be collected at different times from the same site. It is up to the model user to justify substrate selected and understand the assumptions and limitations.

Model Limitations: As identified above, the model is based off limited data for a relatively rare fish of the MMR. Much of the habitat relationships is based off trawling observations that have certain limitations in linking observations with known habitat conditions. However, the trawling data represents the best available information for describing sturgeon chub habitat, especially as it relates to the physical habitat variables of concern. Moreover, trawling observations were also compared to other available data to help improve reliability. In general, trawling observations were in-line with other observations from available literature.

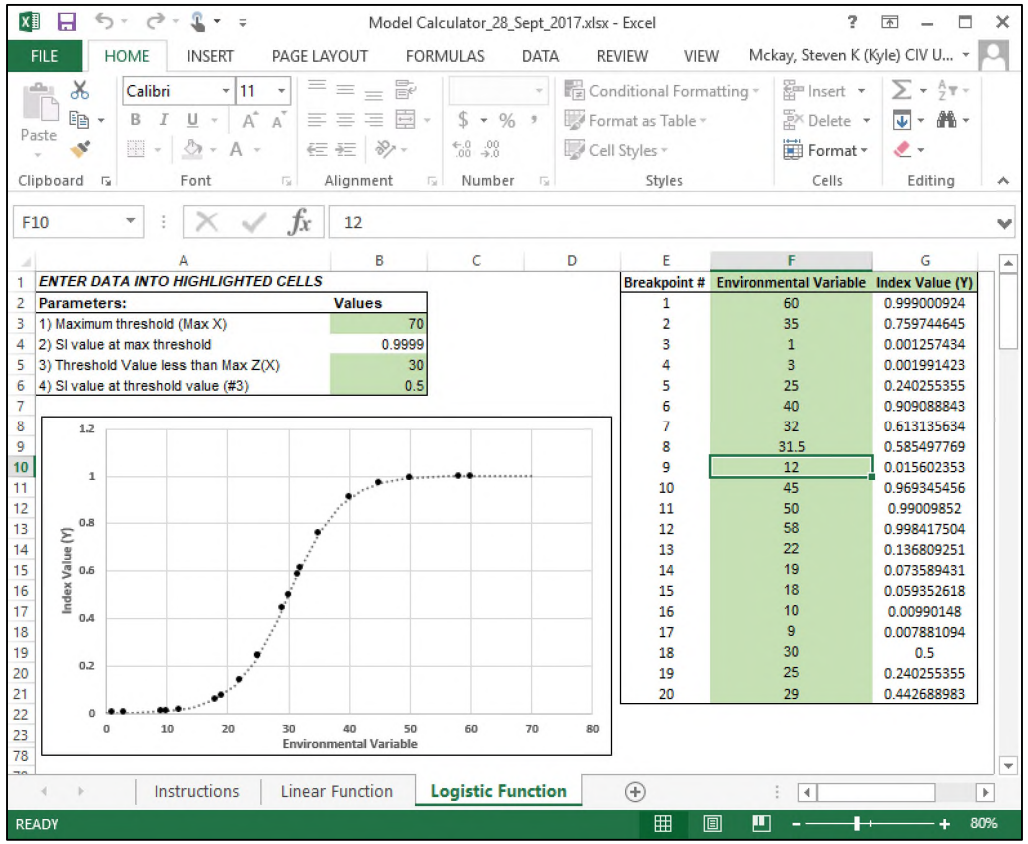
→

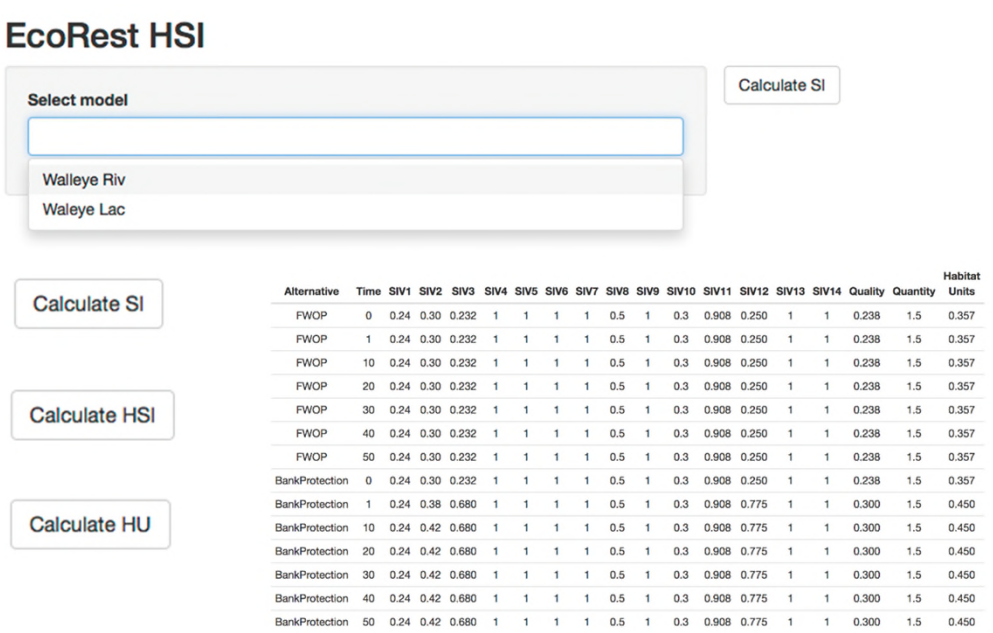
CERTIFICATION

NOTABLE PRODUCTS



MODELING PLATFORMS ARE IMPROVING THE WAY WE DEVELOP, DOCUMENT, AND APPLY MODELS IN A DEFENSIBLE MANNER.



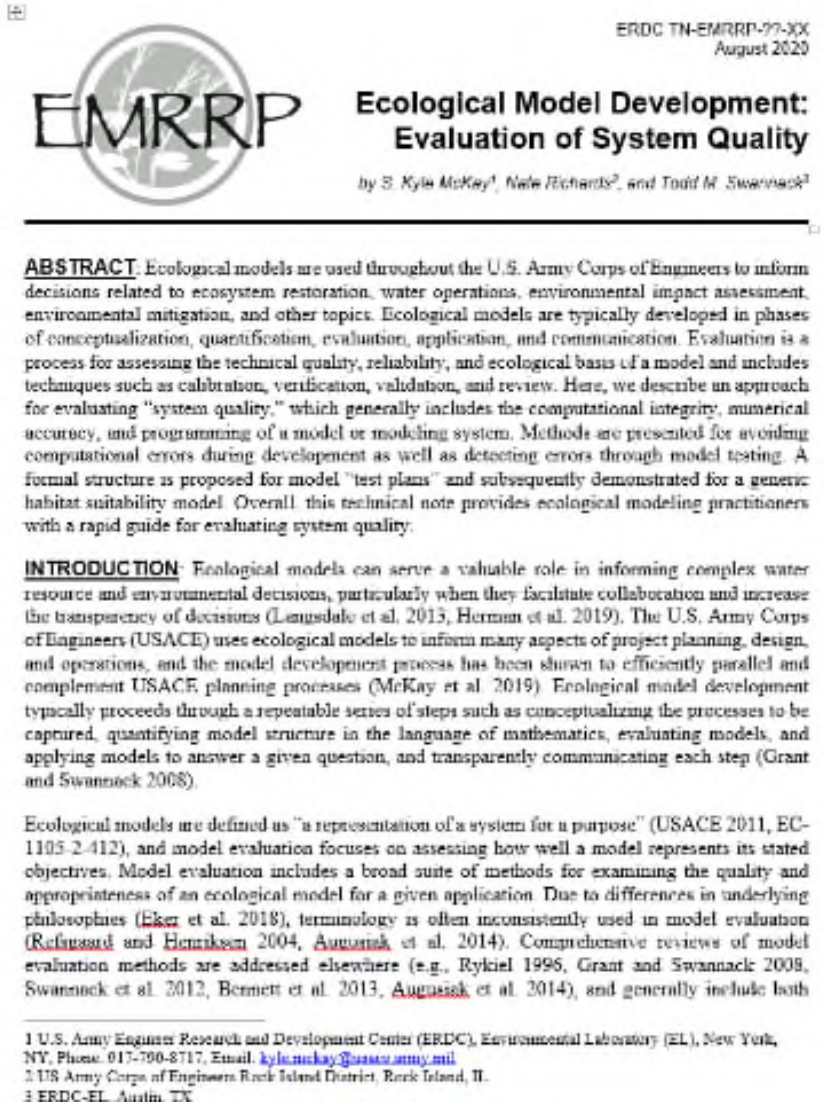


Alternative	Time	SIV1	SIV2	SIV3	SIV4	SIV5	SIV6	SIV7	SIV8	SIV9	SIV10	SIV11	SIV12	SIV13	SIV14	Quality	Quantity	Habitat Units
FWOP	0	0.24	0.30	0.232	1	1	1	1	0.5	1	0.3	0.908	0.250	1	1	0.238	1.5	0.357
FWOP	1	0.24	0.30	0.232	1	1	1	1	0.5	1	0.3	0.908	0.250	1	1	0.238	1.5	0.357
FWOP	10	0.24	0.30	0.232	1	1	1	1	0.5	1	0.3	0.908	0.250	1	1	0.238	1.5	0.357
FWOP	20	0.24	0.30	0.232	1	1	1	1	0.5	1	0.3	0.908	0.250	1	1	0.238	1.5	0.357
FWOP	30	0.24	0.30	0.232	1	1	1	1	0.5	1	0.3	0.908	0.250	1	1	0.238	1.5	0.357
FWOP	40	0.24	0.30	0.232	1	1	1	1	0.5	1	0.3	0.908	0.250	1	1	0.238	1.5	0.357
FWOP	50	0.24	0.30	0.232	1	1	1	1	0.5	1	0.3	0.908	0.250	1	1	0.238	1.5	0.357
BankProtection	0	0.24	0.30	0.232	1	1	1	1	0.5	1	0.3	0.908	0.250	1	1	0.238	1.5	0.357
BankProtection	1	0.24	0.38	0.680	1	1	1	1	0.5	1	0.3	0.908	0.775	1	1	0.300	1.5	0.450
BankProtection	10	0.24	0.42	0.680	1	1	1	1	0.5	1	0.3	0.908	0.775	1	1	0.300	1.5	0.450
BankProtection	20	0.24	0.42	0.680	1	1	1	1	0.5	1	0.3	0.908	0.775	1	1	0.300	1.5	0.450
BankProtection	30	0.24	0.42	0.680	1	1	1	1	0.5	1	0.3	0.908	0.775	1	1	0.300	1.5	0.450
BankProtection	40	0.24	0.42	0.680	1	1	1	1	0.5	1	0.3	0.908	0.775	1	1	0.300	1.5	0.450
BankProtection	50	0.24	0.42	0.680	1	1	1	1	0.5	1	0.3	0.908	0.775	1	1	0.300	1.5	0.450

Carrillo C.C., McKay S.K., and Swannack T. *Forthcoming*. Ecological model development: Toolkit for interActive Modeling (TAM). *ERDC TR-EMRRP*.

McKay S.K. and Hernández-Abrams D.D. *Forthcoming*. ecorest: An R Package for conducting analyses to inform restoration decision making. *R Vignette*.

SYSTEM QUALITY TEST PLANS IMPROVE THE WAY WE DEVELOP APPLICATION PLATFORMS AND COMPUTATIONAL INTEGRITY.



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EMRRP

Ecological Model Development: Evaluation of System Quality

by S. Kyle McKay[1], Nate Richards[2], and Todd M. Swannack[3]

ABSTRACT: Ecological models are used throughout the U.S. Army Corps of Engineers to inform decisions related to ecosystem restoration, water operations, environmental impact assessment, environmental mitigation, and other topics. Ecological models are typically developed in phases of conceptualization, quantification, evaluation, application, and communication. Evaluation is a process for assessing the technical quality, reliability, and ecological basis of a model and includes techniques such as calibration, verification, validation, and review. Here, we describe an approach for evaluating "system quality," which generally includes the computational integrity, numerical accuracy, and programming of a model or modeling system. Methods are presented for avoiding computational errors during development as well as detecting errors through model testing. A formal structure is proposed for model "test plans" and subsequently demonstrated for a generic habitat suitability model. Overall, this technical note provides ecological modeling practitioners with a rapid guide for evaluating system quality.

INTRODUCTION: Ecological models can serve a valuable role in informing complex water resource and environmental decisions, particularly when they facilitate collaboration and increase the transparency of decisions (Langsdale et al. 2013, Herman et al. 2019). The U.S. Army Corps of Engineers (USACE) uses ecological models to inform many aspects of project planning, design, and operations, and the model development process has been shown to efficiently parallel and complement USACE planning processes (McKay et al. 2019). Ecological model development typically proceeds through a repeatable series of steps such as conceptualizing the processes to be captured, quantifying model structure in the language of mathematics, evaluating models, and applying models to answer a given question, and transparently communicating each step (Grant and Swannack 2008).

Ecological models are defined as "a representation of a system for a purpose" (USACE 2011, EC-1105-2-412), and model evaluation focuses on assessing how well a model represents its stated objectives. Model evaluation includes a broad suite of methods for examining the quality and appropriateness of an ecological model for a given application. Due to differences in underlying philosophies (Eker et al. 2018), terminology is often inconsistently used in model evaluation (Refsgaard and Henriksen 2004, Augusiak et al. 2014). Comprehensive reviews of model evaluation methods are addressed elsewhere (e.g., Rykiel 1996, Grant and Swannack 2008, Swannack et al. 2012, Bennett et al. 2013, Augusiak et al. 2014), and generally include both

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Table 1. Model test plan for a hypothetical habitat suitability model coded in R.

Component	Test	Expected Value	Outcome
SI_{cover}	Inputs for expected values (0, 25, 50, 75, 100)	0.0, 0.25, 0.50, 0.75, 1.0	Pass
SI_{cover}	Out of range inputs (-50, -1, 101, 150)	Error message	Pass
SI_{age}	Inputs for expected values (1,0)	1.0, 0.5	Pass
SI_{age}	Out of range inputs (5, -1)	Error message	Pass
SI_{age}	Incorrect format inputs ("Yes", "No")	Error message	Pass
HSI_{total}	Pairs of expected input values (SI_{cover}, SI_{age}): (1,1), (0,1), (1,0), (0.5,0.5), (1,0.5), (0,0.5), (0.01,1)	 1, 0, 0, 0.5 0.71, 0, 0.01	Pass
HSI_{total}	Pairs of out of range inputs (SI_{cover}, SI_{age}): (-1,1), (1,-1), (1,2), (0,"Yes"), (1,"No")	 Error message	Pass

COMMON QUESTIONS & COMMENTS

1. I’m not using a model.

COMMON QUESTIONS & COMMENTS

1. I’m not using a model.

Yes, it most likely is a model by definition.

COMMON QUESTIONS & COMMENTS

2. Does my model need reviewed?

COMMON QUESTIONS & COMMENTS

2. Does my model need reviewed?

Yes, everything we do gets reviewed.

COMMON QUESTIONS & COMMENTS

3. When is model certification or approval required?

COMMON QUESTIONS & COMMENTS

3. When is model certification or approval required?

Model certification or approval is, by definition, required prior to using the model.

TAKE-HOME POINTS