A WEB APPLICATION FOR RIPARIAN MODELS (WARM)

Samantha Wiest, Colton Shaw, and Kyle McKay
Environmental Laboratory

EMRRP Webinar Series
January 2024

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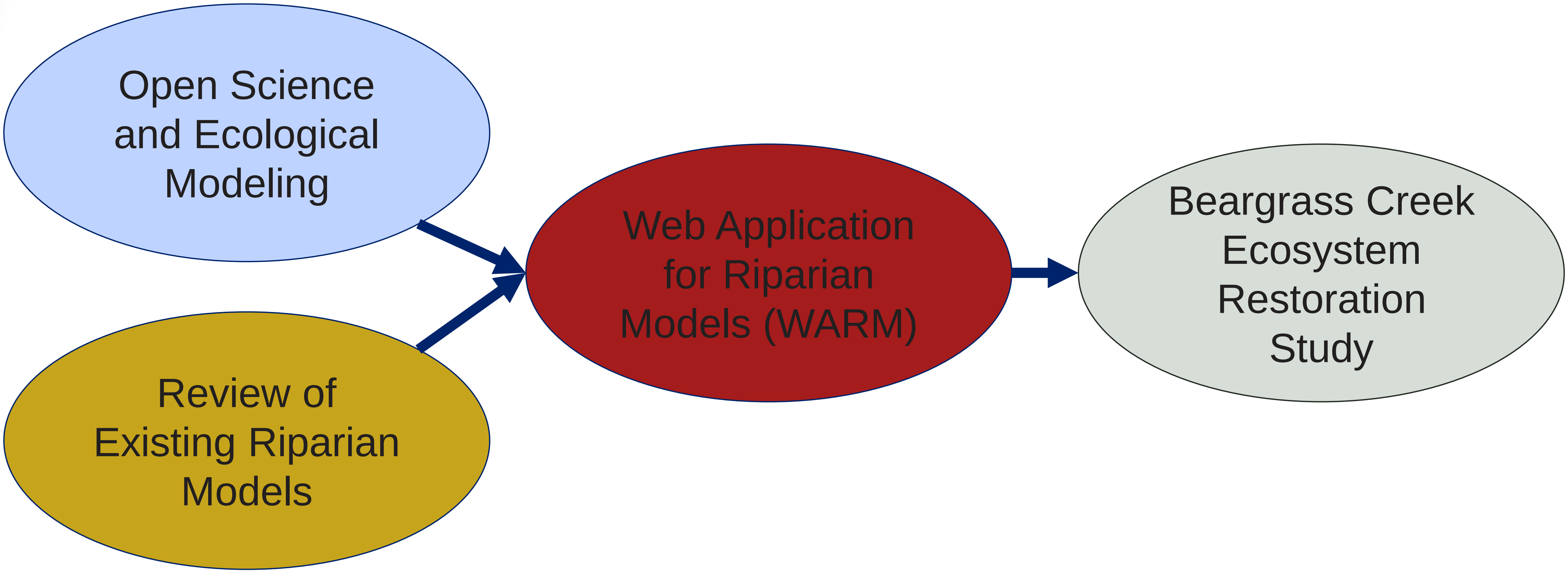
PRESENTATION OVERVIEW



OPEN SCIENCE AND ECOLOGICAL MODELS

Shaw and McKay. *In review*. A guide to applying open science methods in ecological modeling. EMRRP Technical Note Series.

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TRANSPARENCY AS A MEANS TO SCIENTIFIC INTEGRITY

- Decades of work on maintaining the highest levels of scientific integrity in federal projects with a few broad themes emerging

- The use of science in federal decisions
  - e.g., science at the policy table, the role of dissent,…

- The behavior of scientists
  - e.g., cultures of integrity, accountability, peer review,…

- **The execution of scientific methods**
  - **e.g., transparency, replicability, accessibility,…**

Holdren (2010): https://obamawhitehouse.archives.gov/administration/eop/ostp/library/scientificintegrity
Task Force (2021): https://www.whitehouse.gov/ostp/ostps-teams/nstc/scientific-integrity-task-force/

WHAT IS “OPEN WORK”?

Open Work is a philosophical framing characterized by three key features:

- **Open License**: freedom to use, build on, modify, and share
- **Open Access**: reducing barriers of cost, availability, language,…
- **Open Format**: overcoming issues related to proprietary methods, data archival, machine-readability,…

Open Knowledge and the Open Definition Advisory Council: https://opendefinition.org/od/2.1/en/
Figure: https://cega.berkeley.edu/research/promoting-transparency-in-social-science-research/

A SPECTRUM OF OPEN SCIENCE PRACTICES

Hypothetical Scenario	License	Access	Format
USACE restoration study developing models with stakeholders	**High**. Open for anyone to use or adapt.	**High**. Models shared through GitHub and reports available on public website.	**High**. Input and output posted publicly in machine readable formats.
Long-term ecological monitoring at a series of major restoration sites.	**Moderate**. Data repository contains paywall restrictions.	**Moderate**. Models & reports are available for download on a less publicized site.	**High**. Metadata and data are machine readable and well curated.
USACE navigation study assessing actions at a sensitive port facility	**None**. Sensitive information requires following agency procedures and/or proprietary software.	**Low**. Model details are only available in controlled formats and locations.	**High**. Machine readable formats and well-documented code.

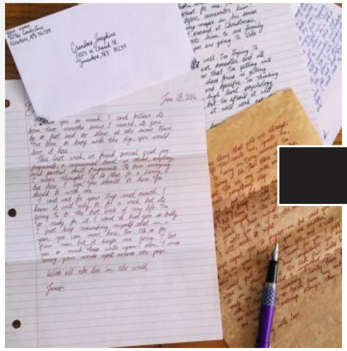
Table adapted from Shaw and McKay (*in review*)

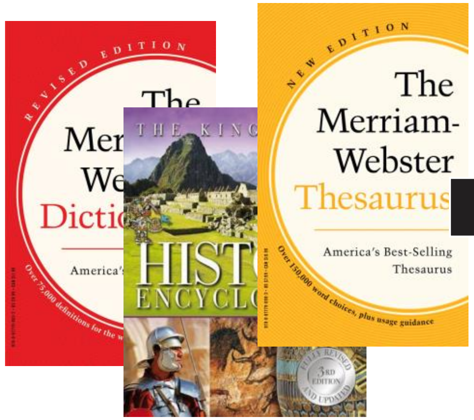
OPEN SCIENCE AND ECOLOGICAL MODELING

Modeling Phase	Entry Points for Open Science
Conceptualization	• Input from diverse technical professionals guides conceptual models • Development of multiple conceptual models to guide competing models • **Transparent documentation of a conceptual model**
Quantification	• **Maximize accessibility in selecting software or programming language** • Integrated download of input data with the model • Free repository access • Version controlled systems allowing for collaboration
Evaluation	• Clear, identifiable methods available through documentation • **Well commented code to guide users through model mechanics** • Transparent model testing procedures
Application	• Data sharing of input and output • **Data storage in transferrable formats with appropriate archival** • Clear identification of model versioning and/or application history
Communication	• Easily identifiable contact information • **Post-processing of outcomes for synthesis by other audiences** • Carefully crafted data visualization

Table from Shaw and McKay (*in review*)

WHAT IS A WEB APPLICATION (WEB APP), AND WHY IS IT A USEFUL TOOL?





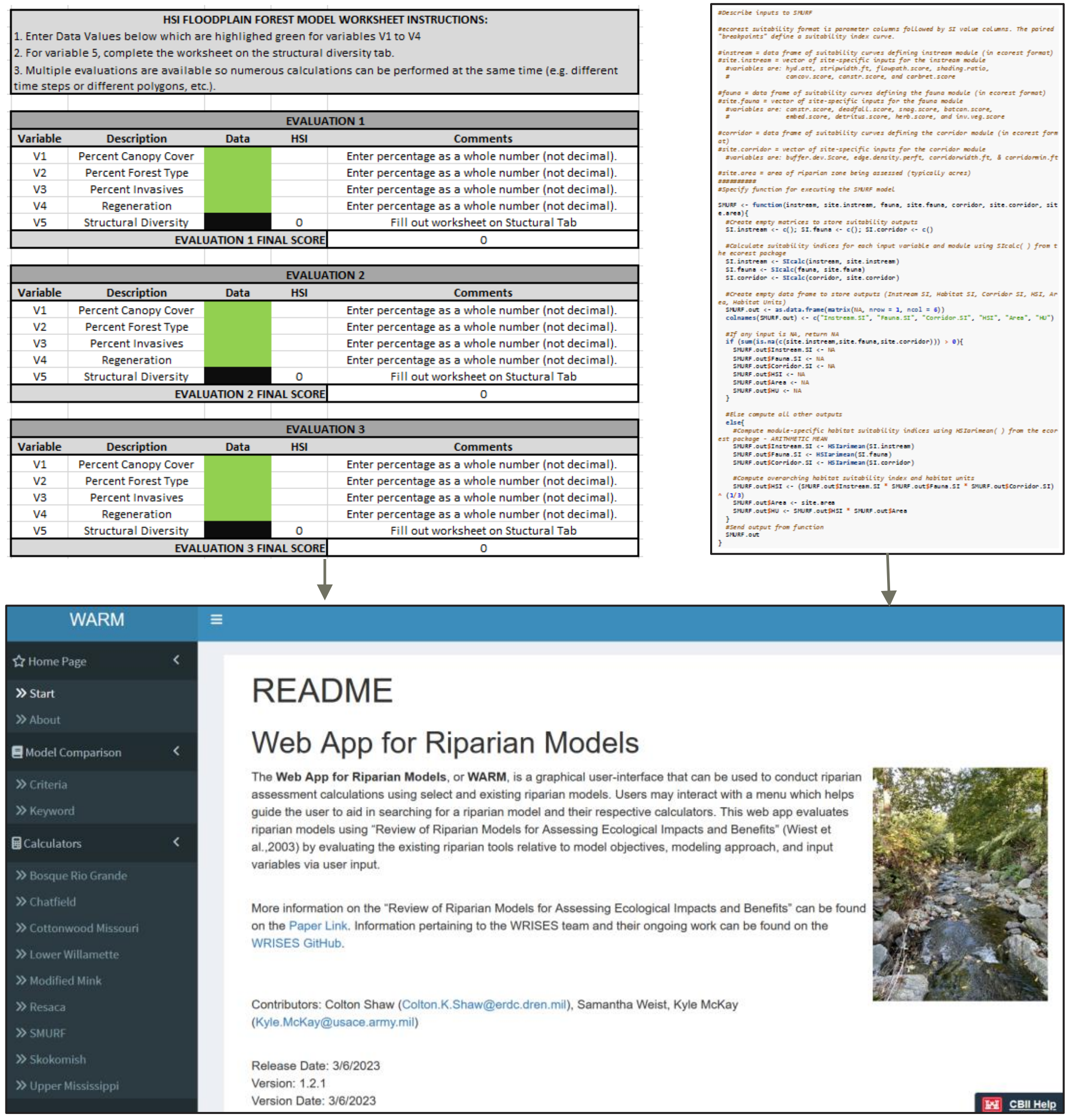
Benefits of web applications:

- Multiple users can access the same model version (which can be updated by developers).
- Users don’t need to install software, just a web browser.
- Users can access the app through various platforms such as a desktop or mobile device.

PROJECT GOALS

- The project seeks to apply the principles of Open Science in development of a suite of (USACE certified) riparian modeling tools.

- These tools seek to:
  - Increase accessibility of existing riparian models
  - Reduce technical barriers to entry (i.e., no coding expertise required)
  - Use Open Work tools to version control models and share source code
  - Provide a platform for future riparian models to be shared



REVIEW OF EXISTING RIPARIAN MODELS

Wiest S., Hernandez-Abrams D.D., and McKay S.K. 2023. Review of riparian models for assessing ecological impacts and benefits. ERDC/TN EMRRP-ER-26. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

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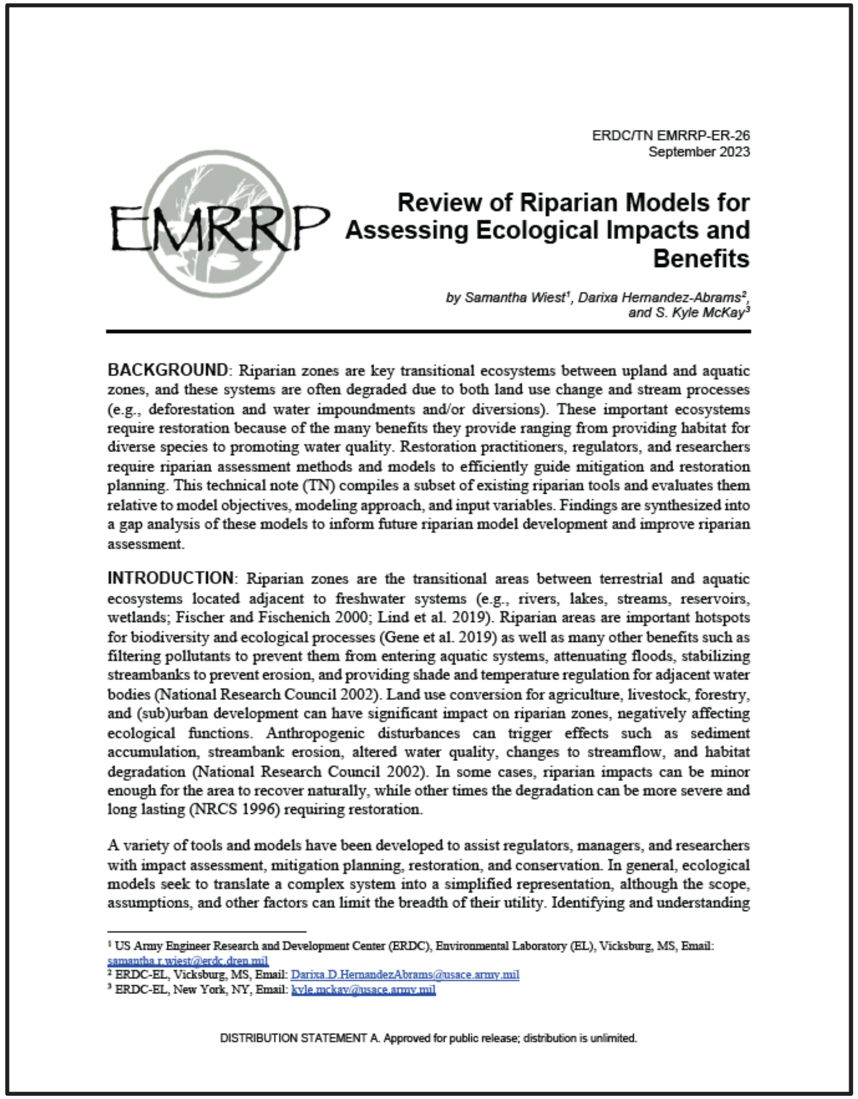
STRUCTURAL REVIEW OF RIPARIAN MODELS

Assessment Objectives

- Review existing riparian models commonly applied within USACE
- Examine the use of these models in management and restoration contexts
- Identify gaps in existing models



ERDC/TN EMRRP-ER-26
September 2023

EMRRP

Review of Riparian Models for Assessing Ecological Impacts and Benefits

by Samantha Wiest[1], Darixa Hernandez-Abrams[2], and S. Kyle McKay[3]

BACKGROUND: Riparian zones are key transitional ecosystems between upland and aquatic zones, and these systems are often degraded due to both land use change and stream processes (e.g., deforestation and water impoundments and/or diversions). These important ecosystems require restoration because of the many benefits they provide ranging from providing habitat for diverse species to promoting water quality. Restoration practitioners, regulators, and researchers require riparian assessment methods and models to efficiently guide mitigation and restoration planning. This technical note (TN) compiles a subset of existing riparian tools and evaluates them relative to model objectives, modeling approach, and input variables. Findings are synthesized into a gap analysis of these models to inform future riparian model development and improve riparian assessment.

INTRODUCTION: Riparian zones are the transitional areas between terrestrial and aquatic ecosystems located adjacent to freshwater systems (e.g., rivers, lakes, streams, reservoirs, wetlands; Fischer and Fischenich 2000; Lind et al. 2019). Riparian areas are important hotspots for biodiversity and ecological processes (Gene et al. 2019) as well as many other benefits such as filtering pollutants to prevent them from entering aquatic systems, attenuating floods, stabilizing streambanks to prevent erosion, and providing shade and temperature regulation for adjacent water bodies (National Research Council 2002). Land use conversion for agriculture, livestock, forestry, and (sub)urban development can have significant impact on riparian zones, negatively affecting ecological functions. Anthropogenic disturbances can trigger effects such as sediment accumulation, streambank erosion, altered water quality, changes to streamflow, and habitat degradation (National Research Council 2002). In some cases, riparian impacts can be minor enough for the area to recover naturally, while other times the degradation can be more severe and long lasting (NRCS 1996) requiring restoration.

A variety of tools and models have been developed to assist regulators, managers, and researchers with impact assessment, mitigation planning, restoration, and conservation. In general, ecological models seek to translate a complex system into a simplified representation, although the scope, assumptions, and other factors can limit the breadth of their utility. Identifying and understanding

[1] US Army Engineer Research and Development Center (ERDC), Environmental Laboratory (EL), Vicksburg, MS, Email: samantha.r.wiest@erdc.dren.mil
[2] ERDC-EL, Vicksburg, MS, Email: Darixa.D.HernandezAbrams@usace.army.mil
[3] ERDC-EL, New York, NY, Email: kyle.mckay@usace.army.mil

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RIPARIAN MODEL REVIEW PROCESS

Model Compilation Methods

- USACE ecosystem restoration model library
- Requests for models through USACE District practitioners and the (ECO-PCX)
- Tools developed by other government organizations (e.g., USDA, USFS)
- Peer-reviewed literature via Google Scholar

Screening Criteria

1. Riverine riparian models
2. Multiple hydrologic, ecological, and/or environmental components of riparian zones
3. Inform riparian conservation, rehabilitation, or other management applications

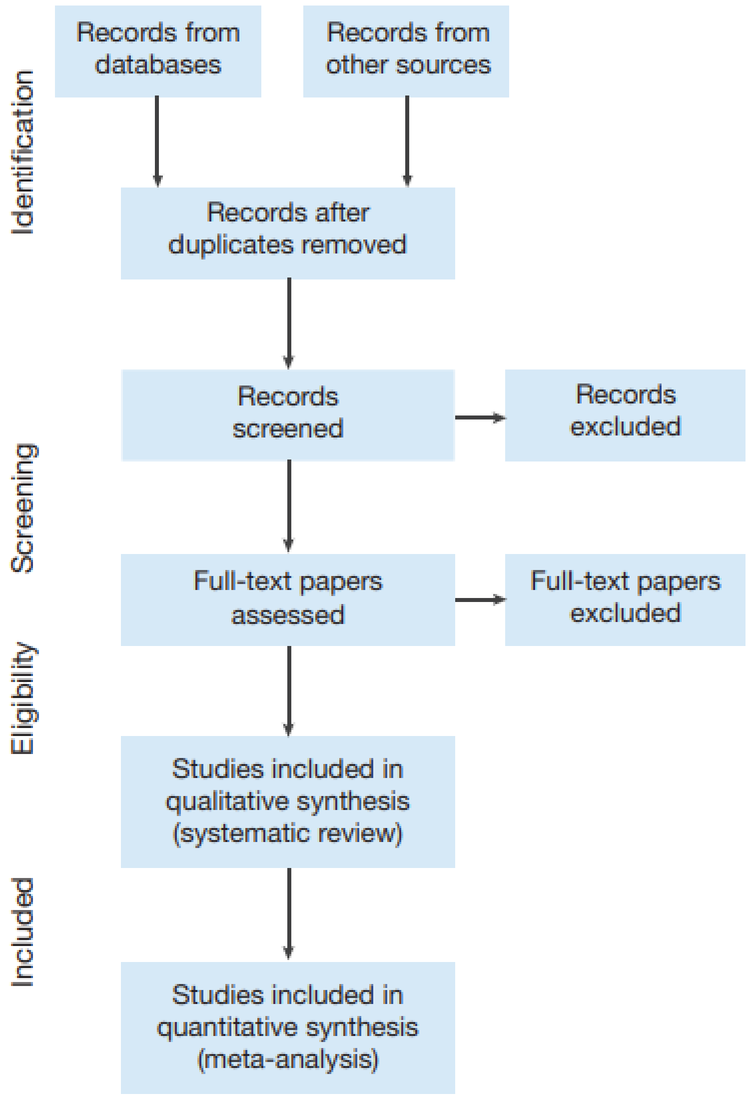

Figure: Gurevitch et al. 2018

DATA COLLECTION AND ANALYSIS

Qualitative Data Collected:

1. Ecological Processes
   - Ecological functions of instream processes
     - Physical characteristics
     - Stream condition
     - Hydrologic processes
     - Adjacent land use
     - Climate and weather
   - Ecological functions of riparian processes
     - Bank characteristics
     - Habitat connectivity
     - Stream habitat
     - Canopy/ground cover
     - Native/invasive species
     - Vegetation composition
     - Species richness
     - Riparian functions
     - Floodplain functions
     - Landscape connectivity
     - Buffer functionality

	Instream Processes					Riparian Zones Processes											
Existing Riparian Modeling Tools	Physical Characteristics	Stream Condition	Stream Hydrologic Processes	Adjacent Land Use	Climate and Weather	Bank Characteristics	Habitat Connectivity	Stream Habitat	Canopy/Groud Cover	Native/Invasive species	Vegetation Composition	Species Richness	Riparian Functions	Floodplain Functions	Landscape Connectivity	Buffer Functionality	Region of Application
1. Resaca Reference Condition Model	1	1				1		1	2	1	1	1					Southwest
2. Upper Mississippi River System									1	1	3						Southeast
3. Modified Riverine HSI Model for Mink		1						1	3		1						Varying
4. Simple Model for Urban Riparian Function	1	1	2				3								2	1	Northeast
5. Community-Based Ecosystem Response Model for the Cottonwood Riparian Forests of Missouri River	2			1					2	1	2	1		1	3		West/Midwest/ Southeast
6. Middle Rio Grande Bosque Riparian Community Index Model	1			1	3	1			5	1				3	3		Southwest
7. Ecological Functions Approach at Chatfield Reservoir	2	1	4				2				1					1	Varying
8. Lower Willamette River Ecosystem Restoration Project Model									8		3						Northwest
9. Skokomish River Ecosystem Restoration Project Environmental Benefits Analysis			1					2	1				1	1			Northwest
10. The Riparian Ecosystem Management Model		2		2	1						1					1	Varying
11. Riparian Aquatic Interaction Simulator											1		1				Northwest
12. Wetland and Riparian Forests in Ouachita Mountains and Crowley's Ridge Regions of Arkansas	3		2				1	1	3		6		2	1		2	South Central
13. Wetland Functions of Riverine Floodplains in the Northern Rocky Mountains	1			1			1		4	1	1		1	2	1		Southwest
14. High-Gradient Headwater Streams and Low-Gradient Perennial Streams in Appalachia	2			1		3			3	1	1	4	1				Southeast/Mid-Atlantic

DATA COLLECTION AND ANALYSIS

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Qualitative Data Collected:

2. Scoping Issues
   - Model type (Swannack et al. 2012)
     - Analytical
     - Conceptual
     - Index
     - Simulation
     - Statistical
     - Spatial
   - Geographic scope
   - Degree of mode review
     - Peer-reviewed, published, USACE certified
   - Numerical Structure
     - (e.g., spreadsheet calculator, coding language, database format, metamodel, executable software)

Table 3. Gap analysis of riparian modeling tools.

Model	Model Type	Geographic Scope	Degree of model review	Numerical Structure
1. Resaca Reference Condition Model	Conceptual Index	Cameron County, TX. Resacas with three vegetation types (Table 1).	USACE certification	Spreadsheet calculator
2. Upper Mississippi River System	Conceptual Index	Wetland forest system dominated by hardwoods in eastern US. Upland forest systems.	Informal review via model development workshop	Spreadsheet calculator
3. Riverine HSI Model for Mink	Index	Inland wetland habitats of North America. Stream/riverine corridors (modified model).	USACE certification	Spreadsheet calculator
4. Simple Model for Urban Riparian Function	Conceptual Index	Urban areas with emphasis on Midwestern streams. Riparian zones to maximum width of 100m.	USACE certification (regional)	Function in the R statistical language
5. Community Model for Cottonwood Riparian Forests of Missouri River	Conceptual Index Analytical Spatial	Cottonwood-forested communities along the Missouri River.	Informal review via development; panel review; USACE certification	Access database format and spreadsheet file
6. Middle Rio Grande Bosque Riparian Community Index	Conceptual Index Analytical Spatial	Riparian habitat between levees along Middle Rio Grande, NM. Arid riparian forests, wetlands, or bosques.	USACE certification (one-time use)	Access database format and spreadsheet file
7. Chatfield Ecological Functions Approach	Conceptual Index Spatial	Great plains riparian vegetation with adjacent undisturbed grassland communities. Ephemeral streams, in-stream ponds, and canals / ditches.	Adapted from prior models	Spreadsheet calculator
8. Lower Willamette River Ecosystem Restoration Project	Index	Aquatic, riparian, & floodplain habitats in the Lower Willamette River between Columbia River and Willamette Falls and Columbia Slough and Tyron Creek.	USACE certification (one-time use)	Spreadsheet calculator
9. Skokomish River Environmental Benefits Analysis	Conceptual Index Spatial	Skokomish river basin. Pacific Northwest native river valley communities.	Adapted from prior models; USACE certification (one-time use)	Spreadsheet calculator
10. The Riparian Ecosystem Management Model	Conceptual Analytical	Built with data from mature riparian forest in south GA but applicable to various sites. Tested on buffer zones averaging 65m width.	Developed cooperatively by multiple agencies	C++ language
11. Riparian Aquatic Interaction Simulator	Conceptual Analytical	Pacific Northwest streams. Riparian stands of Douglas-fir, hemlock, alder, & big leaf maple. Bank full widths from 5 to 25m and gradients less than 6%.	Formally reviewed by universities, government, and industry	Metamodel that uses ORGANON forest simulator
12. HGM for Central Arkansas	Conceptual Spatial	Ouachita Mountains and Crowley's Ridge Regions of Arkansas. Common types of wetlands and riparian forests.	USACE certification (regional)	Spreadsheet calculator
13. HGM for the Northern Rocky Mountains	Conceptual Spatial	Northern Rocky Mountains throughout MT, WY, ID, and northeastern WA. Riverine floodplains on alluvial gravel-bed rivers and low riparian terraces.	USACE certification (regional)	Spreadsheet calculator
14. HGM for Streams in Appalachia	Conceptual Spatial	Appalachia Plateau in KY, VA, TN, OH, and PA. High-gradient headwater and low-gradient perennial streams.	USACE certification (regional)	Spreadsheet calculator

Swannack, T. M., Fischenich J.C., and Tazik D.J. 2012. Ecological Modeling Guide for Ecosystem Restoration and Management. ERDC/EL TR-12-18. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

REVIEW RESULTS – GAP ANALYSIS

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Recognized Patterns

- Habitat Suitability Index (HSI) approaches
- Ecological vs instream function
- Geographic divergence
- Lacking lateral/longitudinal connectivity
- Missing soil metrics
- Urban surrounding land use
- Minimal forecasting capabilities

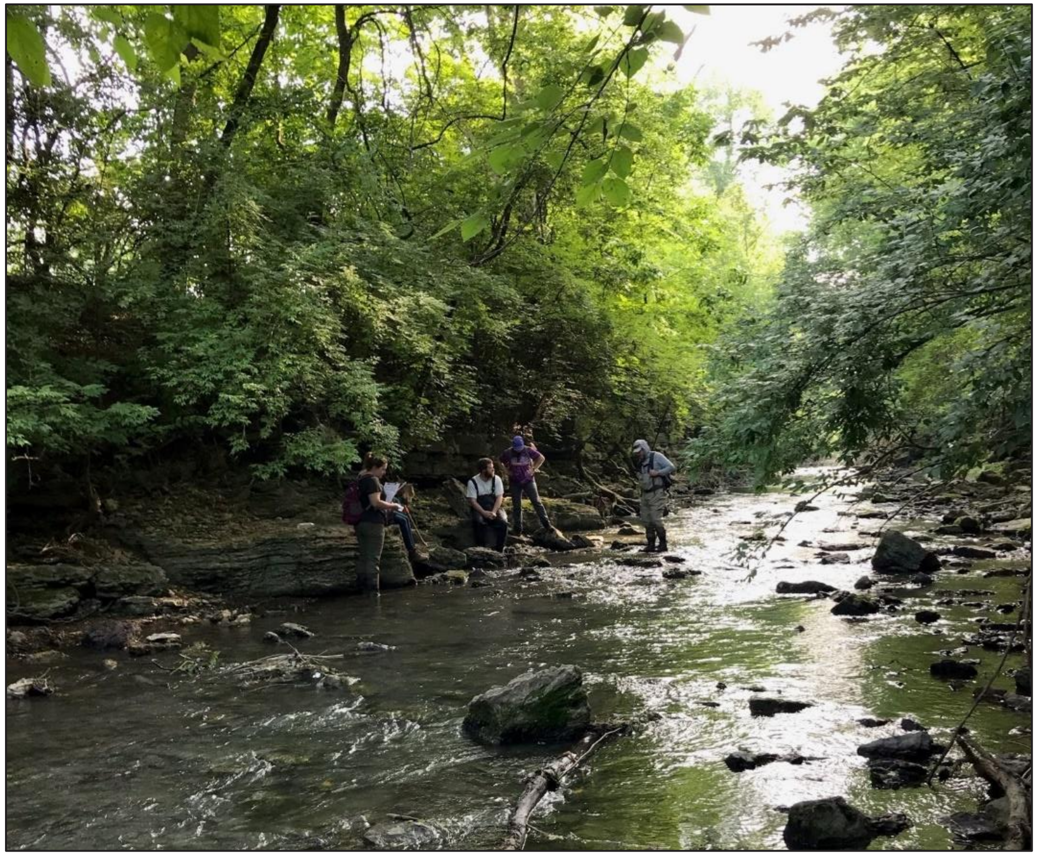

Photo: Beargrass Creek, Louisville, Kentucky (Laura Mattingly)

Numerical tools for models were inconsistently shared, coded in multiple languages, and challenging to locate

WEB APPLICATION FOR RIPARIAN MODELS (WARM)

Shaw C.K. and Wiest S.R. 2023. Increasing accessibility of riparian assessment tools through web applications. ASCE Inspire, American Society of Civil Engineers, November 2023, Arlington, Virginia. https://ascelibrary.org/doi/10.1061/9780784485163.024.

Shaw, Wiest, and McKay. *In draft*. A Web Application for Riparian Models (WARM). EMRRP Technical Note Series.

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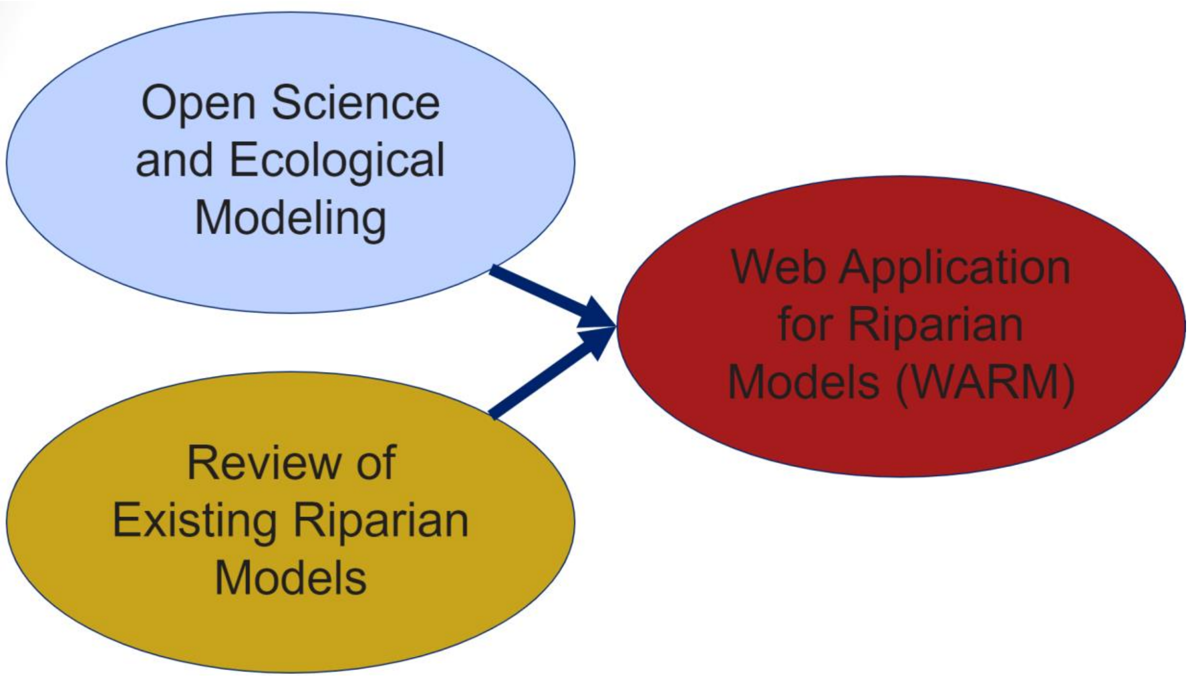
MODEL PURPOSE AND GOALS

WARM improves the ease of use of select, existing riparian modeling tools.

- Promote Open Science
  - Repeatability
  - Reproducibility
  - Accessibility
  - Transparency
- Incorporate Existing Riparian Models
  - Utilize model review
  - Enhance usability
- Standardization of Model Calculators
  - Consistency
  - Toolbox of like models
  - Model developer engagement



TIERED APPROACH TO RIPARIAN MODEL DEVELOPMENT

	Low level of effort	Moderate level of effort	High level of effort
Scope	Rapid, desktop tools for order-of-magnitude estimates comparing sites	Rapid assessment for comparing the relative effects of alternatives at the site-scale	Regionally tailored methods that target specific ecological targets and have often been field verified
Metric Types	Simple geospatial	Simple geospatial Rapid, semi-quantitative field assessment	Typically empirical measurements
Time commitment	minutes-hours	hours-days	varies
Geography	Global meta-analysis	National, on-the-shelf field assessment tool	Regionally scoped models (compiled into a web applications)
Processes included	Instream processes Taxa-oriented outcomes Corridors	Instream processes Taxa-oriented outcomes Corridors	Instream processes Taxa-oriented outcomes Corridors

Levels of effort in ecological modeling:
Harris et al. (2023, ERDC/TN EMRRP-EM-11)

SCOPE

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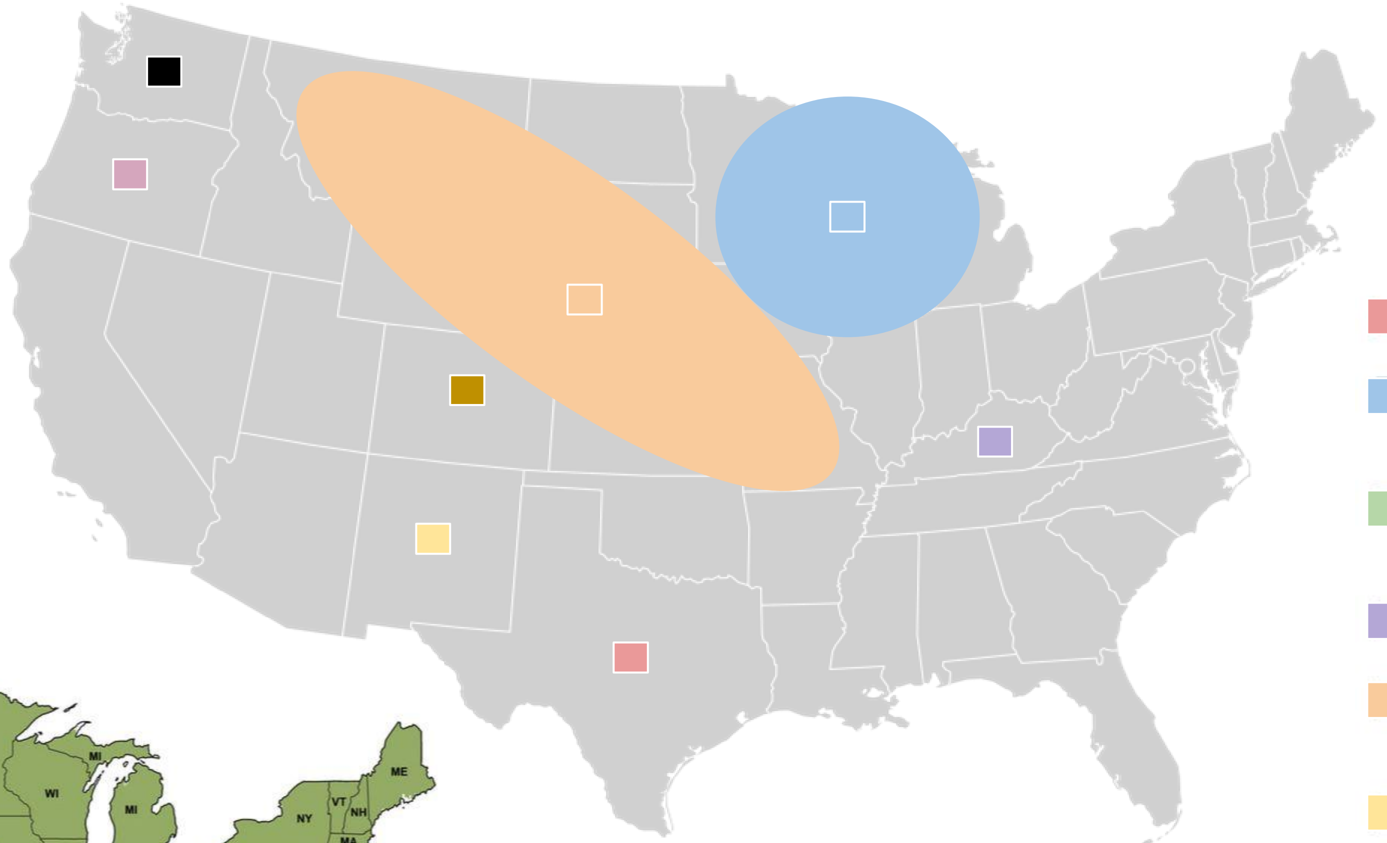
Select riparian modeling tools were chosen from the structural review (S. Wiest, et al.) through the availability of existing documentation per modeling tool.

A total of 9 riparian modeling tools are currently developed as calculators in WARM.

Model	General Description
1. Resaca Reference Condition Model	This model uses a Habitat Suitability Index (HSI) framework[1] to assess restoration sites for resaca ecosystems (a dry channel or former marshy course of a stream) based on three vegetation communities: Texas Ebony Resaca Forest, Subtropical Texas Palmetto Woodland, and Texas Ebony/Snake-eyes Shrubland (USACE, 2016).
2. Upper Mississippi River System	This HSI-based tool is designed to capture habitat changes from common management actions in floodplain forests (also known as "bottomland forests and "wooded swamps and floodplains"). The model assesses "silvicultural prescriptions" at a scale of "management areas", which are typically 5-100 acres (USACE 2021).
3. Modified Riverine HSI Model for Mink	This HSI model evaluates riverine cover types and their potential for providing year-round habitat for the mink species. A modification now includes an additional variable to compare natural vs. channelized streams (Devendorf and Yager, 2013).
4. Simple Model for Urban Riparian Function	This HSI-style model assesses multiple aspects of stream processes for constrained urban riparian zones in the Midwest (specifically Louisville, McKay et al. In Press).
5. Community-Based Model for Cottonwood Riparian Forests of Missouri River	The Missouri River model's purpose is to assess ecosystem benefits, specifically for Cottonwood riparian forests, through a community-based ecosystem response model. The model utilizes community- or ecosystem-scale indices (as opposed to taxa-specific models) to assess ecosystem functions on a broader and more complex, landscape scale (Burkes-Copes, 2016).
6. Middle Rio Grande Bosque Riparian Community Index Model	The Middle Rio Grande model quantifies the effects of changes in 'bosque' (riparian) ecosystems of central New Mexico. The HSI-style model focuses the unique and culturally significant 'bosque' communities in New Mexico due to its diminishing habitat and ecosystem functions (Burkes-Copes and Webb, 2012).
7. Ecological Functions Approach at Chatfield Reservoir	This model utilizes the application of the Colorado-specific model for wetland habitats, FACwet, to account for terrestrial habitats at Chatfield Reservoir. The model quantifies species/habitat and habitat/function relationships to aid in decision-making and mitigation planning within Chatfield (ERO Resources Corporation, 2009).
8. Lower Willamette River Ecosystem Restoration Project	This model assesses riverine, riparian, and floodplain habitats and their connections to fish and wildlife species. The model adapts existing HSI models for a selection of individual species and addresses the concept of how habitat restoration benefits multiple key fish and wildlife species (Tetra Tech, Inc., 2014).
9. Skokomish River Environmental Benefits Analysis	This model was developed for restoration planning and aims to incorporate positive aspects of multiple existing frameworks, including Habitat Evaluation Procedures (HEP), HSI, and the Biodiversity Security Index (Cole, 2010). The approach also compares sets of alternatives to identify key spatial gaps in restoration planning (Klimas and Yuill, 2013).

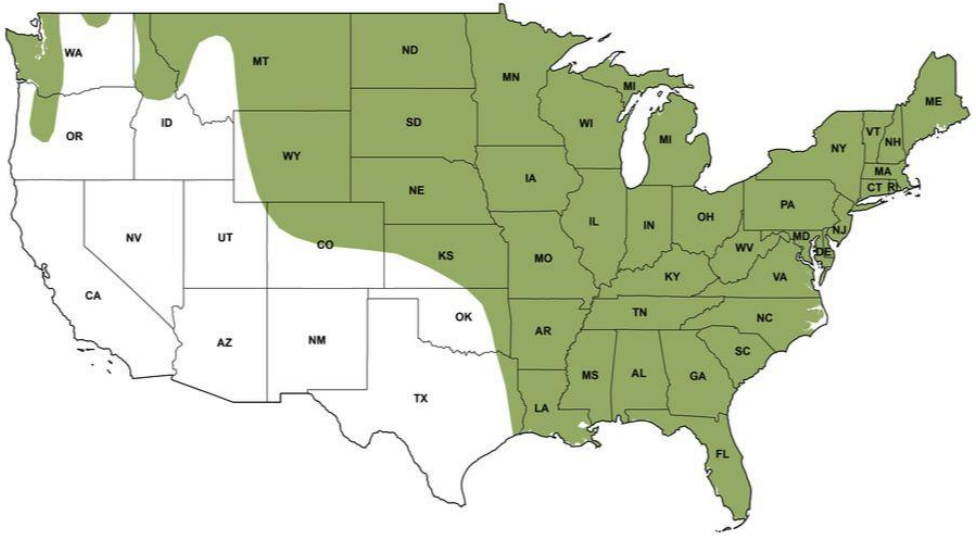
Shaw and Wiest, 2023

MODEL SELECTION FOR WARM



Existing Riparian Models Included in WARM

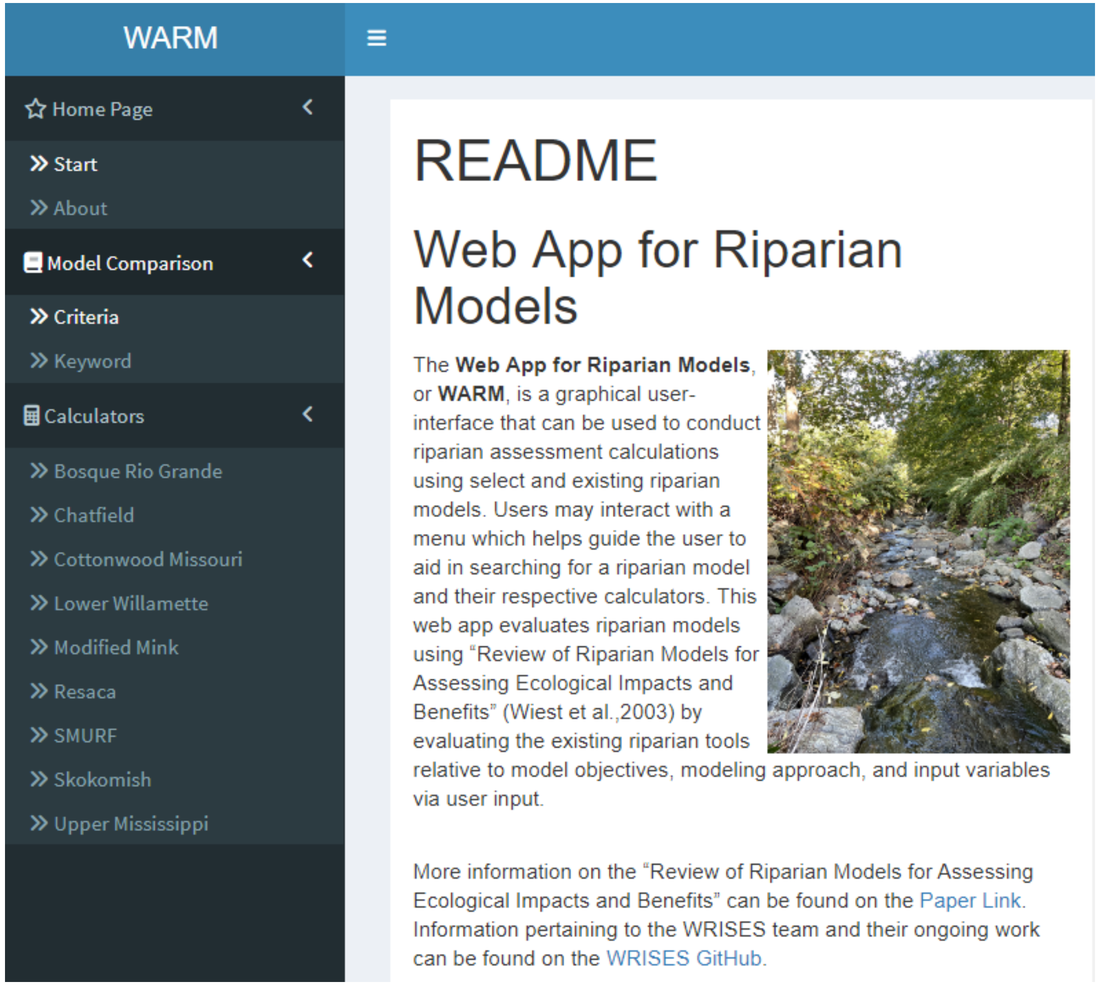
- Resaca Reference Condition Model
- Upper Mississippi River System Floodplain Forest Habitat Model
- Modification of the Riverine Cover Type Component of the HSI Model for Mink
- Simple Model for Urban Riparian Function (SMURF)
- Community-based Model for Cottonwood Riparian Forests of Missouri River
- Middle Rio Grande Bosque Riparian Community Index Model
- Ecological Functions Approach at Chatfield Reservoir
- Lower Williamette River Ecosystem Restoration Project
- Skokomish River Environmental Benefits Analysis



DEVELOPMENT OVERVIEW

The riparian modeling tools can be viewed through the Model Comparison tab, either by select criteria or keyword search.

Each calculator tab holds their respective riparian model calculators. User inputs vary from tab to tab.



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PLATFORM

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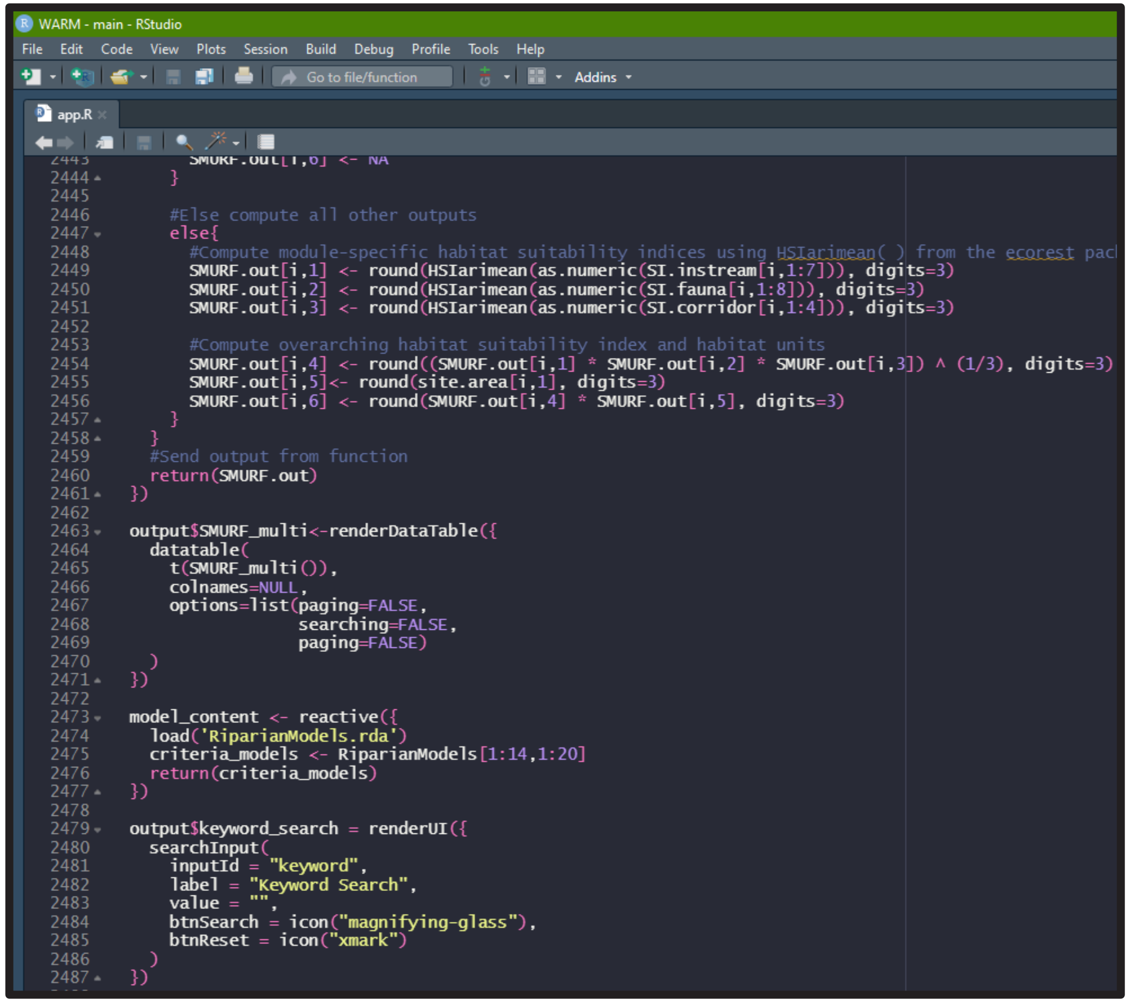
R statistical language

- Many ecological packages are based in R
- Easy setup in RStudio IDE

Shiny App Package

- May develop apps of varying complexity and functions
- Allows development with little to no HTML/CSS/Javascript experience



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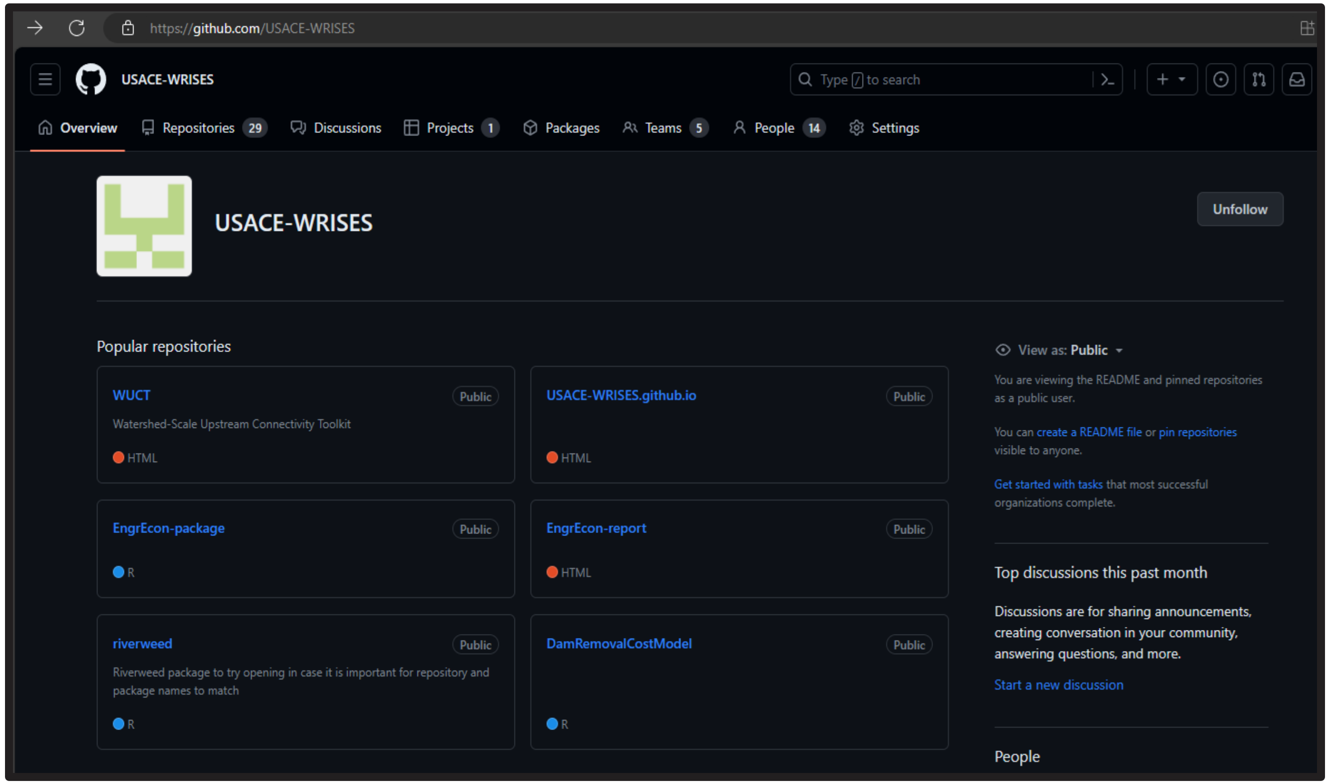
ACCESSIBILITY

WARM can be accessed via:

WRISES GitHub repository
- Download documentation, data, and code enabled
- User may launch webapp locally
- Enables user to version and augment webapp accordingly

Shinyapps.io
- Hosting service
- Webapp interface solely
- No coding experience nor extraordinary software necessary

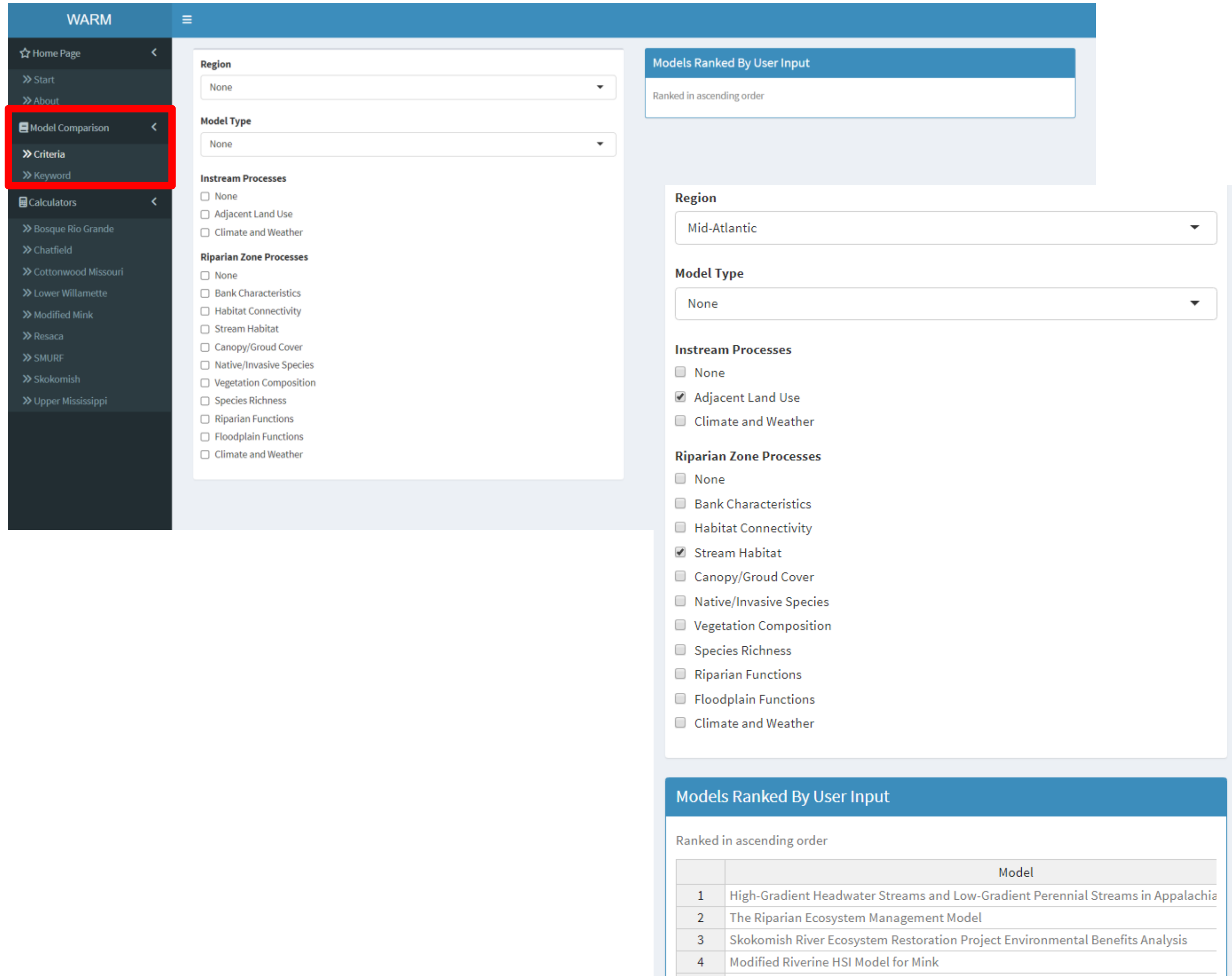


MODEL COMPARISON OVERVIEW

WARM allows the user to compare or search models included in the structural review.

User may select one or multiple criteria to compare models the existing models. For more particular needs, the user may search for a term stored in the model metadata.

This portion of WARM is targeted towards those new to the collection of models and serves as a gateway for new users and curious practitioners. User may choose to skip these tabs altogether.



MODEL COMPARISON DEMO

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Region

Mid-Atlantic

Model Type

None

Instream Processes

- [ ] None
- [x] Adjacent Land Use
- [ ] Climate and Weather

Riparian Zone Processes

- [ ] None
- [ ] Bank Characteristics
- [ ] Habitat Connectivity
- [ ] Stream Habitat
- [ ] Canopy/Groud Cover
- [ ] Native/Invasive Species
- [ ] Vegetation Composition
- [x] Species Richness
- [ ] Riparian Functions
- [x] Floodplain Functions
- [ ] Climate and Weather

Region

None

None
Varying
Southwest
Southeast
Northwest
Northeast
Midwest
Mid-Atlantic

Model Type

None

None
Analytical
Conceptual
Index
Spatial

	Model
1	High-Gradient Headwater Streams and Low-Gradient Perennial Streams in Appalachia
2	Community-Based Ecosystem Response Model for the Cottonwood Riparian Forests of Missouri River
3	Wetland Functions of Riverine Floodplains in the Northern Rocky Mountains
4	Middle Rio Grande Bosque Riparian Community Index Model
5	The Riparian Ecosystem Management Model
6	Wetland and Riparian Forests in Ouachita Mountains and Crowley<92>s Ridge Regions of Arkansas
7	Skokomish River Ecosystem Restoration Project Environmental Benefits Analysis
8	Resaca Reference Condition Model (RRCM)
9	Ecological Functions Approach at Chatfield Reservoir
10	Modified Riverine HSI Model for Mink
11	Riparian Aquatic Interaction Simulator
12	Lower Willamette River Ecosystem Restoration Project Model
13	Simple Model for Urban Riparian Function (SMURF)
14	Upper Mississippi River System (UMRS)

Keyword Search and Choose Model

Keyword Search

wetlands

Models Ranked By User Input

Ranked in ascending order

	Model
1	Middle Rio Grande Bosque Riparian Community Index Model
2	Wetland Functions of Riverine Floodplains in the Northern Rocky Mountains
3	High-Gradient Headwater Streams and Low-Gradient Perennial Streams in Appalachia
4	Wetland and Riparian Forests in Ouachita Mountains and Crowley<92>s Ridge Regions of

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MODEL CALCULATOR OVERVIEW

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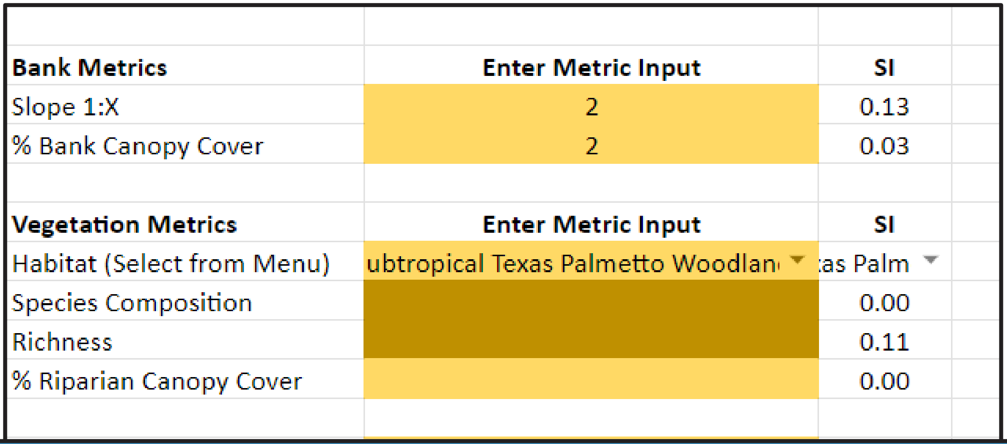
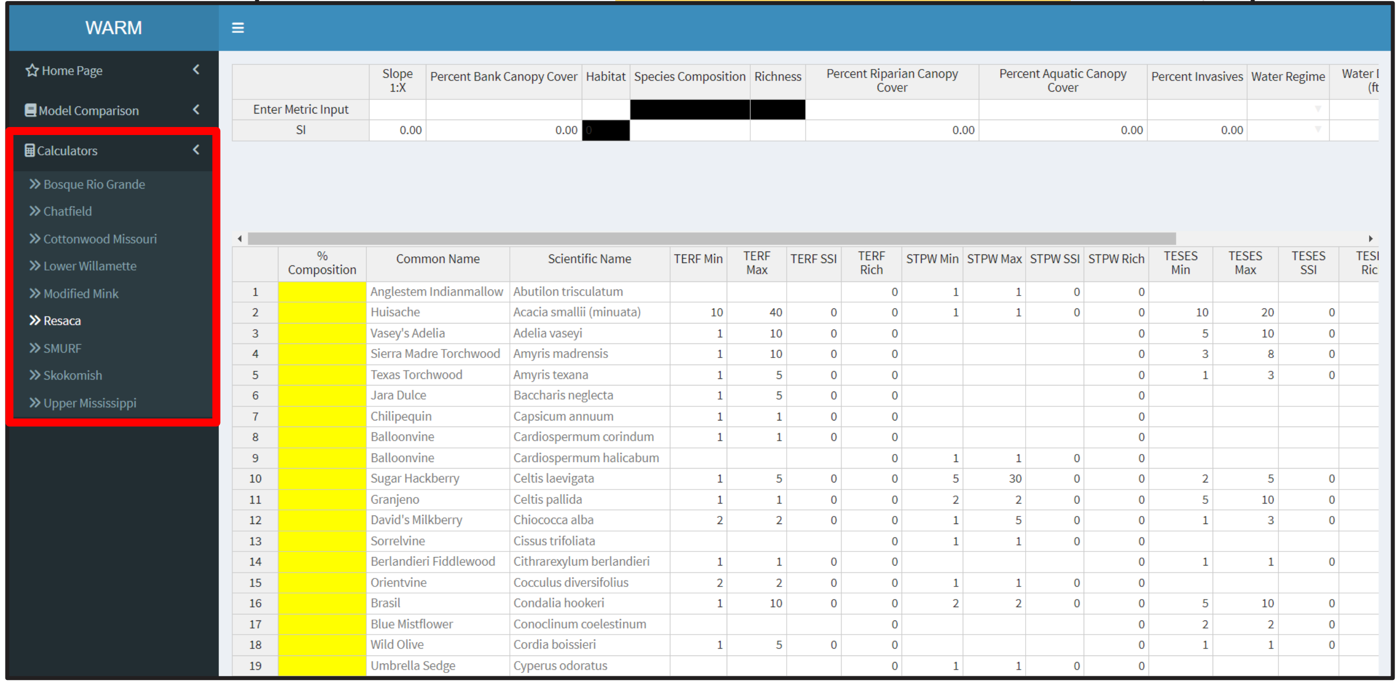
Intended for users who are familiar with a specific model and are wanting to utilize the associated calculator for analysis.

All calculators follow a similar and consistent input/output format.

Users who are intending to use the calculator have likely read the associated model documentation and are familiar with model metrics.



Bank Metrics	Enter Metric Input	SI
Slope 1:X	2	0.13
% Bank Canopy Cover	2	0.03
Vegetation Metrics	**Enter Metric Input**	**SI**
Habitat (Select from Menu)	ubtropical Texas Palmetto Woodlan	:as Palm
Species Composition		0.00
Richness		0.11
% Riparian Canopy Cover		0.00



	Slope 1:X	Percent Bank Canopy Cover	Habitat	Species Composition	Richness	Percent Riparian Canopy Cover	Percent Aquatic Canopy Cover	Percent Invasives	Water Regime	Water l (ft
Enter Metric Input										
SI	0.00	0.00				0.00	0.00	0.00		

	% Composition	Common Name	Scientific Name	TERF Min	TERF Max	TERF SSI	TERF Rich	STPW Min	STPW Max	STPW SSI	STPW Rich	TESES Min	TESES Max	TESES SSI	TESI Ric
1		Anglestem Indianmallow	Abutilon trisculatum				0	1	1	0	0				
2		Huisache	Acacia smallii (minuata)	10	40	0	0	1	1	0	0	10	20	0	
3		Vasey's Adelia	Adelia vaseyi	1	10	0	0				0	5	10	0	
4		Sierra Madre Torchwood	Amyris madrensis	1	10	0	0				0	3	8	0	
5		Texas Torchwood	Amyris texana	1	5	0	0				0	1	3	0	
6		Jara Dulce	Baccharis neglecta	1	5	0	0				0				
7		Chilipequin	Capsicum annuum	1	1	0	0				0				
8		Balloonvine	Cardiospermum corindum	1	1	0	0				0				
9		Balloonvine	Cardiospermum halicabum				0	1	1	0	0				
10		Sugar Hackberry	Celtis laevigata	1	5	0	0	5	30	0	0	2	5	0	
11		Granjeno	Celtis pallida	1	1	0	0	2	2	0	0	5	10	0	
12		David's Milkberry	Chiococca alba	2	2	0	0	1	5	0	0	1	3	0	
13		Sorrelvine	Cissus trifoliata				0	1	1	0	0				
14		Berlandieri Fiddlewood	Cithrarexylum berlandieri	1	1	0	0				0	1	1	0	
15		Orientvine	Cocculus diversifolius	2	2	0	0	1	1	0	0				
16		Brasil	Condalia hookeri	1	10	0	0	2	2	0	0	5	10	0	
17		Blue Mistflower	Conoclinum coelestinum				0				0	2	2	0	
18		Wild Olive	Cordia boissieri	1	5	0	0				0	1	1	0	
19		Umbrella Sedge	Cyperus odoratus				0	1	1	0	0				

MODEL CALCULATORS

Modified Mink

The variable numbers (V1, V5 and V6), related variable descriptions and discussions presented for water and cover are directly from the referenced mink model by Allen (1986).)

SIV1 = Percent (%) of year with surface water present

SIV5 = Percent (%) canopy cover of trees and shrubs within 100 m of the wetland's edge

SIV6 = Percent (%) shoreline cover

Vstream = Stream condition: Highly disturbed=.4, Moderately disturbed=.7, Natural Channel=1. Intermediate values may be entered

	Data	HSI
SIV1		
SIV5		
SIV6		
Vstream		
HSI for Cover		
HSI for Water		
Overall HSI		

Mink HSI Model: (Allen, A.W. 1986. Habitat suitability index models: Mink, revised. U.S. Fish and Wildlife Service Biological Report 82(10.127). 23pp. [First printed as:FWS/OBS 82/10.61, October 1983.])

Sam

SIV1 = Percent (%) of year with surface water present

SIV2 = Percent (%) tree canopy cover

SIV3 = Percent (%) shrub canopy cover

SIV4 = Percent (%) canopy cover of emergent vegetation

SIV5 = Percent (%) canopy cover of trees and shrubs within 100 m of the wetland's edge

SIV6 = Percent (%) shoreline cover

SIFS1 = Cover index for mink in palustrine forested and scrub/shrub wetlands >=405 ha

SIFS2 = Cover index for forested and scrub/shrub wetlands <405 ha

SIRL = Cover index for riverine and lacustrine cover types

SIPE = Cover index for palustrine emergent wetlands

HSI = HSI is equal to the lowest value calculated for either life requisite (water and cover)

	Data	HSI
Year		
Area (Hectares)		
SIV1		
SIV2		
SIV3		
SIV4		
SIV5		
SIV6		
SIFS1		
SIFS2		
SIRL		
SIPE		
HSI		

Bosque Rio Grande

Assessments for Cover Types 1-5 (Forest and Shrubs) should include the following variables:

DEPTHGW: Depth to Groundwater (ft)

WETTEDAREA: Percent of Polygon that is Wet (%)

FLOODFREQ: Frequency of Flooding (#/yr)

DURATION: Average Duration of Flooding Events (days)

CANTREE: Canopy Cover of Overstory Trees (%)

CANSHRUB: Canopy Cover of Shrubs (%)

CANHERB: Canopy Cover of Herbaceous Vegetation (%)

DISTBIGTR: Distance to Biggest Tree from Sample Point (m)

NATIVETREE: Percent of Tall Overstory Tree Canopy that is a Native Species (%)

INDICATHB: Percent of Herbaceous Canopy that is an Undesirable Indicator Species (%)

SPPCOUNT: Number of Native Tree and Shrub Species (presence/absence)

COVGRND: Ground Cover Present (%)

CTGRNDCOV: Count of Ground Cover Categories Present

DEPTHOM: Depth of Organic Matter (cm)

Assessments for Cover Types 6 (Marsh and Wet Prairies) should include the DEPTHGW, WETTEDAREA, FLOODFREQ, DURATION from above as well as the following variables:

CANGRASS: Canopy Cover of Grass Species (%)

CANFORB: Canopy Cover of Forb Species (%)

CANSEDGE: Canopy Cover of Sedge Species (%)

INDICATGR: Percent of Grass Canopy that is an Undesirable Indicator Species (%)

INDICATFB: Percent of Forb Canopy that is an Undesirable Indicator Species (%)

NATIVESDG: Percent of Sedge Canopy that is a Desirable Indicator Species (%)

SPPCOUNT: Number of Native Tree and Shrub Species (presence/absence)

PATCHSIZE: Size of Patch (ac)

TYPDISTURB: Type of Human Disturbance (aka Adjacent Landuse Within 2 km)

DISPATCH: Distance to Nearest Patch (aka Nearest Neighbor of Forest or Meadow) (m)

	Variables
CODE TYPE (1-6)	
DEPTHGW	
WETTEDAREA	
FLOODEDFREQ	
DURATION	
CANTREE	
CANSHRUB	
CANHERB	
DISTBIGTR	
NATIVETREE	
INDICATHB	
SPPCOUNT	
COVGRIND	
CTGRNDCOV	
DEPTHOM	
CANGRASS	
CANFORB	
CANSEDGE	
INDICATGR	
INDICATFB	
NATIVESDG	
SPPCOUNT	
PATCHSIZE	
TYPDISTURB	
DISPATCH	
HSI	

SPREADSHEET TO CALCULATOR

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HSI MINK WORKSHEET INSTRUCTIONS:

1. Enter condition (existing condition, future w/o, etc.) and year.
2. Enter data values for all variables below (highlighted green).
3. Document reasoning for value in Comments column

Condition: | **Enter Year:**

Variable	Description	DATA	HSI	C
V1	Percent of year with surface water present.	80%	1.00	
V5	Percent tree and/or shrub canopy closure within 100 m (328 ft) of water's or wetland's edge.	65%	0.88	
V6	Percent shoreline cover within 1 meter of water's edge	56%	56%	
Vstream	Stream condition: Highly disturbed=.4, Moderately disturbed=.7, Natural Channel=1. Intermediate values may be entered	0.70	0.70	
	HSI for Cover		0.70	
	HSI for Water		1.00	
	Overall HSI (lowest HSI for Cover/Water)		0.70	

WARM

≡

The variable numbers (V1, V5 and V6), related variable descriptions and discussions presented for water and cover are directly from the referenced mink model by Allen (1986).)

SIV1 = Percent (%) of year with surface water present

SIV5 = Percent (%) canopy cover of trees and shrubs within 100 m of the wetland's edge

SIV6 = Percent (%) shoreline cover

Vstream = Stream condition: Highly disturbed=.4, Moderately disturbed=.7, Natural Channel=1. Intermediate values may be entered

	Data	HSI
SIV1	80	1.00
SIV5	65	0.88
SIV6	56	0.56
Vstream	0.7	0.70
HSI for Cover		0.70
HSI for Water		1.00
Overall HSI		0.70

Mink HSI Model: (Allen, A.W. 1986. Habitat suitability index models: Mink, revised. U.S. Fish and Wildlife Service Biological Report 82(10.127). 23pp. [First printed as:FWS/OBS 82/10.61, October 1983.])

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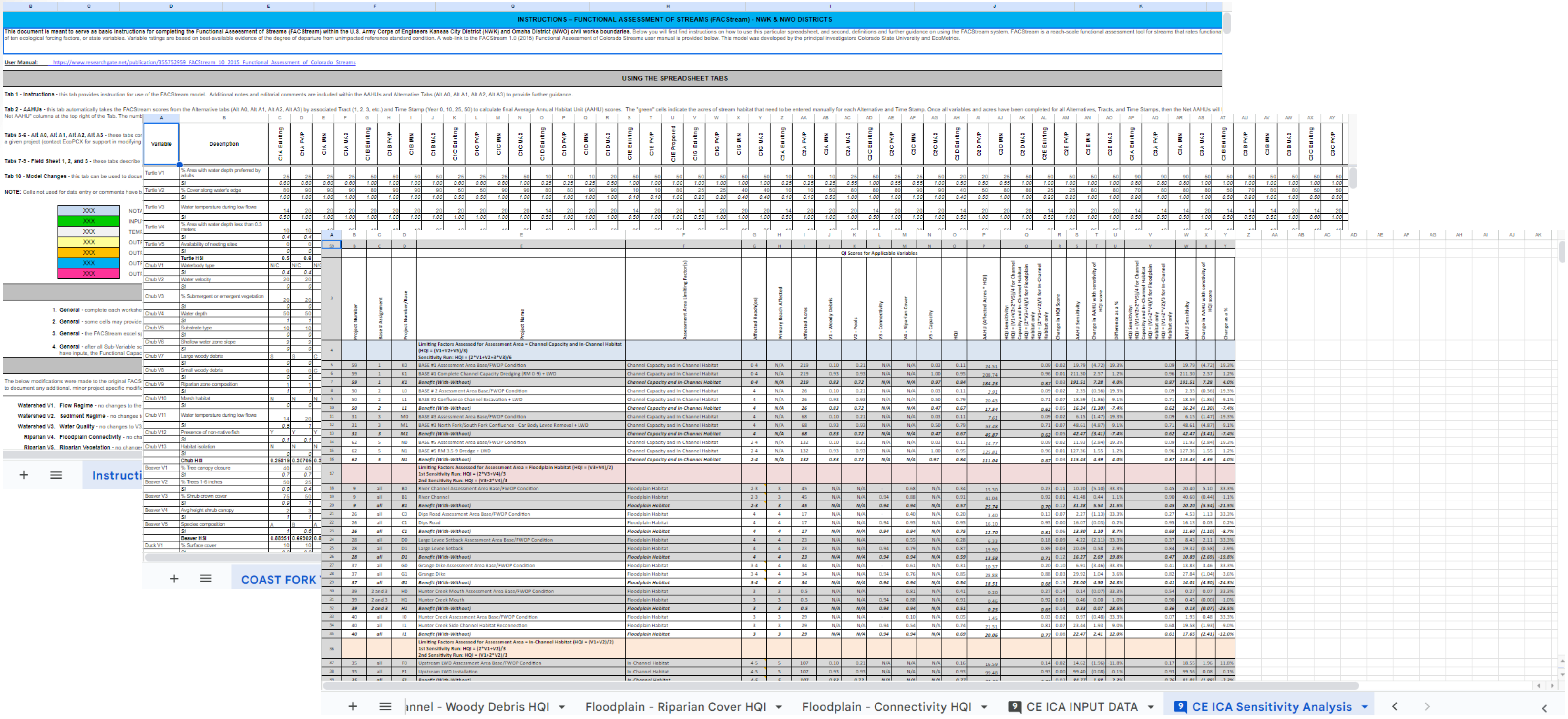
OTHER MODEL EXCEL SPREADSHEETS



UNCLASSIFIED

BEARGRASS CREEK CASE STUDY

This case study is presented for illustrative purposes only. Please consult the project website for additional details: https://www.lrl.usace.army.mil/Missions/Civil-Works/Project-Planning/Beargrass-Creek-Ecosystem-Restoration-Study/

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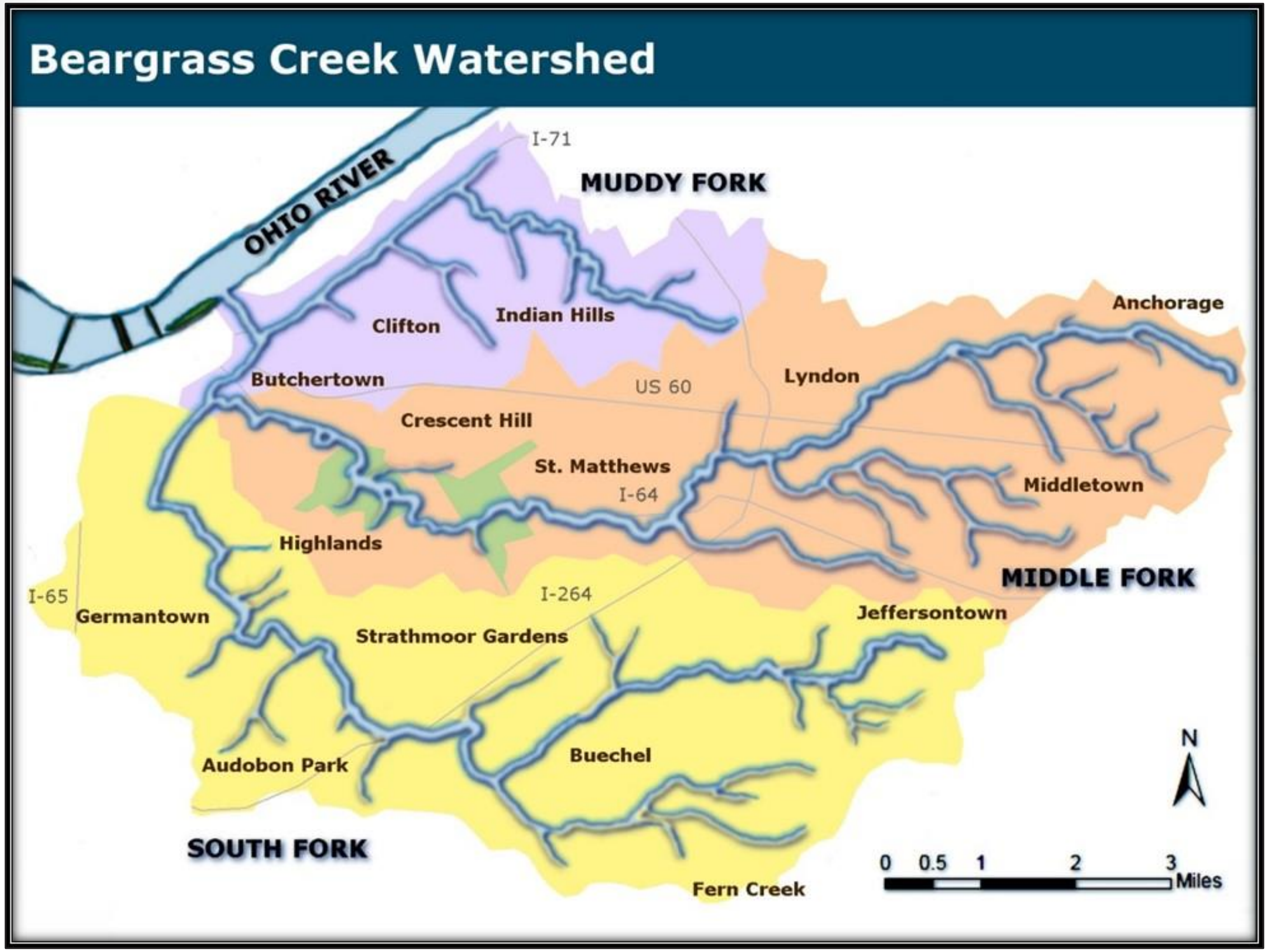
BEARGRASS CREEK, LOUISVILLE, KENTUCKY



ALIGNING OBJECTIVES AND MODELS

Project Objectives	Assessment Approach
Reestablish quality and connectivity of **riverine** habitats	Adapted a regional stream model (QHEI, Rankin 2006) to better incorporate geomorphic change and connectivity
Reestablish quality and connectivity of **riparian** habitats	?
Secondary objectives: • Maximize recreational benefits • Minimize flood risk outcomes • Maximize social outcomes	• Estimates of “unit day value” • Hydraulic modeling (HEC-RAS) • Bespoke scoring system
Constraints • Identify an “affordable” set of actions • Minimize real estate acquisitions	• USACE and city budgets • Resident preferences

SIMPLE MODEL FOR URBAN RIPARIAN FUNCTION (SMURF)

- Focus on riparian condition and function
- Applicable within project timelines (i.e., rapid)
- Alignment of “level of effort” with stream tools
- Capacity to alter parameters for future scenarios
- Capable of distinguishing the relative effects of actions

Indirect effects of riparian zone on instream processes

Provider of faunal habitat

Ecological corridors that provide resiliency

SMURF MODEL DEVELOPMENT PHILOSOPHY

Embraced principles of Open Science (Hampton et al. 2015, Ecosphere)

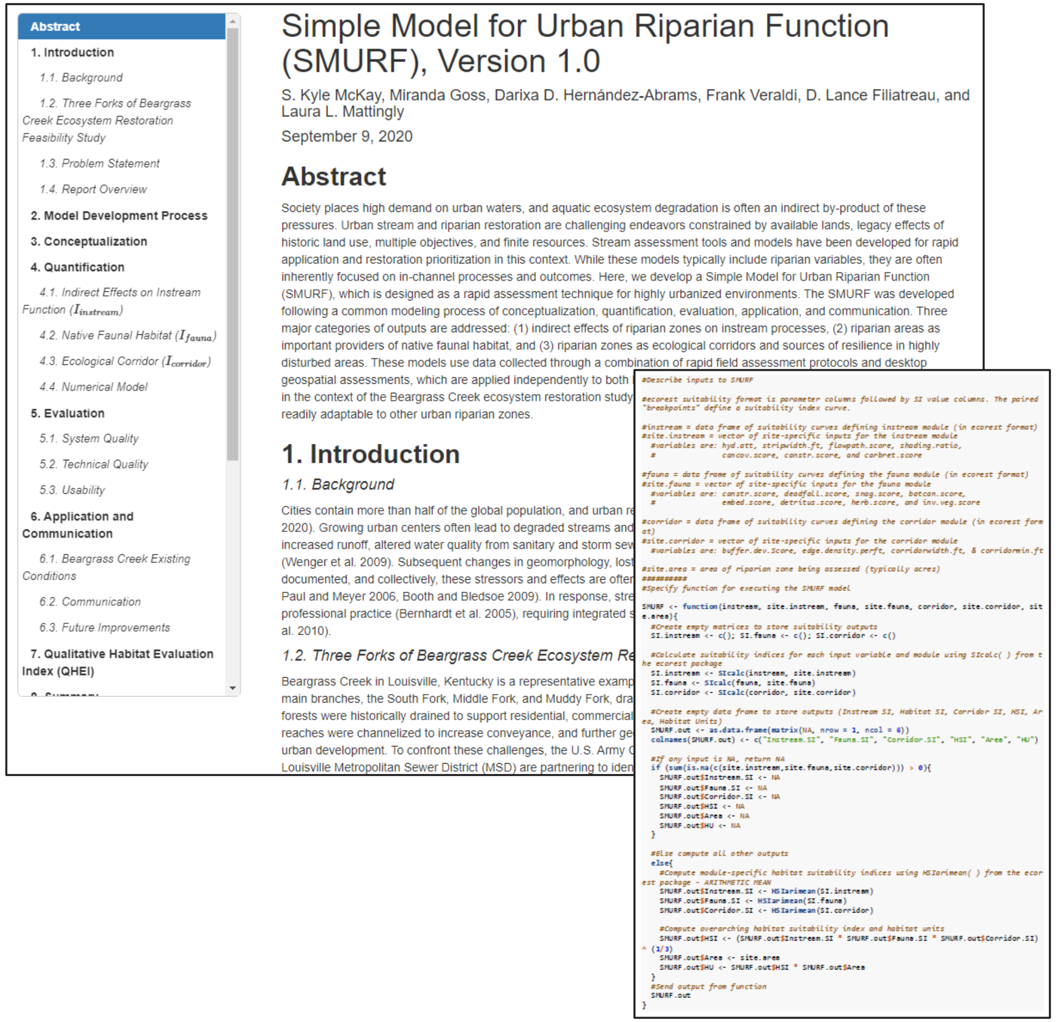
- Open source coding in R
- Application of existing packages (ecorest)
- Transparent development with Markdown
- Central database for all data types and sites

Socialized models during development

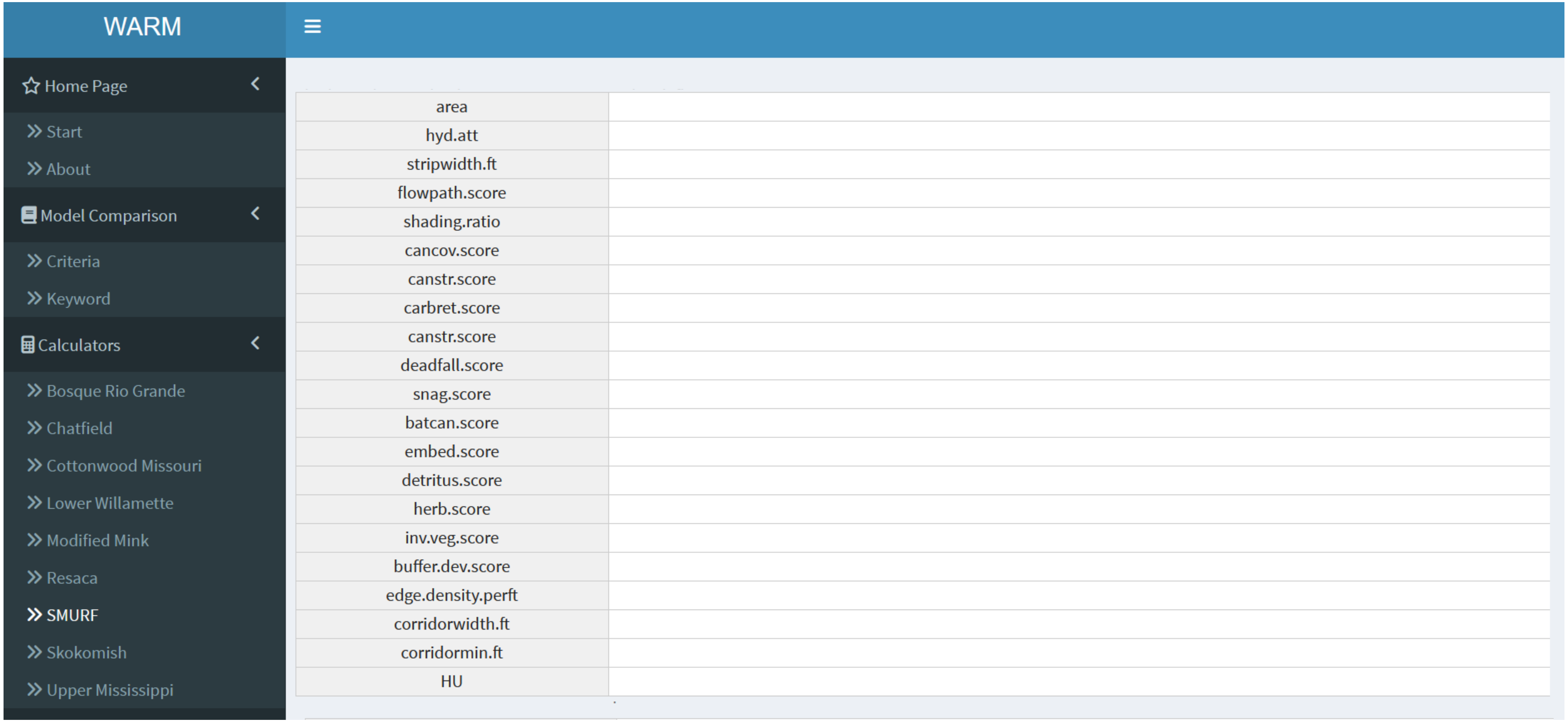
- Interagency project team and "friendly" national experts
- Real-time model documentation

Limits on usability

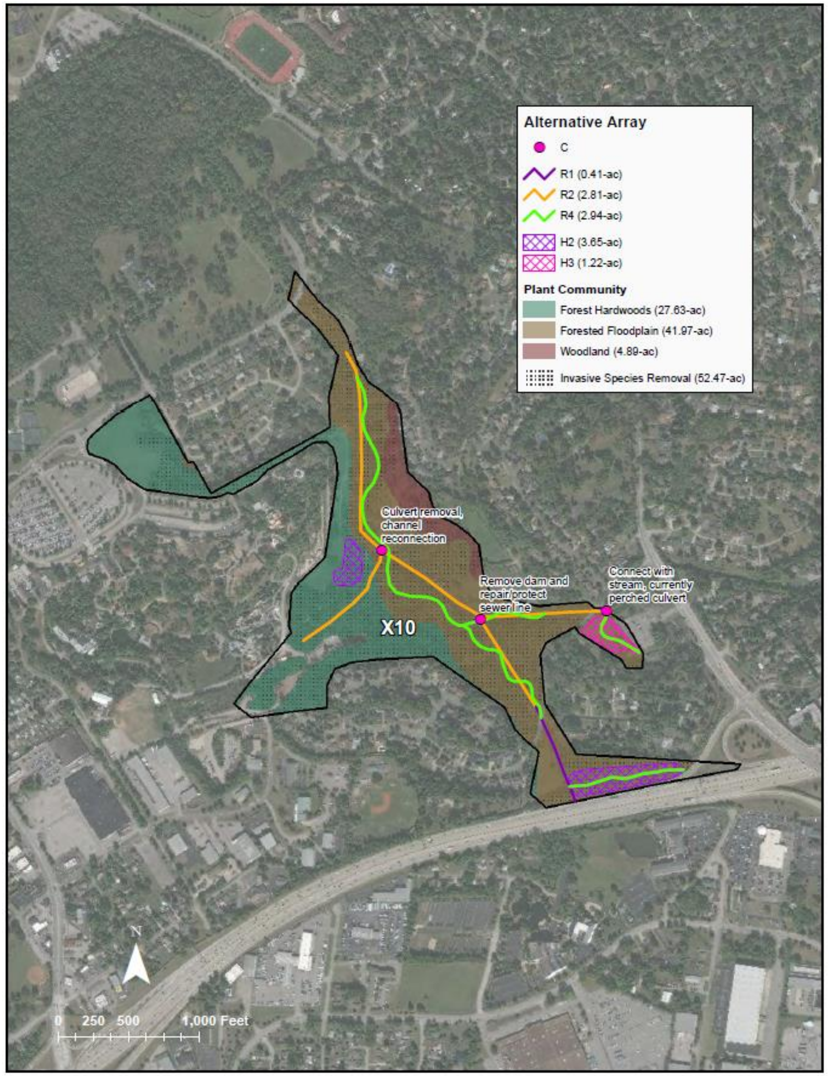
- Script based data processing
- No graphical user interface



INCREASING THE ACCESSIBILITY OF SMURF



A SITE-SPECIFIC APPLICATION



Existing Condition

Alternatives Analysis

area	1.38
hyd.att	0.70
stripwidth.ft	80.00
flowpath.score	5.00
shading.ratio	2.00
cancov.score	15.00
canstr.score	12.00
carbret.score	7.00
canstr.score	18.00
deadfall.score	15.00
snag.score	13.00
batcan.score	14.00
embed.score	9.00
detritus.score	16.00
herb.score	18.00
inv.veg.score	6.00
buffer.dev.score	17.00
edge.density.perft	0.01
corridorwidth.ft	90.00
corridormin.ft	60.00
HU	1.05

ASSESSING EXISTING CONDITIONS

Input data

Geospatial Data

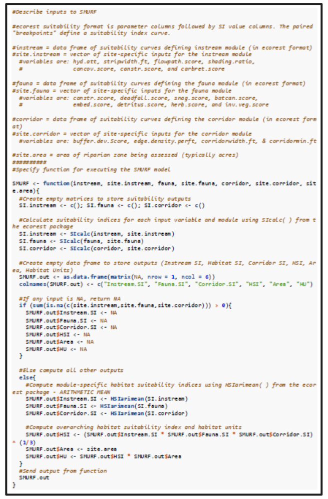
- Buffer width
- Edge length
- …

Field Assessment

- Instream processes
- Faunal habitat
- Corridor functions

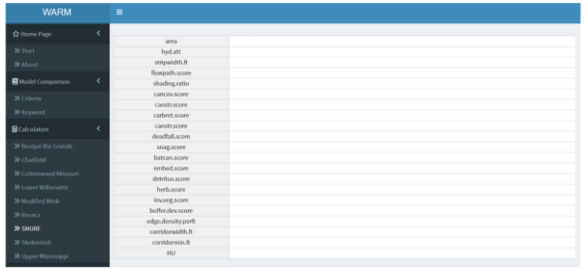
Numerical Model

For the study



```r
#Describe inputs to SMURF

#ecorest suitability format is parameter columns followed by SI value columns. The paired
"breakpoints" define a suitability index curve.

#instream = data frame of suitability curves defining instream module (in ecorest format)
#site.instream = vector of site-specific inputs for the instream module
  #variables are: hyd.att, stripwidth.ft, flowpath.score, shading.ratio,
  #               cancov.score, canstr.score, and carbret.score

#fauna = data frame of suitability curves defining the fauna module (in ecorest format)
#site.fauna = vector of site-specific inputs for the fauna module
  #variables are: canstr.score, deadfall.score, snag.score, batcan.score,
  #               embed.score, detritus.score, herb.score, and inv.veg.score

#corridor = data frame of suitability curves defining the corridor module (in ecorest form
at)
#site.corridor = vector of site-specific inputs for the corridor module
  #variables are: buffer.dev.Score, edge.density.perft, corridorwidth.ft, & corridormin.ft

#site.area = area of riparian zone being assessed (typically acres)
##########
#Specify function for executing the SMURF model

SMURF <- function(instream, site.instream, fauna, site.fauna, corridor, site.corridor, sit
e.area){
  #Create empty matrices to store suitability outputs
  SI.instream <- c(); SI.fauna <- c(); SI.corridor <- c()

  #Calculate suitability indices for each input variable and module using SIcalc( ) from t
he ecorest package
  SI.instream <- SIcalc(instream, site.instream)
  SI.fauna <- SIcalc(fauna, site.fauna)
  SI.corridor <- SIcalc(corridor, site.corridor)

  #Create empty data frame to store outputs (Instream SI, Habitat SI, Corridor SI, HSI, Ar
ea, Habitat Units)
  SMURF.out <- as.data.frame(matrix(NA, nrow = 1, ncol = 6))
  colnames(SMURF.out) <- c("Instream.SI", "Fauna.SI", "Corridor.SI", "HSI", "Area", "HU")

  #If any input is NA, return NA
  if (sum(is.na(c(site.instream,site.fauna,site.corridor))) > 0){
    SMURF.out$Instream.SI <- NA
    SMURF.out$Fauna.SI <- NA
    SMURF.out$Corridor.SI <- NA
    SMURF.out$HSI <- NA
    SMURF.out$Area <- NA
    SMURF.out$HU <- NA
  }

  #Else compute all other outputs
  else{
    #Compute module-specific habitat suitability indices using HSIarimean( ) from the ecor
est package - ARITHMETIC MEAN
    SMURF.out$Instream.SI <- HSIarimean(SI.instream)
    SMURF.out$Fauna.SI <- HSIarimean(SI.fauna)
    SMURF.out$Corridor.SI <- HSIarimean(SI.corridor)

    #Compute overarching habitat suitability index and habitat units
    SMURF.out$HSI <- (SMURF.out$Instream.SI * SMURF.out$Fauna.SI * SMURF.out$Corridor.SI)
^ (1/3)
    SMURF.out$Area <- site.area
    SMURF.out$HU <- SMURF.out$HSI * SMURF.out$Area
  }
  #Send output from function
  SMURF.out
}
```

Using WARM



Outputs

Multi-site

- Habitat quality
- Habitat quantity
- Habitat units

Single-site

- Habitat quality
- Habitat quantity
- Habitat units

FINAL THOUGHTS

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COULD WEB APPS HELP OVERCOME COMMON CHALLENGES IN ECOLOGICAL MODELING?

Common EcoMod challenges	How a web app can help
Difficulty finding numerical models in grey literature	Ease of access and searchability
No access to analytical code or calculators	A one stop shop for materials at varying levels of coding expertise (e.g., web app + source code sharing)
Limited analytical or coding expertise	No coding experience necessary to use
Multiple versions of tools	Versioned repositories and public website(s)

TIPS FOR APP DEVELOPMENT

For Model Developers	For Users
• Rhandsontable allows for more interactive tables at the cost of more coding • Make excel calculators and other forms of documentation available to web app development team for verfication	• Tables are enabled to both copy and paste, allowing users to copy inputs and outputs to and from excel • Additional info on the respective models can be found via a link in the Start page • If a tab doesn't seem to show up when selected, try resizing the window

*Reach out to Colton Shaw about other lesson learned. Our team is happy to facilitate development by others!

WHERE DO WE GO FROM HERE?

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Next Steps

- WARM can serve as a collection point for other USACE riparian models.
  - Riparian buffer width models (EMRRP Webinar on Jan 24)
  - Riparian ecological functions index (EMRRP Webinar on Jan 29)
  - **You can submit your models for inclusion in WARM!**
- Model certification will be pursued in spring 2024 for the initial suite of tools.

Take-home messages

- Open science can increase accessibility, transparency, and replicability of USACE tools.
- A family of regionally tailored riparian models have been incorporated into a Web Application for Riparian Models (WARM).
- Web applications generally increase the accessibility of models, allow more teammates to participate in the modeling process, facilitate versioning, and provide archival of tools.
- Multi-model web applications could be developed for other ecosystems (e.g., stream tools, wetland assessment methods, etc.)

THANK YOU FOR YOUR TIME!

Resources

- The (uncertified) beta-version of WARM:
  - https://wrises.shinyapps.io/warm/
- Shaw and McKay. In review. A guide to applying open science methods in ecological modeling. EMRRP Technical Note Series.
- Shaw C.K. and Wiest S.R. 2023. Increasing accessibility of riparian assessment tools through web applications. ASCE Inspire, American Society of Civil Engineers, November 2023, Arlington, Virginia. https://ascelibrary.org/doi/10.1061/9780784485163.024.
- Wiest S., Hernandez-Abrams D.D., and McKay S.K. 2023. Review of riparian models for assessing ecological impacts and benefits. ERDC/TN EMRRP-ER-26. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.
- Shaw, Wiest, and McKay. In draft. A Web Application for Riparian Models (WARM). EMRRP Technical Note Series.

Acknowledgements

- ERDC Modeling Teams: Todd Swannack, Todd Steissberg,…
- Riparian team: Garrett Menichino, Darixa Hernandez-Abrams, Rosamar Ayala Torres, Lee Dietterich…
- USACE Louisville Team: Laura Mattingly, Nate Moulder, Steele McFadden,…

We want to hear from you!

Samantha Wiest
Vicksburg, Mississippi
samantha.r.wiest@erdc.dren.mil

Colton Shaw
Portland, Oregon
cshaw@bennettaerospace.com

Kyle McKay, Ph.D., P.E.
New York, New York
Kyle.McKay@usace.army.mil