

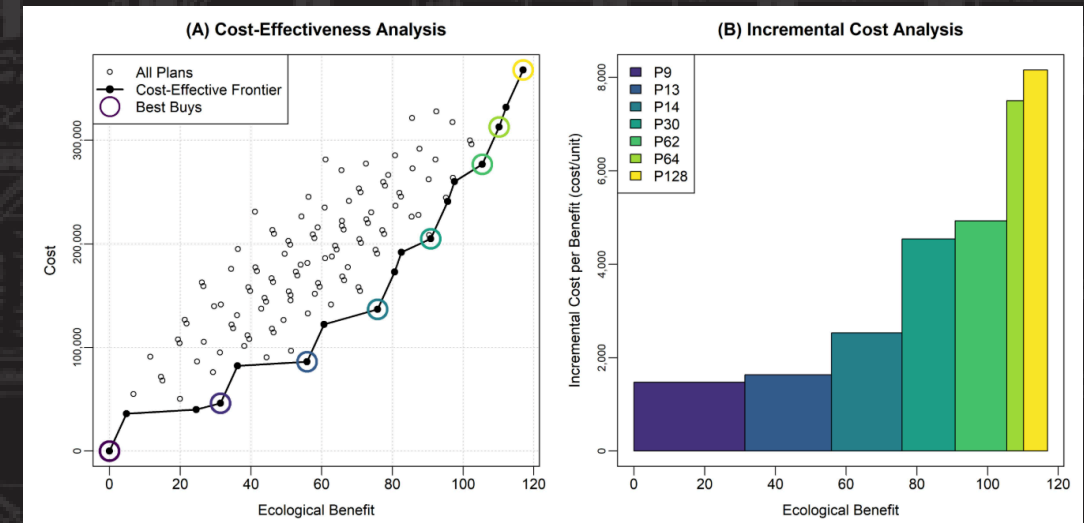
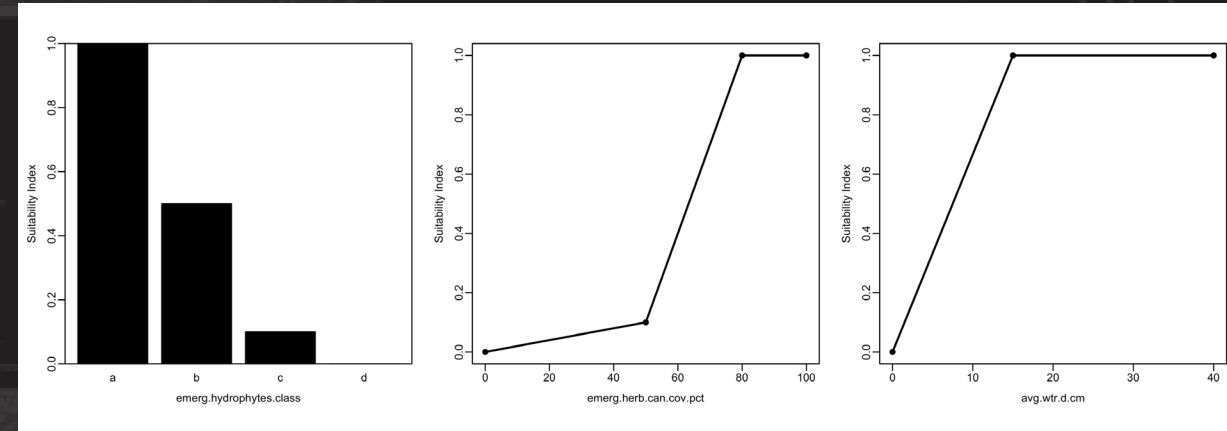
HSI MODELS IN R WITH THE *ECOREST* PACKAGE (PLUS CEICA)

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Environmental Lab

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February 2026



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OVERVIEW



- HSI and *ecorest* background
- Tutorial
 - Bluebook model
 - Custom HSI model
 - *Briefly*: Annualizing benefits & CEICA



HABITAT (OR INDEX-BASED) MODELS

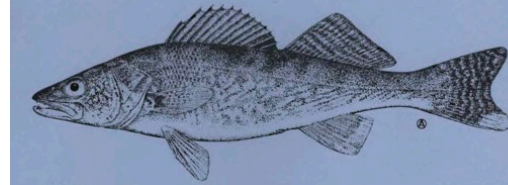
What is a “habitat” suitability model?

- Habitat = Quantity * Quality
- Quantity ~ wetland area, stream length...
- Quality ~ a 0-1 index including multiple variables
- Linking physical changes to ecological outcomes
- Connection to focal taxa (e.g., imperiled species)

Historical US Fish and Wildlife Service models

- Habitat Evaluation Procedures (HEP)
- 100+ Habitat Suitability Index (HSI) models
- 350+ sub-models for life stages, regions, etc.

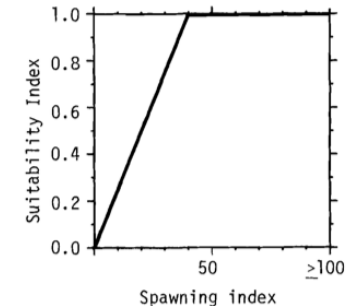
HABITAT SUITABILITY INFORMATION: WALLEYE



V₁₂ Spawning habitat index.

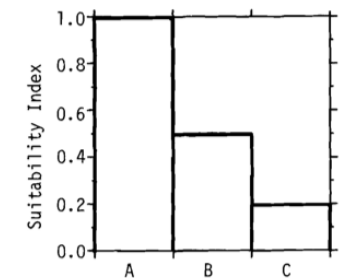
Calculated by multiplying the proportion of the water body composed of riffle or littoral areas > 0.3 m but < 1.5 m deep by the substrate index where the substrate index is defined by the following equation:

Substrate Index = 2(% gravel/rubble 2.5 to 15 cm in diameter) + (% boulders/bedrock) + 0.5(% sand) + 0.5(% dense vegetation) + 0(% silt/detritus).



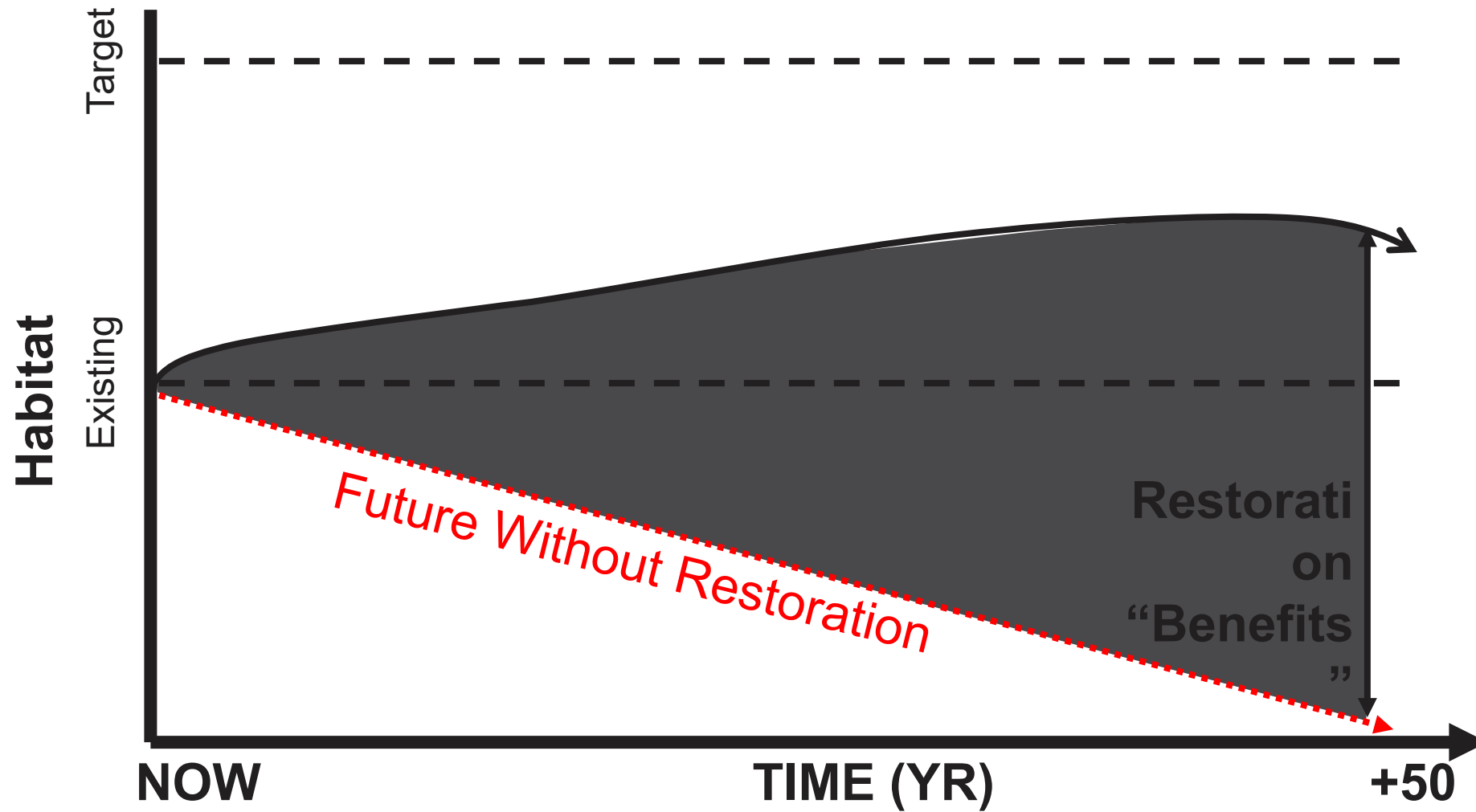
V₁₃ Water level during spawning and embryo development (embryo).

- A) Rising or normal and stable: abundance of shallow shoreline or shoal areas for spawning.
- B) Low: many spawning areas are exposed, and never inundated.
- C) Fluctuating: fluctuations sufficient to alternately expose and flood spawning areas.





HABITAT MODELS IN THEORY





HOW DOES INFORMATION GET USED IN RESTORATION DECISIONS?

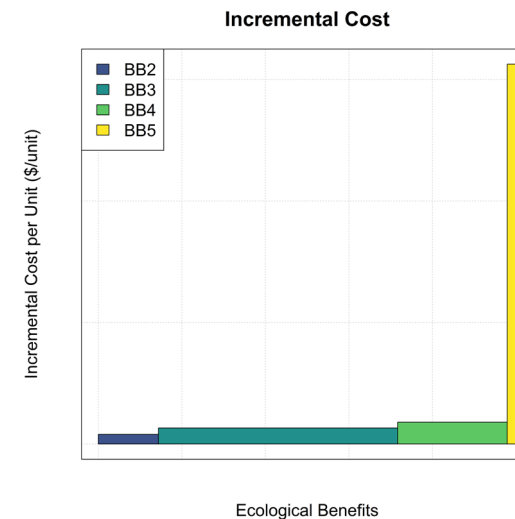
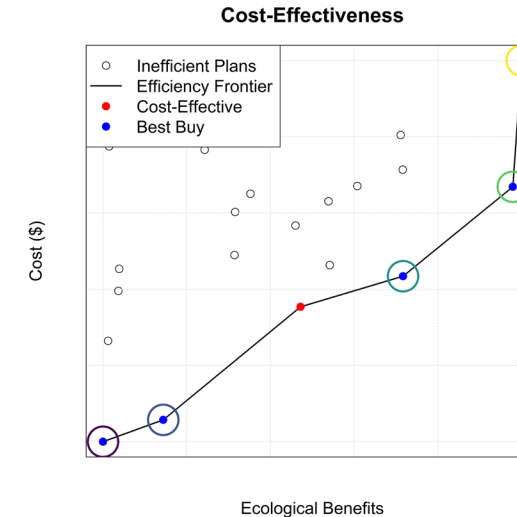
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Habitat benefits are compiled for each alternative and assessed relative to costs

Cost-effectiveness and incremental cost analysis provide tools for relative comparison

Decision makers must decide how much restoration is “worth” the investment (value judgment)



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HABITAT MODELS IN PRACTICE

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HSI BLUEGILL MODEL WORKSHEET INSTRUCTIONS:					
Riverine		1. Please Choose Riverine or Lacustrine from the box at left			
		2. Enter Data Values below which are highlighted green			
Enter Condition:		FWOP (216 acres)	Enter Year:	0	
Variable	Habitat	Description	DATA	HSI	Comments
V1	R	% Pool Area	53.4%	0.89	
V2	R and L	% Cover (logs & brush)	10.9%	0.64	
V3	R and L	% Cover (vegetation)	14.3%	0.95	
V4	L	% Littoral Area			
V5	L	Avg. Total Dissolved Solids (TDS) (in ppm)			
V6	R and L	Avg. Turbidity (ppm)	64	0.93	
V7	R and L	pH Range	A	1.00	
V8	R and L	Min. Dissolved Oxygen (DO) - Summer	A	1.00	
V9	R and L	Salinity (ppt)	-1	nf	
V10	R and L	Max. Midsummer Temp. (Adult) (C)	29.1	0.30	
V11	R and L	Avg. Water Temp. (Spawning) (C)	22.4	1.00	
V12	R and L	Max. Early Summer Temp. (Fry) (C)	24.2	0.94	
V13	R and L	Max. Midsummer Temp. (Juvenile) (C)	29.8	0.99	
V14	R	Avg. Current Velocity (cm/s)	5.01	1.00	
V15	R	Avg. Current Velocity (Spawning) (cm/s)	5.59	1.00	
V16	R	Avg. Current Velocity (Fry) (cm/s)	5.59	0.61	
V17	R	Avg. Current Velocity (Juvenile) (cm/s)	6.8	0.79	
V18	R	Stream Gradient (m/km)	0.1	1.00	
V19	L	Reservoir Drawdown during spawning (m)			
V20	R and L	Substrate Composition	B	0.70	
		Food (Cf)		0.81	
		Cover (Cc)		0.79	
		Water Quality (Cwq)		0.87	
		Reproduction (Cr)		0.89	
		Other (Cot)		0.90	
		Summer HSI		0.86	
WITH WINTER HSI MODIFICATIONS					
Variable	Description				
Va	R and L	% of Backwater > 4 Feet in Depth	0.9%	0.21	
Vb	R and L	Min. Dissolved Oxygen (DO) - Winter	B	0.70	
Vc	R and L	Water Temperature (C)	1.4	0.57	
Vd	R and L	Current Velocity (cm/s)	1.4	0.24	
		Winter Cover (Cw-c)		0.21	
		Winter Water Quality (Cw-wq)		0.66	
		Winter Other (Cw-ot)		0.24	
		Winter HSI		0.39	
		Overall HSI with Winter Modifications		0.39	

Ad hoc spreadsheet models for:

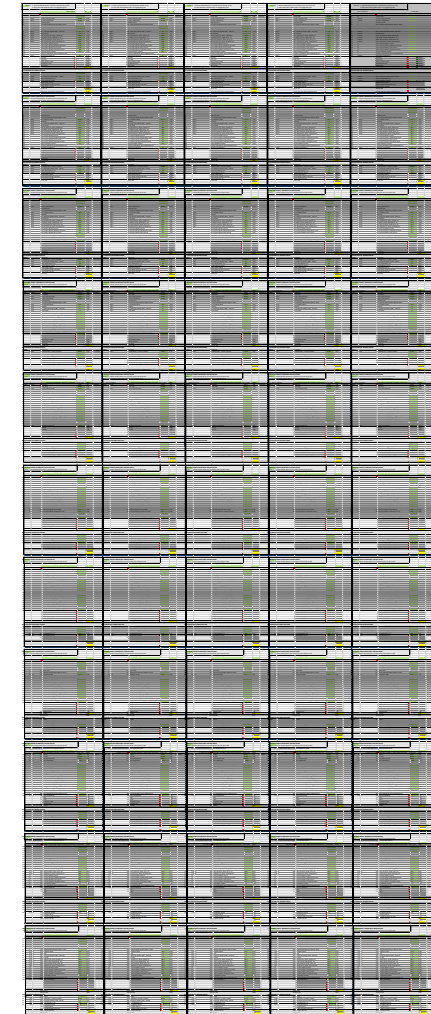
- a single taxa
- one location
- one restoration alternative
- one point in time

NO PROBLEM!

Ad hoc spreadsheet models for:

- multiple taxa
- multiple location
- multiple restoration alternatives
- multiple points in time

WELL....



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WHY BUILD AN R PACKAGE?

Problem for Restoration Practitioners	Why an R package would help
Habitat models have complex structure and lots of input parameters	Compile existing USFWS habitat models in one place
Ad hoc spreadsheet models commonly contain errors	Error-checking and code review are part of R package approval
Ad hoc spreadsheet models are not widely available	R packages are publicly available (and free)
Spreadsheets may have limited visualization capability	Functions can be developed for high-end, rapid data viz
Habitat analyses are often separate from decision tools and require sequential analyses in multiple softwares	One-stop-shopping for integrated habitat and decision modeling
Some practitioners may not be comfortable with modeling	R packages can be accessed through user-friendly “shiny” apps



ECOREST R PACKAGE: HABITAT DATA



Compiled 350+
habitat suitability
models from USFWS

All models and
metadata loaded into
the package

Generic data
structure for user-
defined models

pl.area.avg.summer.flow.pct	pl.area.avg.summer.flow.SIV	cov.pls.litt.area.summer.pct	cov.pls.litt.area.summer.SIV	cov.aq.veg.pct	cov.aq.veg.SIV
0	0	0	0.2	0	0
60	1	20	1.0	15	1
100	1	60	1.0	30	1
NA	NA	100	0.2	100	0
NA	NA	NA	NA	NA	NA
NA	NA	NA	NA	NA	NA
NA	NA	NA	NA	NA	NA

model	submodel	species	geography	ecosystem	documentation	note	HSI.equation
bluegillRiv	RIVERINE Food Component	Lepomis macrochirus	Wherever bluegills occur in North America	Fish Passage, Fresh Wetland, Lake, Large River, Stream	Stuber, RJ, G Gebhart and OE Maughan. 1982. Habitat Suitability Index Models: Bluegill. USFWS Report FWS/OBS- 82/10.8. 26pp.		$\text{ifelse}(\text{CWQ} \mid \text{CR} \leq 0.4, \min(\text{CF}, \text{CC}, \text{CWQ}, \text{CR}), (\text{CFCC}(\text{CWQ}^2) * \text{CR})^{(1/5)})$
bluegillLac	LACUSTRINE Food Component	Lepomis macrochirus	Wherever bluegills occur in North America	Fish Passage, Fresh Wetland, Lake, Large River, Stream	Stuber, RJ, G Gebhart and OE Maughan. 1982. Habitat Suitability Index Models: Bluegill. USFWS Report FWS/OBS- 82/10.8. 26pp.	drop SVI19 in natural lake	$\text{ifelse}(\text{CWQ} \mid \text{CR} \leq 0.4, \min(\text{CF}, \text{CC}, \text{CWQ}, \text{CR}), (\text{CFCC}(\text{CWQ}^2) * \text{CR})^{(1/5)})$

<https://cran.r-project.org/web/packages/ecorest/index.html>



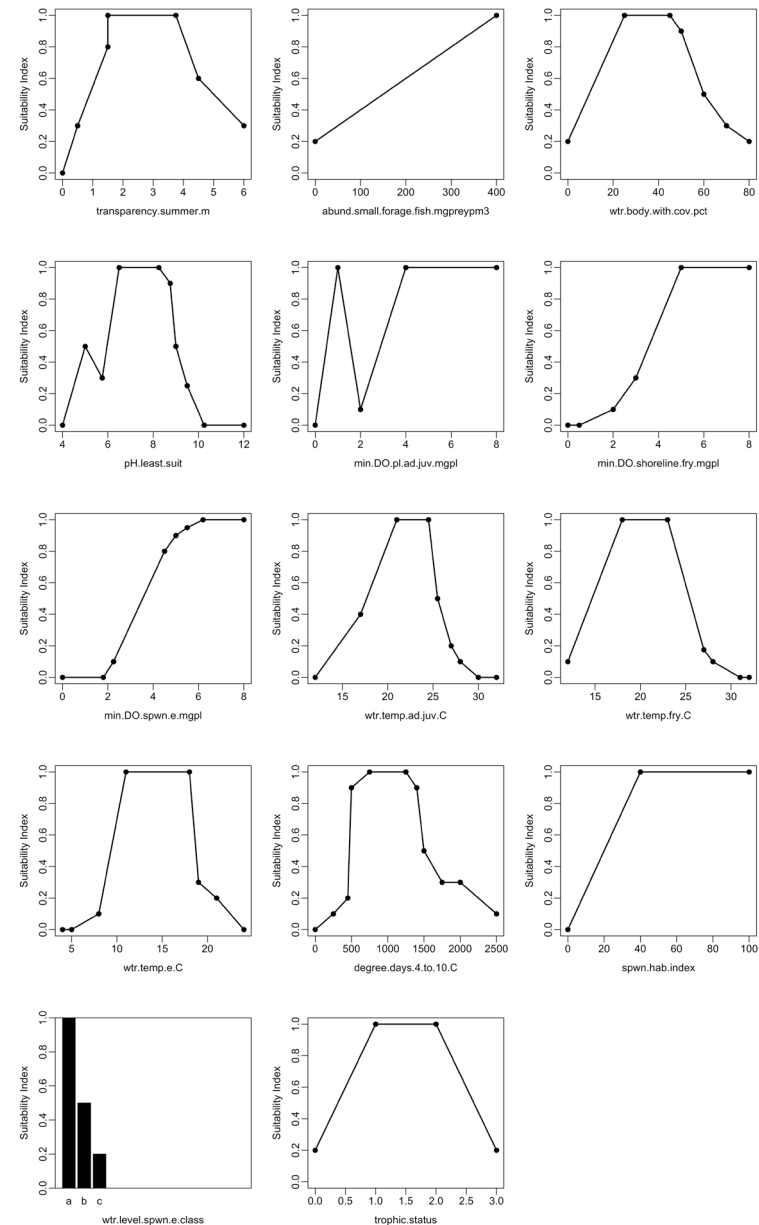
ECOREST R PACKAGE: HABITAT MODELING

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HSIplotter() - plots habitat suitability index curves
SIcalc() - computes suitability

HSleqtn() - Computes patch quality with model equation
HSlarimean() - arithmetic mean
HSIwarimean() - weighted arithmetic mean
HSlgeomean() - geometric mean
HSImin() - minimum of a set of suitability indices



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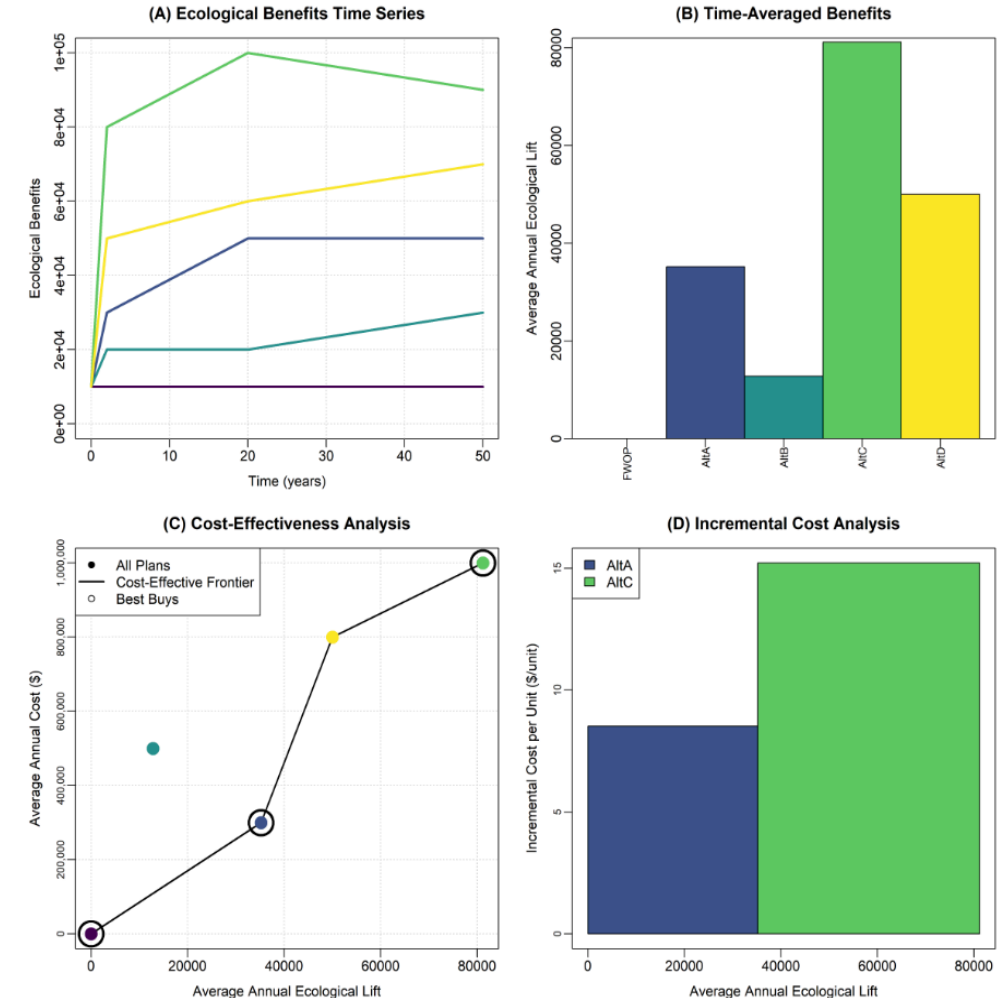


ECOREST PACKAGE: DECISION SUPPORT

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annualizer() - Computes time-averaged
outcomes over the life of a project
CEfinder() - Identifies “cost-effective” plans
BBfinder() - Identifies “best buy” plans
CEICAplotter() - Creates a multi-panel
decision summary



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USER-FRIENDLY WEB-BASED APP (HSI)

EcoRest

★ Home Page

>> Description

>> Website

>> Reference Manual

Model Selection

>> Choose model

>> Visualize model

Habitat Suitability Calculator

>> SI Calculator

>> HU Calculator

Cost-effective Incremental Cost Analysis

>> Annualizer

>> CEICA Plotter

Download Outputs

>> Export Files

Metadata

Click to view your metadata and verify this is the model you need. If model does not meet your needs, please use the user-specified model tab to build your own model.

The search tab to the left can be used to find a specified category.

Search:

barredowl

model	barredowl
species	Strix varia
ecosystem	Floodplain, Fresh Wetland
documentation	Allen, A.W. 1987. Habitat suitability index models: barred owl. U.S. Fish Wild. Serv. Biol. Rep. 82(10.143). 17 pp.
website	https://archive.usgs.gov/archive/sites/www.nwrc.usgs.gov/wdb/pub/hsi/hsi-143.pdf
SIV1	num.trees.mtoe51cm.dbh.0.4ha.SIV
SIV2	avg.dbh.overstory.trees.SIV
SIV3	can.cov.overstory.trees.SIV
Eqtn	$((SIV1 * SIV2)^{(1/2)} * (SIV3))$

Suitability Plots (HSIplotter)

Activate Windows
Go to Settings to activate Windows.

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USER-FRIENDLY WEB-BASED APP (CEICA)

EcoRest

Home Page

Description

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Reference Manual

Model Selection

Choose model

Visualize model

Habitat Suitability Calculator

SI Calculator

HU Calculator

Cost-effective Incremental Cost Analysis

Annualizer

CEICA Plotter

Download Outputs

Export Files

Inputs

Annualizer computes time-averaged quantities based on linear interpolation.
Please enter the numeric vector of time intervals
Below is an example format
Example Format Download
Upload .csv File
Browse... timvec.csv
Upload complete
Please enter the numeric vector of values to be interpolated
Below is an example format
Example Format Download
Upload .csv File
Browse... benefits.csv
Upload complete

Output

indexing 0.csv [=====]
[1] 87.2

EcoRest

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Reference Manual

Model Selection

Choose model

Visualize model

Habitat Suitability Calculator

SI Calculator

HU Calculator

Cost-effective Incremental Cost Analysis

Annualizer

CEICA Plotter

Download Outputs

Export Files

Inputs

CEICApotter Plots Cost-effective Incremental Cost Analysis (CEICA) in
Below is an example format
Example Format Download
Upload .csv File
Browse... CEICA.csv
Upload complete

Output

(A) Cost-Effectiveness Analysis

Ecological Benefit	Cost
0	0
100	1
200	2
300	3
400	4
500	5



TUTORIAL LEARNING OBJECTIVES



- Understand the benefits of conducting HSI modeling programmatically with ecoREST
- Learn how to use ecoREST to implement blue book HSI models
- Build a custom HSI model using ecoREST
- Observe how to use R for a planning-specific analysis



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Current web location

<https://usace-wrises.github.io/USACE.EcoMod.Training>