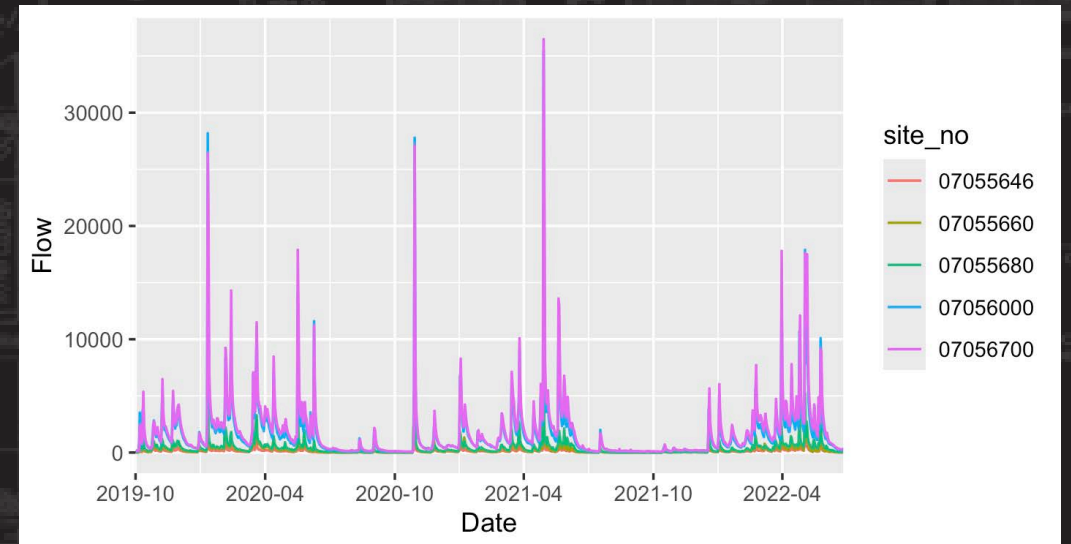
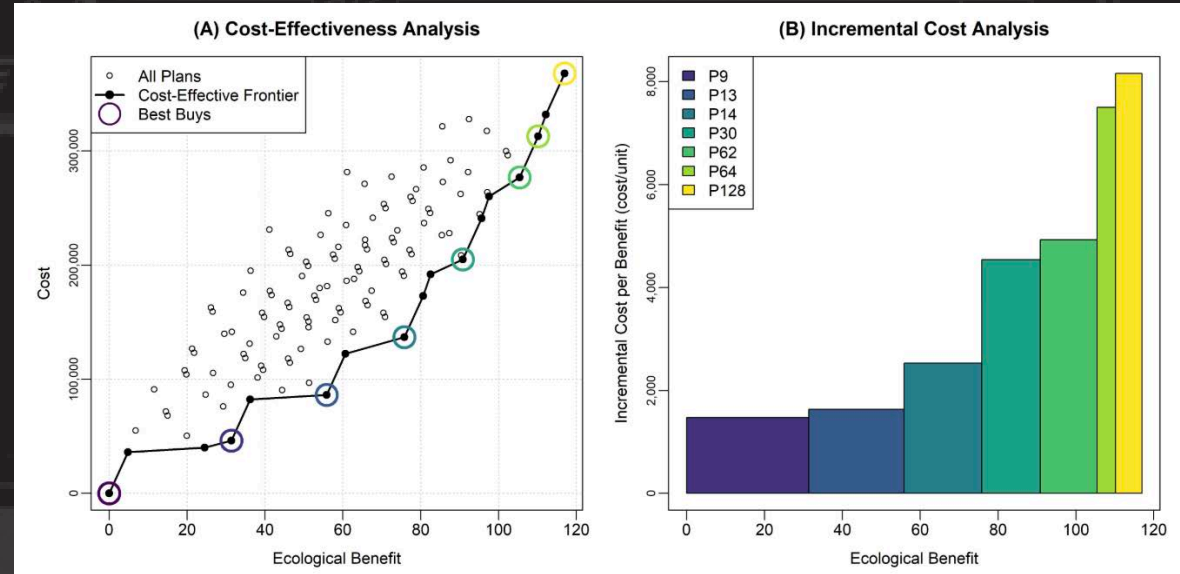


ECOLOGICAL MODELING FOR USACE RESTORATION PLANNING USING R: A TRAINING SERIES

Edward Stowe, PhD

Environmental Lab

EMRRP Webinar
January 2025



U.S. ARMY



US Army Corps
of Engineers®



ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER



OVERVIEW



- Ecological models in restoration/project planning
- Benefits of using R in the planning context
- Overview of training material & different modules
- Future presentations



ECOLOGICAL MODELS FOR RESTORATION PLANNING



Ecological models are used extensively within restoration planning to estimate benefits (or impacts) of projects

Accuracy and validity of models has important consequences for ecosystems





CURRENT MODELING PRACTICES

UNCLASSIFIED

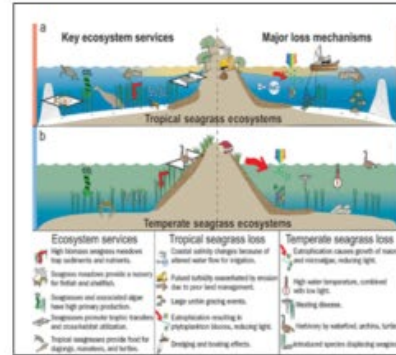


Default approach:
Spreadsheet-based
deterministic habitat
models (esp. habitat
suitability index models)

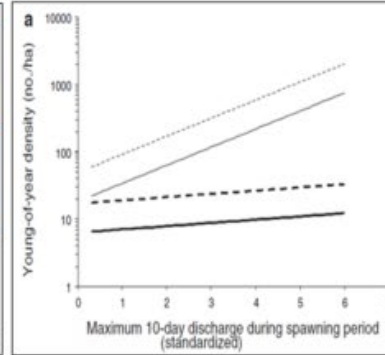
Approach

Outcome

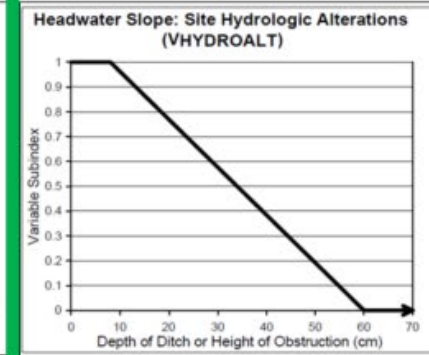
Conceptual



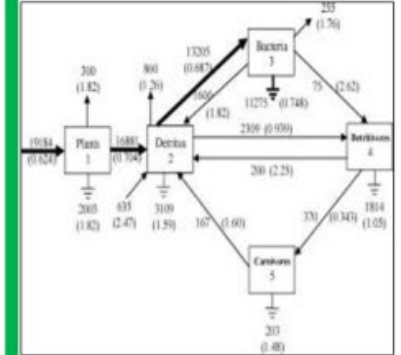
Statistical



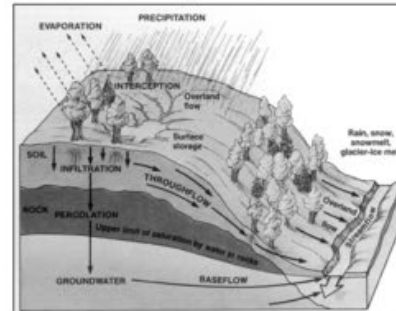
Index-based



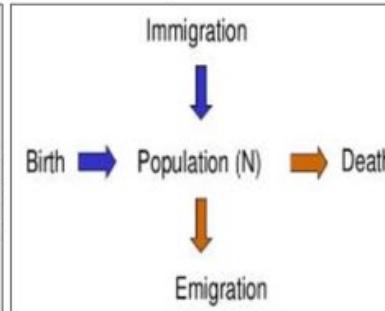
Mass Balance



Physical



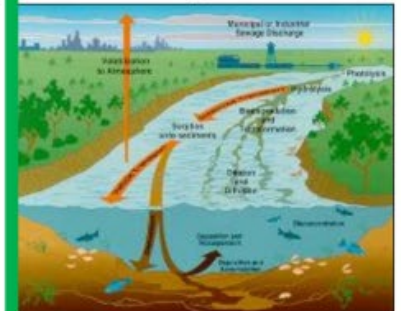
Population



Habitat



Ecosystem



UNCLASSIFIED

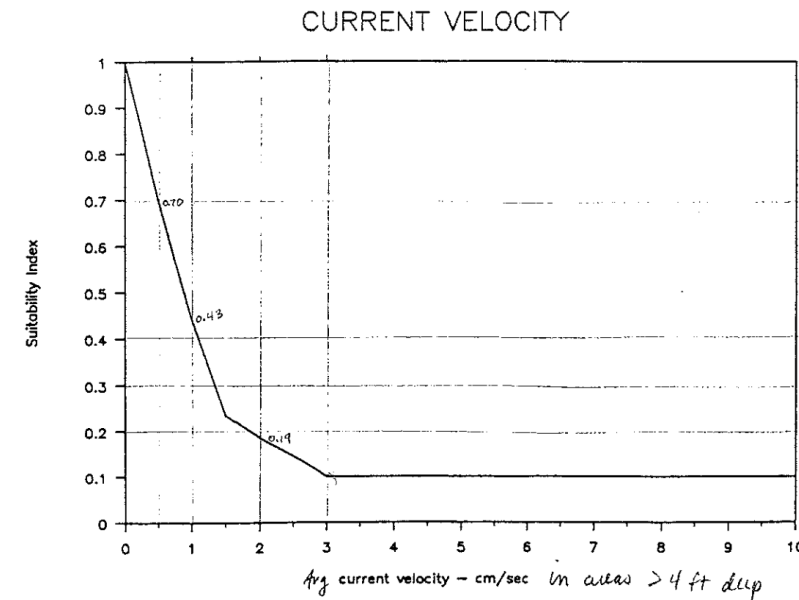
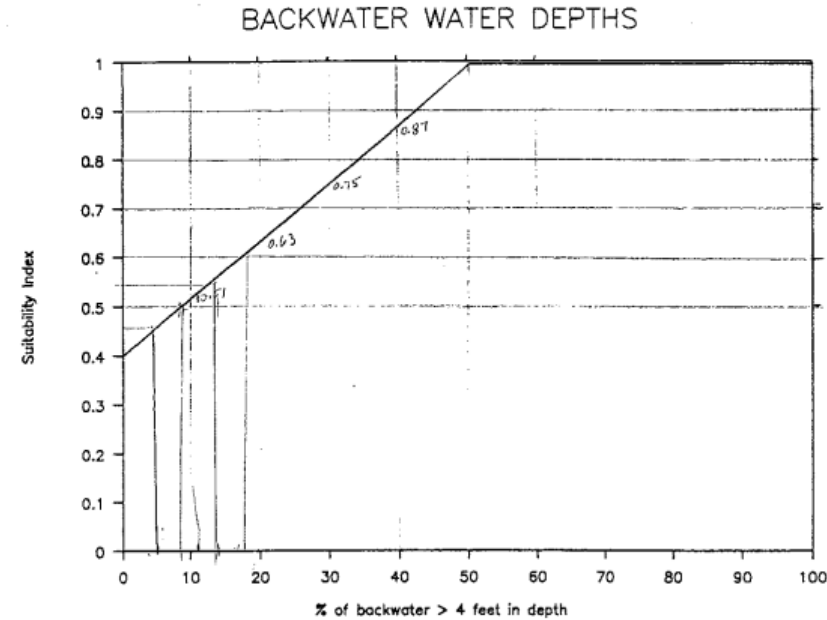


HSI MODELS



Benefits:

- Comprehensible
- Easy to communicate and implement
- Low data requirements
- Parameterized with expert opinion
- High familiarity



Overwintering
Bluegill HSI
Model



HSI MODELS



Benefits:

- Comprehensible
- Easy to communicate and implement
- Low data requirements
- Parameterized with expert opinion
- High familiarity

Shortcomings:

- Rarely validated
- No uncertainty
- Parameterized with expert opinion
- Site-scale variables
- Biased towards frequently utilized species
- Prone to numerical errors



MODERN ECOLOGICAL MODELING



Explosive growth in the research world: proliferation of techniques and resources

Benefits

- Directly predict/measure project objectives
 - E.g. # of individuals instead of units of habitat)
 - Project reduces extinction risk by 50% versus project provides 12.2 habitat units
- Harness modern analytical techniques/computing power/large datasets
- Empirical validation is the standard
- Improved estimates of uncertainty/risk
- Improved communication



Ecological modeling workshop

Vicksburg, MS
September 2023





OPTIONS FOR INCORPORATING INTO PLANNING

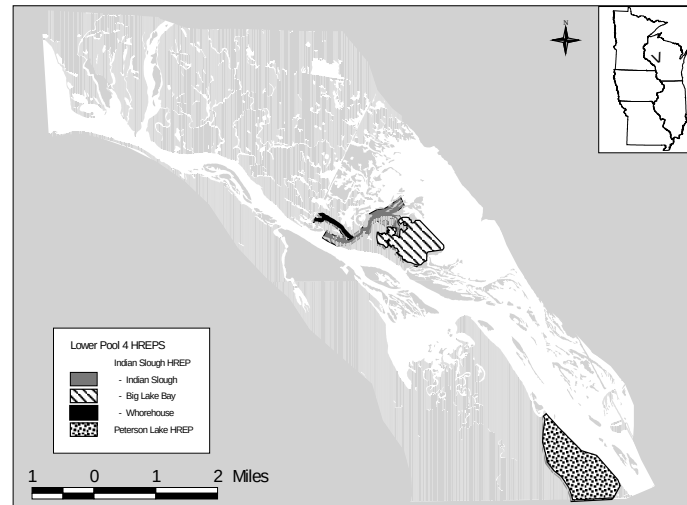


Develop custom models/tools

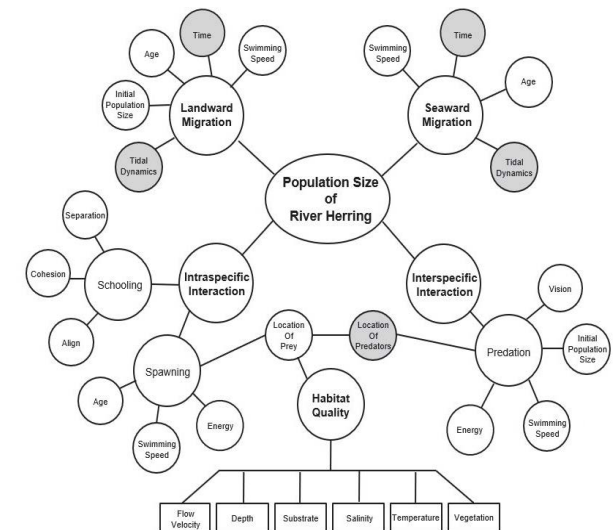
Rio Grande Silvery Minnow Population Model



Upper Mississippi Backwater Fish Community Model



River Herring Agent-based Model





OPTIONS FOR INCORPORATING INTO PLANNING



Cultivate more technical skills

- Using modern models requires more technical skill in some contexts
- Providing trainings that teach/transfer relevant code may be especially fruitful



WHAT IS R?

- Open-source programming language and environment designed for statistical computing and data visualization
- Widely used in academia/industry by data scientists, statisticians, and researchers for data analysis, machine learning, and reporting
- R is often utilized within RStudio, an integrated development environment (IDE) (i.e., a set of tools built to help you be more productive with R)





REASONS TO USE R

Easier to use
than ever
before

- Broad supportive network of users

The screenshot shows a Stack Overflow page for a question titled "Set the size of ggsave exactly". The page is part of the "R Language Collective". The question was asked 8 years, 6 months ago and has been viewed 129k times. The question text is: "I got so confused by the width, height, dpi and unit. Why the following two size different?". Below the question, there are two code snippets for ggsave. The first snippet is: `ggsave(filename = "foo.png", ggplot(mtcars, aes(x=wt, y=mpg)) + geom_point(size=2, shape=23), width = 5, height = 4, dpi = 300, units = "in", d`. The second snippet is: `ggsave(filename = "foo.png", ggplot(mtcars, aes(x=wt, y=mpg)) + geom_point(size=2, shape=23), width = 5, height = 4, dpi = 72, units = "`. The page also features a sidebar with navigation links: Home, Questions, AI Assist, Chat, Articles, Users, Jobs, Companies, COLLECTIVES, and STACK INTERNAL.

UNCLASSIFIED



UNCLASSIFIED

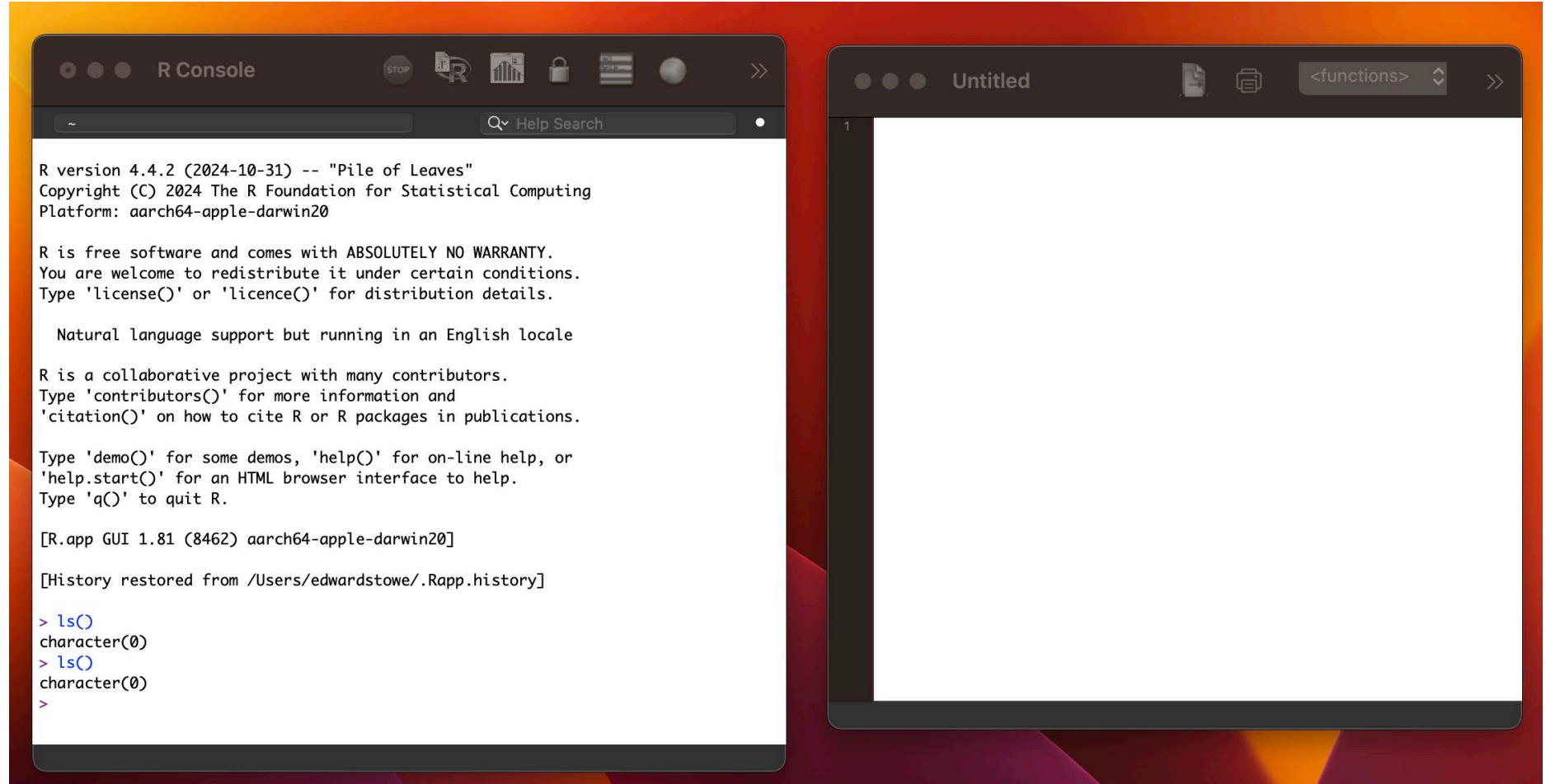


REASONS TO USE R

Easier to use
than ever
before

~15 years ago

- RStudio





Easier to use
than ever
before

- RStudio

UNCLASSIFIED

example_project - RStudio

example_script.R*

```
1 obj_example <- c(1,2)
```

Environment History Connections Tutorial

R Global Environment

Values

obj_example	num [1:2] 1 2
-------------	---------------

Files Plots Packages Help Viewer Presentation

New Folder New File Delete Rename More

Home > Documents > orise > example_project

Name	Size	Modified
..		
.Rproj.user		
data		
example_project.Rproj	253 B	Jan 21, 2026, 12:23 PM
example_script.R	29 B	Jan 21, 2026, 12:27 PM
output		

Console Terminal Background Jobs

R 4.4.2 · ~/Documents/orise/example_project/

Platform: aarch64-apple-darwin20

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

```
> obj_example <- c(1,2)
>
```

UNCLASSIFIED



Easier to use
than ever
before

- RStudio

UNCLASSIFIED

example_project - RStudio

example_script.R*

1 obj_example <- c(1,2)

Script

1:22 (Top Level) R Script

Console

Terminal

Background Jobs

R 4.4.2 · ~/Documents/orise/example_project/

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> obj_example <- c(1,2)

> |

Environment

History

Connections

Tutorial

Import Dataset 97 MiB

R Global Environment

Values

obj_example num [1:2] 1 2

Environment

Files

Plots

Packages

Help

Viewer

Presentation

New Folder New File Delete Rename More

Home Documents orise example_project

	Name	Size	Modified
	..		
	.Rproj.user		
	data		
	example_project.Rproj	253 B	Jan 21, 2026, 12:23 PM
	example_script.R	29 B	Jan 21, 2026, 12:27 PM
	output		

Directory



Easier to use
than ever
before

- RStudio

UNCLASSIFIED

example_project - RStudio

example_script.R

```
1 obj_example <- c(1,2)
2
3 matrix
```

Environment History Connections Tutorial

R Global Environment

Values

obj_example	num [1:2] 1 2
-------------	---------------

Files Plots Packages Help Viewer Presentation

New Folder New File Delete Rename More

Home > Documents > orise > example_project

Name	Size	Modified
..		
.Rproj.user		
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Type 'q()' to quit R.

```
> obj_example <- c(1,2)
>
```

UNCLASSIFIED



Easier to use
than ever
before

- RStudio

UNCLASSIFIED

example_project - RStudio

example_script.R*

Source on Save

Run

Source

```
1 obj_example <- c(1,2)
2
3 matrix|
```

matrix {base}

matrixStats::

Matrix::

MatrixModels::

matrix(data = NA, nrow = 1, ncol = 1, byrow = FALSE, dimnames = NULL)

Matrices

matrix creates a matrix from the given set of values.

as.matrix attempts to turn its argument into a matrix.

is.matrix tests if its argument is a (strict) matrix.

Press F1 for additional help

3:7 (Top Level)

R Script

Console

Terminal

Background Jobs

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> obj_example <- c(1,2)

> |

Environment

History

Connections

Tutorial

Import Dataset

129 MiB

List

R

Global Environment

Values

obj_example num [1:2] 1 2

Files

Plots

Packages

Help

Viewer

Presentation

New Folder

New File

Delete

Rename

More

Home

Documents

orise

example_project

Name

Size

Modified

..

.Rproj.user

data

example_project.Rproj

example_script.R

output

253 B

29 B

Jan 21, 2026, 12:23 PM

Jan 21, 2026, 12:27 PM



Easier to use
than ever
before

- RStudio

example_script.R*

Source on Save

Run

Source

```
1 obj_example <- c(1,2)
2
3 matrix(NA, 3, 4)
4
5 ggplot2::
```

Environment

History

Connections

Tutorial

220 MiB

Global Environment

obj_example

num [1:2] 1 2

geom_bin_2d

geom_bin2d

geom_blank

geom_boxplot

geom_col

geom_contour

geom_contour_filled

geom_count

geom_crossbar

{ggplot2}

{ggplot2}

{ggplot2}

{ggplot2}

{ggplot2}

{ggplot2}

{ggplot2}

{ggplot2}

geom_contour(mapping = NULL, data = NULL, stat = "contour", position = "identity", ..., bins = NULL, binwidth = NULL, breaks = NULL, lineend = "butt", linejoin = "round", linemitre = 10, na.rm = FALSE, show.legend = NA, inherit.aes = TRUE)

2D contours of a 3D surface

ggplot2 can not draw true 3D surfaces, but you can use geom_contour(), geom_contour_filled(), and geom_tile() to visualise 3D surfaces in 2D.

These functions require regular data, where the x and y coordinates form an equally spaced grid, and each combination of x and y appears once. Missing values of z are allowed, but contouring will only work for grid points where all four corners are non-missing. If you have irregular data, you'll need to first interpolate on to a grid before visualising, using

Press F1 for additional help

Console

Terminal

Background Jobs

R 4.4.2 · ~/Documents/orise/example_project/

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> obj_example <- c(1,2)

> |

Viewer

Presentation

Delete

Rename

More

example_project

Size

Modified

data

example_project.Rproj

example_script.R

output

253 B

Jan 21, 2026, 12:23 PM

29 B

Jan 21, 2026, 12:27 PM



Easier to use
than ever
before

- RStudio

UNCLASSIFIED

example_project - RStudio

example_script.R*

Source on Save

Run

Source

1 obj_example <- c(1,2)

2

3 matrix(NA, 3, 4)

4

5 plot(rnorm(25))

6

6:1 (Top Level) R Script

Console

Terminal

Background Jobs

R 4.4.2 · ~/Documents/orise/example_project/

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Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> obj_example <- c(1,2)
> plot(rnorm(25))
>

Environment

History

Connections

Tutorial

Import Dataset

91 MiB

List

R Global Environment

Values

obj_example num [1:2] 1 2

Files

Plots

Packages

Help

Viewer

Presentation

Zoom

Export

Publish

norm(25)

Index

1

0

-1

-2

5

10

15

20

25



REASONS TO USE R

Easier to use
than ever
before

- Chatbots

ChatGPT

Give me R Code to make a scatterplot in ggplot with a dataframe called 'example_dat'.

Here's a simple, clean example using **ggplot2**. I'll assume your dataframe has two numeric columns called `x` and `y`. You can swap those names for your actual variables.

```
r                                                                    Copy code

library(ggplot2)

ggplot(example_dat, aes(x = x, y = y)) +
  geom_point() +
  theme_minimal()
```

Common useful variants

Add color by a grouping variable

```
r                                                                    Copy code

ggplot(example_dat, aes(x = x, y = y, color = group)) +
  geom_point() +
  theme_minimal()
```

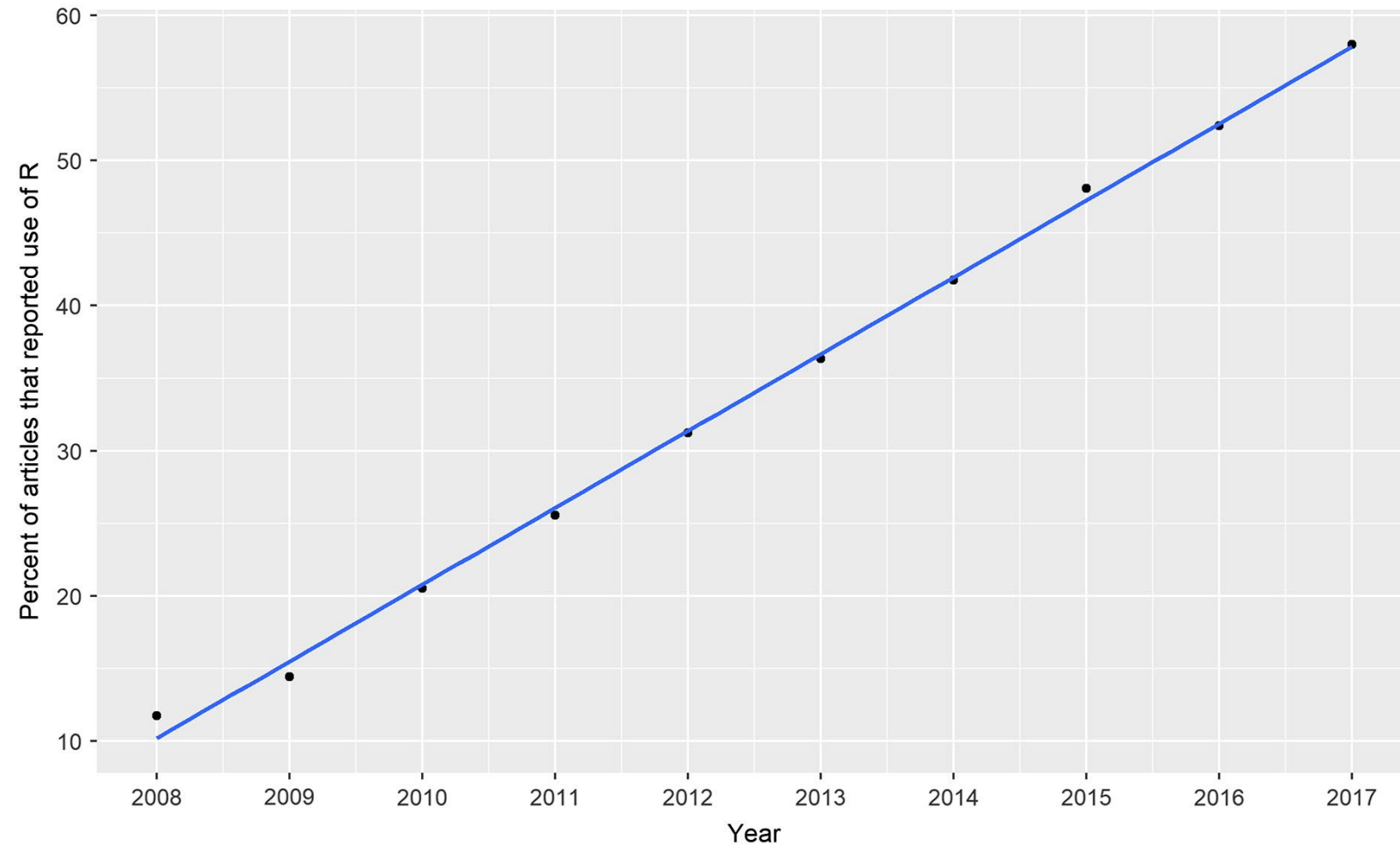
Add transparency and point size

```
r                                                                    Copy code
```



REASONS TO USE R

R underpins
the vast
majority of
ecological
research



Lai et al. 2019



REASONS TO USE R



Enables models that are well-documented & reproducible

- Code files (scripts) document all the steps of an analysis (i.e., no pointing and clicking)
- Re-do analysis by re-running code
- Scripts can be used to share what you did or adapted for similar projects

```

HSI_models_ecorest.Rmd x
Knit on Save ABC 🔍 🌐 Knit ⚙️ +c ⬆️ ⬆️ ⬆️ Run 🔄 Publish
Source Visual Outline
249 ### Cumulative HSI and habitat units
250
251 Next, we'll calculate the habitat units associated with the project, assuming a
total project area of 300 acres.
252 ```{r}
253 # Calculate habitat units by multiplying total HSI by project area (300 acres)
254 area_marsh <- 300
255
256 si_total_hu<-si_total %>%
257   mutate(HUs = area_marsh*total_hsi)
258 ```
259
260 Finally, we can create an output table with all of the data.
261 ```{r}
262 output_tab <- bind_cols(marsh_alts, si_total_hu) %>%
263   set_names(c("Alternative", "PTR", "MA", "HTR", "E", "PTR-SI", "MA-SI",
264             "HTR-SI", "E-SI", "HSI-Total", "Marsh Units"))
265
266 ## Habitat Suitability Index models with `ecorest`
1:1 # Habitat Suitability Index models with `ecorest` R Markdown
  
```



REASONS TO USE R



Enables models that are interdisciplinary & extensible

- Connect to thousands of packages for specialized kinds of analyses
 - Image analysis
 - GIS
 - Time series
 - Hydrologic data
 - Watershed data

Hydrological data sources (surface water/groundwater quantity and quality)

- [dataRetrieval](#): Collection of functions to help retrieve U.S. Geological Survey (USGS) and U.S. Environmental Protection Agency (EPA) water quality and hydrology data from web services.
- [dbhydroR](#): Client for programmatic access to the South Florida Water Management District's 'DBHYDRO' database at <https://www.sfwmd.gov/science-data/dbhydro>, with functions for accessing hydrologic and water quality data.
- [ie2miscdata](#): A collection of Irucka Embry's miscellaneous USGS data sets (USGS Parameter codes with fixed values, USGS global time zone codes, and US Air Force Global Engineering Weather Data). Irucka created these data sets while a Cherokee Nation Technology Solutions (CNTS) United States Geological Survey (USGS) Contractor and/or USGS employee.
- [dbhydroR](#): Client for programmatic access to the South Florida Water Management District's [DBHYDRO database](#), with functions for accessing hydrologic and water quality data.
- [echor](#): An R interface to [United States Environmental Protection Agency \(EPA\) Environmental Compliance History Online \('ECHO'\)](#). Provides functions to locate facilities with discharge permits and download discharge records.
- [FedData](#): Functions to Automate Downloading Geospatial Data Available from Several Federated Data Sources.
- [hubeau](#): Get Data from the French National Database on Water [Hub 'Eau'](#), the free and public French National APIs on water.
- [isoWater](#): R interface to the [Waterisotopes Database](#). Provides functions to query and obtain stable H and O isotope data from water samples collected at >60,000 sites worldwide.



REASONS TO USE R

Accessibility:

- Free
- Open-source
- On ACE-IT machines



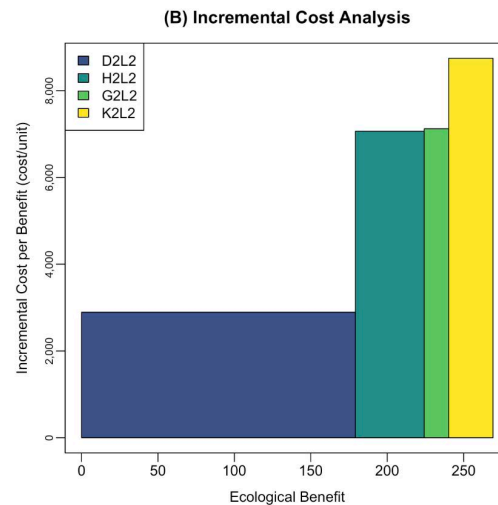
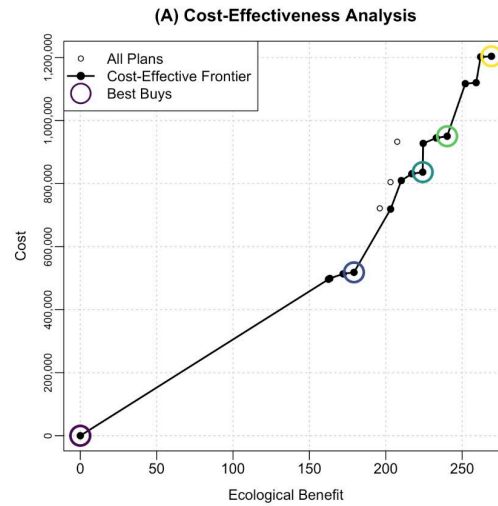
REASONS TO USE R

UNCLASSIFIED

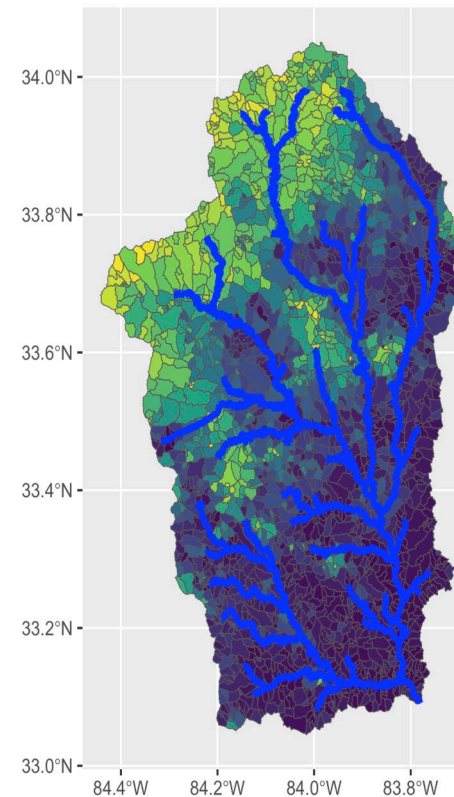


High-quality graphics and interfaces

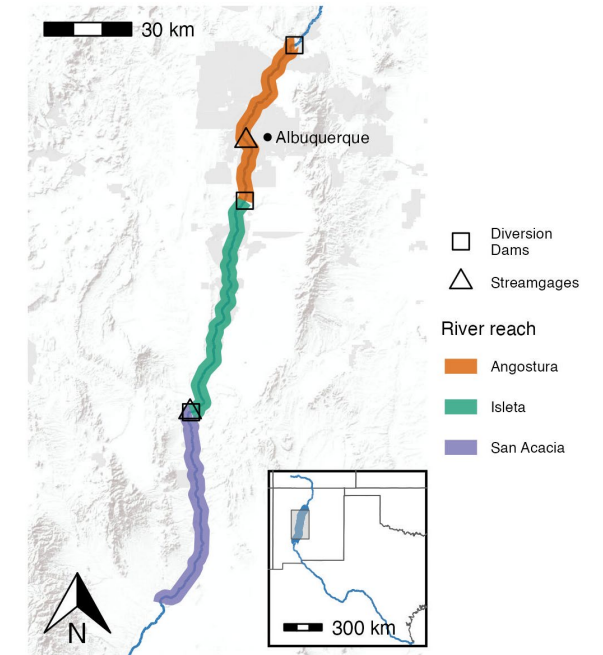
CEICA
plots



Watershed analyses



Maps



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REASONS TO USE R

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High-quality graphics and interfaces

1. Introduction
2. Project Planning Framework
Plan Formulation Strategy
Ecological Models
Monetary Costs
Summary of Inputs to CEICA
3. Site-by-site analysis
Site 17F2M
Site 17D2E
Site 17B
Site 2A
Site 2B
Site 3E
Site 3F
Site 19A
4. Watershed-scale analysis:
Ecological Benefits
5. Economics, Socioeconomics, and Human Resources
Watershed Demographic Analysis
Restoration Site Demographics
Regional Economic Development (RED) Benefits
6. Summary of Recommendations
References Cited
Appendix A: Acronyms
Appendix B: Site-scale Ecological and Cost Data
Appendix C: CEICA Outcomes for All Watershed-scale Plans

Socioeconomic Analysis

S. Kyle McKay, Stephen Phillips, Liya E. Abera, and Garrett Menichino

December 2024

Corresponding Author:

Kyle McKay, PhD, PE

Environmental Laboratory (EL)

U.S. Army Engineer Research and Development Center (ERDC)

U.S. Army Corps of Engineers (USACE)

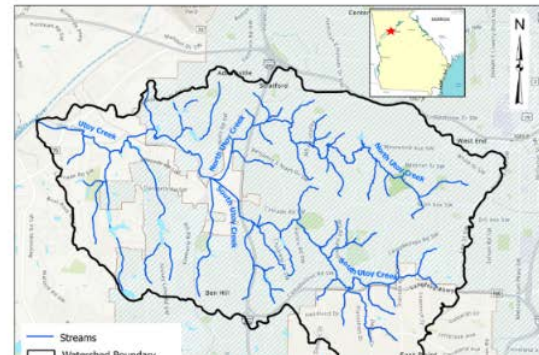
Email: kyle.mckay@usace.army.mil

Model Accessibility: An interactive version of this report may be accessed [here](#). The underlying numerical code as well as an MS Word version of this analysis may be downloaded from [this github repository](#).

Disclosure: This Appendix represents a conglomeration of work between ERDC and Mobile District for a stream restoration study in Utoy Creek, Atlanta, Georgia. The study is led by the Mobile District of the U.S. Army Corps of Engineers (USACE) in partnership with the City of Atlanta.

1. Introduction

The Utoy Creek watershed drains the southwest portion of the City of Atlanta into the Chattahoochee River (Figure 1). This small-to-middle order stream is within the Piedmont region of the southeastern United States, and Utoy Creek exhibits many common characteristics of regional streams, such as historical channel degradation due to poor sediment management as well as modern challenges like flashy runoff from urban development (Jackson et al. 2023). The majority of Utoy Creek's watershed is situated within City of Atlanta boundaries; however, downstream portions of the watershed are within Fulton County. Two main tributaries, North and South Utoy Creeks, unite to form the main stem approximately five river miles upstream the Chattahoochee River (EPA, 2016). The total combined length of the main stem and primary tributaries is approximately 22 miles (Walker, 2016). Including sub-tributaries, the total length of stream is over 50 miles in the Utoy Creek watershed. The total drainage basin is approximately 33.7 square miles with 64% developed and 18% impervious.



UNCLASSIFIED



REASONS TO USE R

Reads data of all shapes and sizes

- Spreadsheets
- Spatial data (shapefiles, etc.)
- Hydrologic data
- JSON files
- SQL and other database files
- NetCDF
- ...



ERDC-DEVELOPED WEB-BASED TRAINING MATERIAL

UNCLASSIFIED



[Using R for ecological modeling in USACE](#)

Table of contents

[Using R for ecological modeling in USACE restoration planning](#)

[Required set-up for the course](#)

Basic Training on R and RStudio

[1 Introduction to R and RStudio](#)

[2 Data Visualization with ggplot2](#)

[3 Exploring and understanding data](#)

[4 Manipulating Tabular Data](#)

Ecological Modeling

[5 Conceptual Ecological Models](#)

Habitat Models

Using R for ecological modeling in USACE restoration planning

Motivation

Ecological models are an important tool for ecosystem restoration planning within the U.S. Army Corps of Engineers. Models are used to estimate the ecosystem benefits of different restoration alternatives or projects. Ecosystem benefits are coupled with cost data to identify cost effective plans at different price levels, and to ultimately select restoration plans to undertake. So, the outputs of ecological models are very important in determining what projects are built! However, ecological modeling within USACE is primarily a spreadsheet-based activity featuring deterministic habitat models. The ecological modeling capacity of USACE biologists can be greatly improved by incorporating modern data science practices, especially the uptake of R, a programming language that is used in the majority of ecological research being conducted today. R promotes research that is well-documented, reproducible, interdisciplinary, and extensible. R also works on all kinds of data, produces high-quality graphics, has a broad supportive network of

On this page

[Using R for ecological modeling in USACE restoration planning](#)

[Motivation](#)

[Intended audience](#)

[Learning objectives](#)

[Module format](#)

[Module structure](#)

[Additional resources to be provided by instructors](#)

[Course subject matter](#)

Current web location

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

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MATERIAL OVERVIEW



- Developed/adapted to relate specifically to ecological planning
- Modules include code to carry out specific analyses along with background/explanation/interpretation
- Material exists as a living repository with continual new content and adaptations
- Not just R: provides additional modules on ecological modeling in USACE context
- Can be accessed by users independently or adapted into workshops/short courses
- Videos to be included as they occur



CURRENT MODULES



Using R

- Intro to R & Rstudio
- [Visualization using ggplot \(March 25\)](#)
- Data Basics
- Data Wrangling

Habitat Modeling

- Conceptual Ecological Models
- Intro. to Habitat Modeling
- [HSI Models with ecoREST package \(Feb. 11\)](#)
- HSI Uncertainty and Sensitivity Analysis

Decision Support

- Annualization of Costs and Benefits
- Cost Effectiveness and Incremental Cost Analysis
- Model Integration

Linear Modeling

- Linear Models
- Generalized Linear Models

Machine Learning

- [Random Forest \(March 4\)](#)

Other Ecological Models

- Network Models
- Population Models
- Agent-based Models

R for Data Access

- Public Data Sources
- Hydrologic Data (Gages)
- Watershed Data (NHD)



SHORT COURSES



Topics

- Habitat Suitability Index models with the *ecorest* package in R (Feb. 11)
- Machine learning with R for USACE Planning (March 4)
- Data visualization in R using *ggplot* (March 25)

Participant options

- Material to do so will be accessible ahead of time
- Follow code along with the presenter
- Watch without coding



SHORT COURSES

Habitat Suitability Index models with the *ecorest* package in R (Feb. 11)

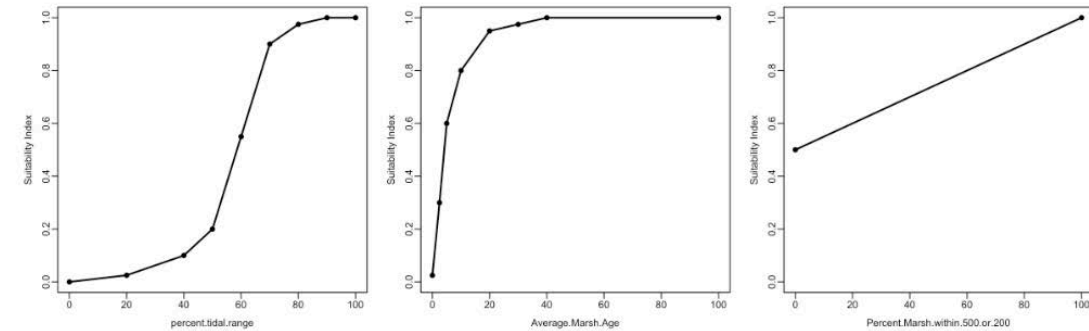
- Background on *ecorest* (350 Blue Book HSI models)
- Overview of some of the functions in *ecorest*
- Run an example Blue Book model
- Run a custom HSI model

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HSI Plots derived with *ecorest*

```
HSIplotter(marsh_model,"images/marsh_model.jpg")
```



Output generated by *ecorest*

Alternative	PTR	MA	HTR	E	PTR-SI	MA-SI	HTR-SI	E-SI	HSI-Total	Marsh Units
FWOP	0	0	0	0	0.00	0.03	0.5	0.5	0.00	0.00
Alt1a	20	100	0	0	0.03	1.00	0.5	0.5	0.23	69.62
Alt1b	50	100	0	0	0.20	1.00	0.5	0.5	0.46	139.25
Alt1c	100	100	0	0	1.00	1.00	0.5	0.5	0.79	238.11
Alt2a	20	100	20	100	0.03	1.00	0.6	1.0	0.27	81.43
Alt2b	50	100	20	100	0.20	1.00	0.6	1.0	0.54	162.87

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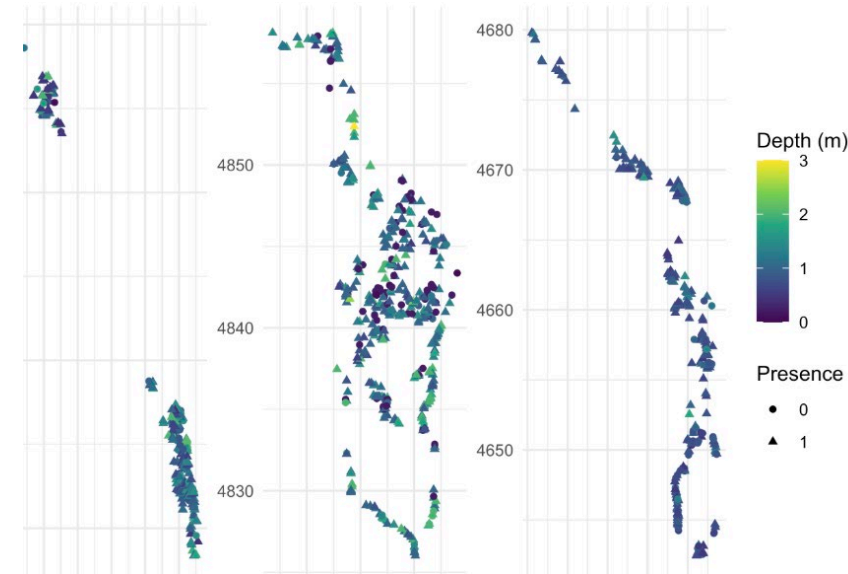
SHORT COURSES

Machine learning with R for USACE Planning (March 4)

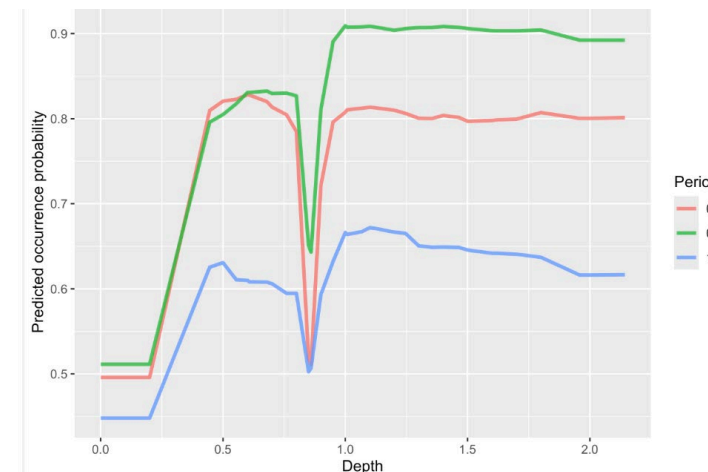
- Background on machine learning in the context of restoration planning
- Special emphasis on random forest algorithm
- Case study with full random forest workflow using *tidymodels* that predicts bluegill presence in response to environmental features

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Upper Mississippi River Fish Dataset



Partial Dependence Plot



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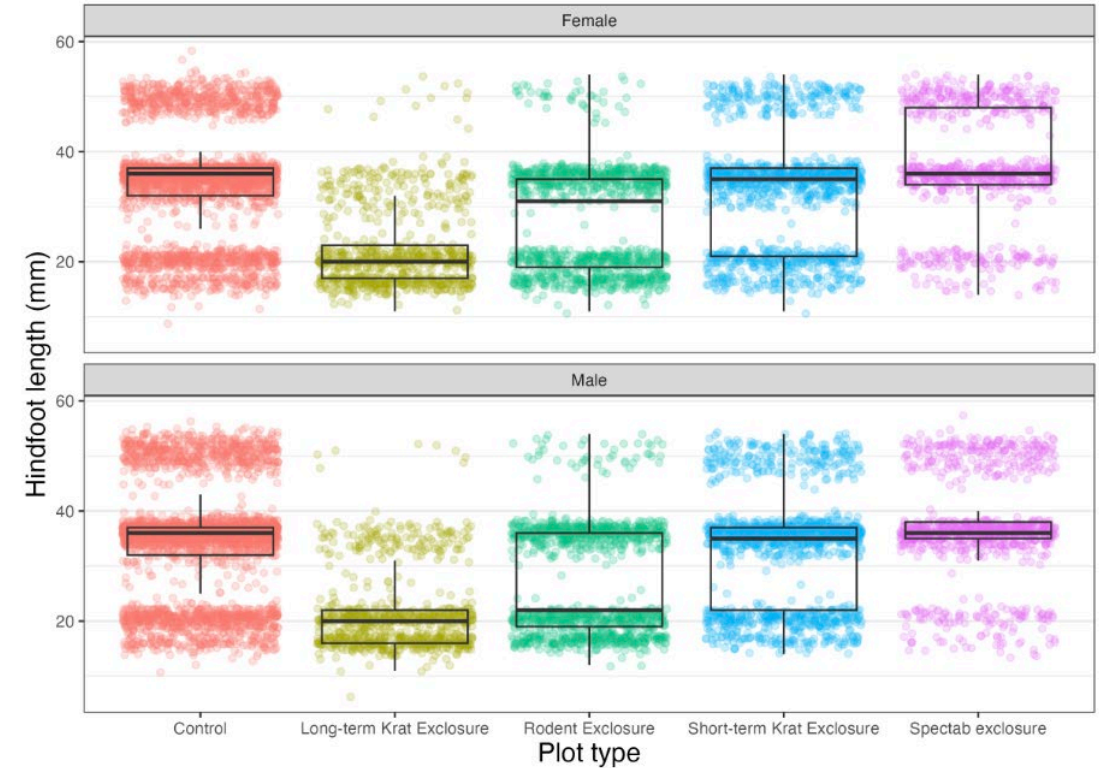
SHORT COURSES

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Data visualization in R using *ggplot* (March 25)

- Learn how to use the powerful *ggplot2* package to make figures in R
- Overview of the architecture of ggplot
- Demonstration of different plot types, themes, scale modifications, faceting



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CONCLUSION



- Ecological modeling and data science with R have the potential to augment restoration planning
- Uniquely suited for the interdisciplinary and science-driven work of the USACE
- Learning R can be daunting but there are more resources than ever before, and users do not need to be experts immediately
- Training materials represent one way of expanding on current ecological modeling practices



ACKNOWLEDGEMENTS



Research funding

- Ecosystem Management and Restoration Research Program (EMRRP)



Material developers

- Kiara Cushway
- Todd Swannack
- Kyle McKay
- Brian Breaker
- Edmund Howe
- Water Research Integrating Socio-ecological and Engineered Systems (WRISES) Team

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Current web location

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



Easier to use
than ever
before

- RStudio

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The screenshot displays the RStudio environment with the following components:

- Script Editor:** Contains a single line of R code: `obj_example <- c(1,2)`.
- Environment:** Shows the 'Global Environment' with a variable 'obj_example' of type 'num' containing values 1 and 2.
- Console:** Displays the R version (4.4.2), platform (aarch64-apple-darwin20), and a series of help messages. It also shows the execution of `> 2+2` resulting in `[1] 4`, and `> obj_example <- c(1,2)`.
- Files:** Lists installed and available packages.

Name	Description	Version
System Library		
☐ abind	Combine Multidimensional Arrays	1.4-8
☐ afex	Analysis of Factorial Experiments	1.5-0
☐ amadeus	Accessing and Analyzing Large-Scale Environmental Data	1.2.3
☐ aplot	Decorate a 'ggplot' with Associated Information	0.2.8
☐ archive	Multi-Format Archive and Compression Support	1.1.12
☐ arrow	Integration to 'Apache' 'Arrow'	21.0.0
☐ askpass	Password Entry Utilities for R, Git, and SSH	1.2.1
☐ assertthat	Easy Pre and Post Assertions	0.2.1
☐ backports	Reimplementations of Functions Introduced Since R-3.0.0	1.5.0
☐ baguette	Efficient Model Functions for Bagging	1.1.0
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☐ BayesFactor	Computation of Bayes Factors for Common Designs	0.9.12-4.7

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- RStudio

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script_file.R x

1 obj_example <- c(1,2)

Script

1:22 (Top Level) R Script

Console Terminal Background Jobs

R 4.4.2 · ~/Documents/orise/umr/umr_analysis/

Copyright (C) 2024 The R Foundation for Statistical Computing
Platform: aarch64-apple-darwin20

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> 2+2
[1] 4
> obj_example <- c(1,2)
> |

umr_analysis - main - RStudio

Environment History Connections Git Tutorial

Import Dataset 99 MiB

R Global Environment

Values

obj_example num [1:2] 1 2

Environment

Files Plots Packages Help Viewer Presentation

Install Update

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System Library		
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38



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- RStudio

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The screenshot displays the RStudio environment with the following components:

- Script Editor:** Contains the code:

```
1 obj_example <- c(1,2)
2
3 matrix|
```
- Environment:** Shows the Global Environment with a variable `obj_example` of type `num` with values `[1:2] 1 2`.
- Console:** Displays the R version `R 4.4.2`, platform `aarch64-apple-darwin20`, and various help messages. It also shows the execution of `> 2+2` resulting in `[1] 4` and `> obj_example <- c(1,2)`.
- Files:** Lists installed and available packages.

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System Library		
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script_file.R*

1 obj_example <- c(1,2)

2

3 matrix|

matrix {base}

matrixStats::

Matrix::

MatrixModels::

matrix(data = NA, nrow = 1, ncol = 1, byrow = FALSE, dimnames = NULL)

Matrices

matrix creates a matrix from the given set of values.

as.matrix attempts to turn its argument into a matrix.

is.matrix tests if its argument is a (strict) matrix.

Press F1 for additional help

3:7 (Top Level)

R Script

Console

Terminal

Background Jobs

R 4.4.2 · ~/Documents/orise/umr/umr_analysis/

Copyright (C) 2024 The R Foundation for Statistical Computing

Platform: aarch64-apple-darwin20

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Type 'q()' to quit R.

> 2+2

[1] 4

> obj_example <- c(1,2)

> |

Environment

History

Connections

Git

Tutorial

Import Dataset

224 MiB

R

Global Environment

Values

obj_example num [1:2] 1 2

Files

Plots

Packages

Help

Viewer

Presentation

Install

Update

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The screenshot displays the RStudio environment with the following components:

- Source Editor:** Contains a script named `script_file.R` with the following code:

```
1 obj_example <- c(1,2)
2
3 rnorm(25) |>
4   plot()
5 |
```
- Environment Panel:** Shows the `obj_example` variable with values `num [1:2] 1 2`.
- Console:** Displays the R session output, including a message about natural language support and a list of contributors. It also shows the execution of `2+2` resulting in `[1] 4`, and an error message for `rnorm(3) >|`: `Error: unexpected '|' in "rnorm(3) >|"`. The current prompt is `>`.
- Plots Panel:** Shows a scatter plot of `rnorm(25)` values against their `Index` (1 to 25). The y-axis ranges from -2.0 to 1.0.

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IMPROVED DATA SCIENCE PRACTICES



Some improvements in ecological modeling for planning can be accomplished with the same models but improved data science techniques

Coding enables:

Reproducibility

Clear communication

Easier data visualization and sharing