

Package ‘hydromeso’

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Title Classify Fluvial Mesohabitats from Depth and Velocity

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Description Classifies hydraulic conditions into nominal fluvial mesohabitat categories using water depth and velocity. It implements the eight-class scheme in the preprint by Cordero and Harris <[doi:10.2139/ssrn.7100727](https://doi.org/10.2139/ssrn.7100727)>, supports validated rectangular custom schemes, and works with tabular and spatial data through 'terra'. Outputs describe hydraulic classes and do not by themselves establish biological habitat quality or species occurrence.

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URL <https://el-cordero.github.io/hydromeso/>,
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classify_mesohabitat	<i>Classify fluvial mesohabitats</i>
----------------------	--------------------------------------

Description

Main dispatcher for numeric values, tables, spatial vectors, and rasters. All forms use the same lower-inclusive, upper-exclusive rule engine.

Usage

```
classify_mesohabitat(  
  x,  
  velocity = NULL,  
  depth_col = NULL,  
  velocity_col = NULL,  
  ...  
)
```

Arguments

<code>x</code>	Numeric depth values, a table, a <code>SpatVector</code> , a <code>SpatRaster</code> , or a supported file path.
<code>velocity</code>	Numeric velocity values or a velocity raster/path.
<code>depth_col, velocity_col</code>	Table/vector column selectors.
<code>...</code>	Arguments passed to the type-specific classifier.

Value

The corresponding classified data frame, `SpatVector`, or categorical `SpatRaster`.

See Also

[classify_mesohabitat_values\(\)](#), [classify_mesohabitat_table\(\)](#), [classify_mesohabitat_vector\(\)](#), [classify_mesohabitat_raster\(\)](#)

Examples

```
classify_mesohabitat(c(0.2, 0.8), c(0.1, 0.4))
```

```
classify_mesohabitat_raster
```

Classify depth and velocity rasters

Description

Supports separate rasters or a selected pair in one multilayer raster. Depth is always the geometry template. Continuous velocity is aligned only when explicitly requested and always with bilinear interpolation.

Usage

```
classify_mesohabitat_raster(
  depth,
  velocity = NULL,
  scheme = meso_scheme_default(),
  depth_layer = NULL,
  velocity_layer = NULL,
  align = c("error", "velocity_to_depth"),
  aoi = NULL,
  mask_aoi = TRUE,
  assume_crs = NULL,
  dry_threshold = NULL,
  invalid = c("error", "NA"),
  filename = "",
```

```

    overwrite = FALSE,
    ...
)

```

Arguments

depth	A SpatRaster or raster path. It may contain both selected layers when velocity = NULL.
velocity	A separate SpatRaster or path, or NULL.
scheme	A validated meso_scheme; values must use its units.
depth_layer, velocity_layer	Optional layer names or positions.
align	"error" or "velocity_to_depth".
aoi	Optional SpatVector or vector path.
mask_aoi	If TRUE, crop and polygon-mask; otherwise rectangular crop.
assume_crs	Optional CRS assigned only to inputs missing a CRS. This does not transform coordinates and emits a message.
dry_threshold, invalid	Classification controls.
filename	Optional output filename.
overwrite	Permit overwriting filename.
...	Additional <code>terra::writeRaster()</code> options.

Value

A categorical integer SpatRaster on the (possibly AOI-cropped) depth geometry, with a complete class table.

See Also

`classify_mesohabitat_series()`, `write_mesohabitat()`

Examples

```

d <- terra::rast(nrows = 2, ncols = 4, xmin = 0, xmax = 4, ymin = 0, ymax = 2,
  crs = "EPSG:32615", vals = c(0.2, 0.8, 1.5, 0.2, 0.2, 0.8, 0.8, 1.5))
v <- d
terra::values(v) <- c(0.1, 0.1, 0.1, 0.4, 0.8, 0.4, 0.8, 0.8)
classify_mesohabitat_raster(d, v)

```

```
classify_mesohabitat_series
```

Classify paired hydraulic raster scenarios

Description

Named scenarios are paired by unique names. Unnamed inputs are rejected unless positional pairing is explicitly requested.

Usage

```
classify_mesohabitat_series(  
  depth,  
  velocity,  
  scenario_names = NULL,  
  positional = FALSE,  
  scheme = meso_scheme_default(),  
  ...  
)
```

Arguments

<code>depth, velocity</code>	Multilayer SpatRaster objects, lists of rasters, or lists of raster paths.
<code>scenario_names</code>	Optional unique names that explicitly define both lists.
<code>positional</code>	Permit explicit position-based pairing when names are absent.
<code>scheme</code>	A <code>meso_scheme</code> .
<code>...</code>	Passed to classify_mesohabitat_raster() .

Value

A categorical multilayer SpatRaster, one layer per scenario.

See Also

[mesohabitat_from_median_hydraulics\(\)](#), [modal_mesohabitat\(\)](#)

Examples

```
d <- terra::rast(nrows = 1, ncols = 2, vals = c(0.2, 0.8), crs = "EPSG:32615")  
v <- terra::rast(d); terra::values(v) <- c(0.1, 0.4)  
classify_mesohabitat_series(list(low = d), list(low = v))
```

```
classify_mesohabitat_table
```

Classify a table of depth and velocity observations

Description

Classify a table of depth and velocity observations

Usage

```
classify_mesohabitat_table(
  x,
  depth_col,
  velocity_col,
  scheme = meso_scheme_default(),
  class_col = "mesohabitat_class",
  label_col = "mesohabitat",
  keep_input = TRUE,
  overwrite = FALSE,
  dry_threshold = NULL,
  invalid = c("error", "NA"),
  ...
)
```

Arguments

<code>x</code>	A data frame, matrix, or path to a CSV file.
<code>depth_col, velocity_col</code>	Column names or one-based positions.
<code>scheme</code>	A validated <code>meso_scheme</code> .
<code>class_col, label_col</code>	Names for appended output fields.
<code>keep_input</code>	Keep all input columns; if FALSE, return selected inputs and classifications only.
<code>overwrite</code>	Permit replacing existing output columns.
<code>dry_threshold, invalid</code>	Passed to classify_mesohabitat_values() .
<code>...</code>	Additional arguments passed to utils::read.csv() for a path.

Value

A data frame in the original row order.

See Also

[classify_mesohabitat_vector\(\)](#), [write_mesohabitat\(\)](#)

Examples

```
x <- data.frame(site = letters[1:3], d = c(0.2, 0.8, 2), v = c(0.1, 0.4, 0.7))
classify_mesohabitat_table(x, "d", "v")
```

```
classify_mesohabitat_values
```

Classify numeric depth and velocity values

Description

Applies one authoritative rule-table engine. Lower bounds are inclusive, upper bounds are exclusive, missing inputs remain missing, and zero depth and velocity are classified mathematically (Class 1 under the default scheme).

Usage

```
classify_mesohabitat_values(
  depth,
  velocity,
  scheme = meso_scheme_default(),
  dry_threshold = NULL,
  invalid = c("error", "NA")
)
```

Arguments

depth, velocity	Numeric vectors in the units declared by scheme. Length-one inputs may be deliberately recycled; other unequal lengths fail.
scheme	A validated meso_scheme.
dry_threshold	NULL to preserve the scheme exactly, or a nonnegative depth at or below which classifications become NA.
invalid	Either "error" (default) or "NA" for negative and infinite observations. Values are never clamped or replaced with zero.

Value

A data frame containing depth, velocity, integer mesohabitat_class, and unordered factor mesohabitat.

References

Cordero, E. and Harris, A. (Preprint). SSRN. doi:[10.2139/ssrn.7100727](https://doi.org/10.2139/ssrn.7100727).

See Also

[classify_mesohabitat\(\)](#), [classify_mesohabitat_table\(\)](#), [convert_hydraulic_units\(\)](#)

Examples

```
classify_mesohabitat_values(c(0.2, 0.61, 1.37), c(0.1, 0.61, 0.3))
```

```
classify_mesohabitat_vector
```

Classify spatial vector features from depth and velocity attributes

Description

Geometry, CRS, feature order, and existing attributes are retained. Points, lines, and polygons are accepted because classification uses attributes.

Usage

```
classify_mesohabitat_vector(
  x,
  depth_col,
  velocity_col,
  scheme = meso_scheme_default(),
  class_col = "mesohabitat_class",
  label_col = "mesohabitat",
  overwrite = FALSE,
  dry_threshold = NULL,
  invalid = c("error", "NA"),
  layer = NULL,
  ...
)
```

Arguments

<code>x</code>	A <code>terra::SpatVector</code> or vector dataset path supported by <code>terra</code> .
<code>depth_col, velocity_col</code>	Attribute names or positions.
<code>scheme, class_col, label_col, overwrite, dry_threshold, invalid</code>	As in classify_mesohabitat_table() .
<code>layer</code>	Optional layer name when reading a multi-layer vector dataset.
<code>...</code>	Additional arguments passed to terra::vect() for a path.

Value

A `terra::SpatVector` with integer class and label attributes.

See Also

[classify_mesohabitat_raster\(\)](#), [write_mesohabitat\(\)](#)

Examples

```
x <- data.frame(x = 1:3, y = 1:3, depth = c(0.2, 0.8, 2),
               velocity = c(0.1, 0.4, 0.7))
v <- terra::vect(x, geom = c("x", "y"), crs = "EPSG:32615")
classify_mesohabitat_vector(v, "depth", "velocity")
```

compare_mesohabitat	<i>Compare two classified mesohabitat rasters</i>
---------------------	---

Description

Reports nominal transitions, gains and losses by class, unchanged area, and percentage changed. Numeric differences between IDs are never interpreted.

Usage

```
compare_mesohabitat(before, after, align = c("error", "after_to_before"))
```

Arguments

before, after	Single-layer classified SpatRaster objects.
align	"error" (default) or "after_to_before"; explicit alignment uses nearest-neighbor resampling because class values are categorical.

Value

A list of ordinary data frames and scalar area metrics.

See Also

[summarize_mesohabitat\(\)](#)

convert_hydraulic_units	<i>Convert hydraulic depth and velocity units</i>
-------------------------	---

Description

Explicitly converts values before classification. The default scheme remains defined at exactly 0.61 and 1.37 m and 0.30 and 0.61 m/s; converted imperial values can differ slightly at rounded published boundaries.

Usage

```
convert_hydraulic_units(
  depth = NULL,
  velocity = NULL,
  depth_from = "m",
  depth_to = "m",
  velocity_from = "m/s",
  velocity_to = "m/s"
)
```

Arguments

`depth`, `velocity` Optional numeric values.
`depth_from`, `depth_to` One of "m", "cm", or "ft".
`velocity_from`, `velocity_to` One of "m/s", "cm/s", or "ft/s".

Value

A list with converted depth and velocity.

Examples

```
convert_hydraulic_units(depth = 2, velocity = 1,
  depth_from = "ft", velocity_from = "ft/s")
```

hydromeso_example	<i>Synthetic hydraulic observations</i>
-------------------	---

Description

A small redistributable data frame with every default mesohabitat class, exact and adjacent threshold cases, coordinates, and missing values. Depth is in metres and velocity is in metres per second. Coordinates are synthetic UTM Zone 15N metres (EPSG:32615).

Usage

```
hydromeso_example
```

Format

A data frame with 18 rows and four variables:

x Synthetic easting.
y Synthetic northing.
depth Water depth in metres.
velocity Velocity in metres per second.

Source

Created synthetically for this package.

Examples

```
hydromeso_example
classify_mesohabitat_table(hydromeso_example, "depth", "velocity")
```

```
mesohabitat_example_rasters
```

Load example HEC-RAS hydraulic rasters

Description

Loads a compact pair of depth and velocity GeoTIFFs derived from the 31 May 2022 HEC-RAS model output used by Cordero and Harris (Preprint). The sample shows the Big Blue-Kansas Rivers confluence near Manhattan, Kansas. Source cells were cropped to the manuscript's detailed visualization extent, aggregated from 3-foot to 18-foot cells, and converted to metres and metres per second. The raster geometry remains in the source project's documented NAD 1983 (CORS96) StatePlane Kansas North coordinate system.

Usage

```
mesohabitat_example_rasters(paths = FALSE)
```

Arguments

paths	Logical. If FALSE (default), return loaded SpatRaster objects. If TRUE, return their installed GeoTIFF paths.
-------	---

Value

A named list with depth and velocity rasters or file paths.

References

Cordero, E. and Harris, A. (Preprint). *Semi-Supervised and Supervised Machine Learning Approaches to Predicting Fluvial Mesohabitats from Satellite Data*. SSRN. doi:10.2139/ssrn.7100727.

Examples

```
x <- mesohabitat_example_rasters()
classify_mesohabitat_raster(x$depth, x$velocity)
```

```
mesohabitat_example_vector
```

Create a synthetic example spatial vector

Description

Create a synthetic example spatial vector

Usage

```
mesohabitat_example_vector()
```

Value

A point terra::SpatVector in EPSG:32615 made from [hydromeso_example](#).

Examples

```
mesohabitat_example_vector()
```

```
mesohabitat_from_median_hydraulics
```

Mesohabitat derived from median hydraulic surfaces

Description

Calculates cellwise median depth and median velocity, then classifies those hydraulic surfaces. This is not a numeric median of nominal class IDs and should not be called "median mesohabitat".

Usage

```
mesohabitat_from_median_hydraulics(
  depth,
  velocity,
  na.rm = TRUE,
  scheme = meso_scheme_default(),
  ...
)
```

Arguments

depth, velocity	Multilayer SpatRaster objects or scenario lists.
na.rm	Remove missing values in the cellwise medians.
scheme	A meso_scheme.
...	Passed to classify_mesohabitat_raster() .

Value

A named list containing median_depth, median_velocity, and mesohabitat_from_median_hydraulics.

See Also

[classify_mesohabitat_series\(\)](#), [modal_mesohabitat\(\)](#)

mesohabitat_palette	<i>Stable mesohabitat class colors</i>
---------------------	--

Description

Stable mesohabitat class colors

Usage

```
mesohabitat_palette(scheme = meso_scheme_default())
```

Arguments

scheme A meso_scheme.

Value

A named character vector keyed by class label.

meso_scheme	<i>Construct a mesohabitat classification scheme</i>
-------------	--

Description

Creates and validates a rectangular classification in depth-velocity space. Every lower bound is inclusive and every upper bound is exclusive. Class IDs are nominal identifiers, not ecological ranks.

Usage

```
meso_scheme(
  rules,
  name = "Custom mesohabitat scheme",
  description = NULL,
  depth_units = "m",
  velocity_units = "m/s",
  citation = NULL,
  source_doi = NULL,
  allow_gaps = FALSE,
  allow_negative = FALSE
)
```

Arguments

rules	A data frame with class_id, label, depth_min, depth_max, velocity_min, and velocity_max.
name	Nonempty scheme name.
description	Optional description.
depth_units, velocity_units	Nonempty unit labels.
citation	Optional source citation.
source_doi	Optional source DOI.
allow_gaps	Whether uncovered regions at nonnegative depth and velocity are permitted.
allow_negative	Whether negative rule minima are permitted.

Value

An object of class meso_scheme.

See Also

`validate_meso_scheme()`, `meso_scheme_default()`, `classify_mesohabitat_values()`

Examples

```
rules <- data.frame(
  class_id = c(1L, 2L), label = c("Slow", "Fast"),
  depth_min = c(0, 0), depth_max = c(Inf, Inf),
  velocity_min = c(0, 0.5), velocity_max = c(0.5, Inf)
)
meso_scheme(rules, name = "Two velocity classes")
```

meso_scheme_default	<i>Default eight-class fluvial mesohabitat scheme</i>
---------------------	---

Description

Returns the exact depth-velocity classification used by Cordero and Harris (Preprint). The broader depth-velocity framework is informed by Aadland (1993), whose paper describes six habitat types and should not be read as the source of the two added high-velocity class names. Inputs must be metres and metres per second unless explicitly converted before classification.

Usage

```
meso_scheme_default()
```

Value

A validated meso_scheme with eight nominal classes.

References

Cordero, E. and Harris, A. (Preprint). *Semi-Supervised and Supervised Machine Learning Approaches to Predicting Fluvial Mesohabitats from Satellite Data*. SSRN. doi:10.2139/ssrn.7100727.

Aadland, L. P. (1993). Stream Habitat Types: Their Fish Assemblages and Relationship to Flow. *North American Journal of Fisheries Management*, 13, 790-806. doi:10.1577/15488675(1993)013<0790:SHTTFA>2.3.CO;2

See Also

`meso_scheme()`, `plot_meso_scheme()`

Examples

```
meso_scheme_default()
```

<code>meso_scheme_rules</code>	<i>Extract the rules from a mesohabitat scheme</i>
--------------------------------	--

Description

Extract the rules from a mesohabitat scheme

Usage

```
meso_scheme_rules(x)
```

Arguments

`x` A `meso_scheme`.

Value

A plain data frame containing the rule table.

Examples

```
meso_scheme_rules(meso_scheme_default())
```

modal_mesohabitat	<i>Modal mesohabitat across scenarios</i>
-------------------	---

Description

Computes the most frequent nominal class per cell. It never calculates a numeric median of class IDs.

Usage

```
modal_mesohabitat(x, ties = c("NA", "lowest_class"), na.rm = TRUE)
```

Arguments

x	A classified multilayer SpatRaster.
ties	"NA" (default) or "lowest_class".
na.rm	Ignore missing scenarios.

Value

A single categorical SpatRaster.

plot_mesohabitat	<i>Plot classified mesohabitat output</i>
------------------	---

Description

Plot classified mesohabitat output

Usage

```
plot_mesohabitat(
  x,
  depth_col = "depth",
  velocity_col = "velocity",
  class_col = "mesohabitat_class",
  label_col = "mesohabitat",
  scheme = .scheme_from_object(x),
  palette = mesohabitat_palette(scheme),
  legend = TRUE,
  legend_ncol = 4,
  legend_cex = 0.75,
  ...
)
```

Arguments

x	A classified table, SpatVector, or SpatRaster.
depth_col, velocity_col	Table columns for depth and velocity.
class_col, label_col	Classification columns.
scheme	A meso_scheme.
palette	Named colors.
legend	Show one shared legend below the plot or plot panels.
legend_ncol	Number of columns in the shared legend.
legend_cex	Legend text size multiplier.
...	Additional plotting arguments.

Value

x, invisibly.

plot_meso_scheme	<i>Plot a mesohabitat classification scheme</i>
------------------	---

Description

Plot a mesohabitat classification scheme

Usage

```
plot_meso_scheme(
  scheme = meso_scheme_default(),
  xlim = NULL,
  ylim = NULL,
  reverse_depth_axis = FALSE,
  palette = mesohabitat_palette(scheme),
  ...
)
```

Arguments

scheme	A meso_scheme.
xlim, ylim	Optional finite velocity and depth limits.
reverse_depth_axis	Reverse the displayed depth axis only when TRUE.
palette	Named class colors.
...	Additional arguments passed to <code>graphics::plot.default()</code> .

Value

The scheme, invisibly.

summarize_mesohabitat *Summarize mesohabitat classes*

Description

Summarizes classified tables, vectors, rasters, and raster scenarios. Raster areas use `terra::cellSize()` and are valid for projected or geographic grids.

Usage

```
summarize_mesohabitat(
  x,
  class_col = "mesohabitat_class",
  label_col = "mesohabitat",
  denominator = c("classified", "non_na", "mask"),
  analysis_mask = NULL
)
```

Arguments

<code>x</code>	A classified data frame, <code>SpatVector</code> , or <code>SpatRaster</code> .
<code>class_col</code> , <code>label_col</code>	Classification field names for tables/vectors.
<code>denominator</code>	Raster percentage denominator: "classified", "non_na", or "mask". The first two are equivalent for a classified raster; "mask" uses <code>analysis_mask</code> area.
<code>analysis_mask</code>	Optional raster mask.

Value

An ordinary data frame.

See Also

`compare_mesohabitat()`

validate_meso_scheme	<i>Validate a mesohabitat classification scheme</i>
----------------------	---

Description

Performs deterministic breakpoint-based checks of rule structure, metadata, overlaps, gaps, and reachability. The nonnegative depth-velocity plane is the required domain unless gaps are allowed. No random sampling is used.

Usage

```
validate_meso_scheme(x)
```

Arguments

x	A meso_scheme object.
---	-----------------------

Value

The validated object, invisibly.

See Also

[meso_scheme\(\)](#)

Examples

```
validate_meso_scheme(meso_scheme_default())
```

write_mesohabitat	<i>Write classified mesohabitat output</i>
-------------------	--

Description

Dispatches to a categorical GeoTIFF or other raster format, a terra vector format, or CSV. Shapefile output uses short safe class field names to avoid silent truncation.

Usage

```
write_mesohabitat(  
  x,  
  filename,  
  overwrite = FALSE,  
  sidecar = TRUE,  
  create_dir = FALSE,  
  scheme = .scheme_from_object(x),  
  ...  
)
```

Arguments

<code>x</code>	A classified data frame, <code>SpatVector</code> , or <code>SpatRaster</code> .
<code>filename</code>	Output path.
<code>overwrite</code>	Permit replacement.
<code>sidecar</code>	Write a CSV class table beside the output.
<code>create_dir</code>	Create missing parent directories only when TRUE.
<code>scheme</code>	A <code>meso_scheme</code> used for the sidecar.
<code>...</code>	Format-specific writer arguments.

Value

The normalized output path, invisibly.

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