Package ‘spacemodR’

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Title Workflow for Environmental Risk Assessment: Habitat, Food Web, Dispersal, Exposure and Risk

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Description A set of tools dedicated to modeling food web transfer based on an initial ground raster. It provides a directed acyclic graph structure for a set of rasters representing the flow of elements (e.g., food, energy, contaminants). It also includes tools for working with dispersal algorithms, enabling the combination of flux data with population movement.

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Contents

`add_habitat` *Add habitat zones to a Habitat object*

Description

Add habitat zones to a Habitat object

Usage

```
add_habitat(hab, sf_data, weight = 1, ...)
```

Arguments

`hab`	A Habitat object
`sf_data`	An sf object containing geometries to add
`weight`	A weight to apply on the habitat feature. Can then be used as resistance for dispersal functions for instance.
`...`	Additional arguments

Value

A Habitat object with new geometries added as habitat

`add_link` *Add links to a trophic table*

Description

Adds one or several directed links to a trophic_tbl object.

Usage

```
add_link(tbl, from, to, weight = 1)
```

Arguments

`tbl`	A `trophic_tbl` object.
`from`	A single character string indicating the source node.
`to`	A character vector indicating target nodes.
`weight`	A numeric vector of weights associated with each link. If a single value is provided, it is recycled to match the length of `to`.

Details

The function performs several checks:

- `from` must be a scalar character string
- `to` must be a character vector
- Links must be unique
- Self-loops (from == to) are forbidden
- The resulting graph must remain acyclic

Value

A validated `trophic_tbl` object with the new links added.

Examples

```
net <- trophic() |>
  add_link("a", "b", weight = 1)
```

`add_nohabitat` *Add non-habitat zones to a Habitat object*

Description

Add non-habitat zones to a Habitat object

Usage

```
add_nohabitat(hab, sf_data, ...)
```

Arguments

`hab`	A Habitat object
`sf_data`	An sf object containing geometries to add
`...`	Additional arguments

Value

A Habitat object with new geometries added as non-habitat

`compute_dispersal` *Compute dispersal or spread map (Generic Engine)*

Description

Low-level function to apply spatial processing (Convolution or External algorithms) to a raster. It handles NA masking and method dispatch to Julia if necessary.

Usage

```
compute_dispersal(x, method = "convolution", options = list(), mask = NULL)
```

Arguments

`x`	SpatRaster. Source layer to disperse.
`method`	Character. "convolution" or "omniscape" (placeholder).
`options`	List. Parameters (e.g., ‘kernel‘ for convolution).
`mask`	SpatRaster (optional). A mask to apply after dispersion (e.g., maintain original NA structure).

Value

A `SpatRaster` object containing the dispersed values.

`compute_kernel` *Create a 2D Gaussian motion kernel as a SpatRaster*

Description

Create a 2D Gaussian motion kernel as a SpatRaster

Usage

```
compute_kernel(radius, GSD, size_std = 1.5)
```

Arguments

`radius`	Numeric, std of the distribution in meters
`GSD`	Numeric, ground sampling distance in meters per pixel
`size_std`	Numeric, how many std to extend kernel on each side

Value

A matrix defining the kernel

`dispersal` *Disperse a species or variable over the landscape*

Description

Applies a dispersal mechanism to a specific layer of the ‘spacemodel‘ object. This function acts as a wrapper around `compute_dispersal` to handle the ‘spacemodel‘ class structure.

Usage

```
dispersal(
  spacemodel,
  layer = 1,
  method = "convolution",
  method_option = list()
)
```

Arguments

`spacemodel`	A `spacemodel` object.
`layer`	Character or Integer. The name or index of the layer to disperse (e.g., "Fox", 1).
`method`	Character. The dispersal method to use. Options are: • `"convolution"` (default): Uses a moving window (kernel). • `"omniscape"`: Uses Circuit Theory (via Julia and Omniscape.jl).
`method_option`	A list of parameters specific to the chosen method: • For `"convolution"`: must contain `kernel` (a matrix). • For `"omniscape"`: must contain `resistance` (SpatRaster) and `radius` (numeric).

Value

The `spacemodel` object with the specified layer updated with dispersed values.

See Also

`compute_dispersal`

Examples

```
## Not run:
# 1. Convolution example
my_kernel <- matrix(1, nrow=3, ncol=3)
sm_updated <- dispersal(sm, layer = "Predator", method = "convolution",
                        method_option = list(kernel = my_kernel))

# 2. Omniscape example (requires Julia)
sm_updated <- dispersal(sm, layer = "Predator", method = "omniscape",
                        method_option = list(resistance = res_map, radius = 10))

## End(Not run)
```

`flux` *Apply trophic flux from a resource layer*

Description

Computes the contribution of a resource raster to a consumer layer using the normalized weight and a flux function stored in the trophic table.

Usage

```
flux(raster, intakes, from, to)
```

Arguments

`raster`	A `SpatRaster` (or similar) representing exposure from the resource.
`intakes`	A `trophic_tbl` object that must contain a column `normalized_weight` and a column `flux`.
`from`	Character string, name of the source node.
`to`	Character string, name of the target node.

Details

The function extracts the link corresponding to `from -> to` from the trophic table and applies:

1. the associated flux function to the raster values
2. the normalized weight of the link

An error is thrown if no such link exists.

Value

A raster object with transformed values.

`get_departements_for_roi`

Identify codes of departments intersecting a region of interest

Description

This function takes a region of interest (ROI) as an ‘sf‘ or ‘sfc‘ object and returns the codes of departments intersecting this region.

Usage

```
get_departements_for_roi(roi)
```

Arguments

`roi`	A spatial object of type ‘sf‘ or ‘sfc‘ representing the region of interest. Use only the first geometry (polygon).

Value

A character vector containing the codes of departments intersecting the region of interest.

Examples

```
library(sf)
roi <- sf::st_as_sfc(sf::st_bbox(
  c(xmin = 600000, ymin = 6600000, xmax = 650000, ymax = 6650000),
  crs = 2154)
)
departments <- get_departements_for_roi(roi)
```

`get_ocsge_data_fgb` *Efficiently retrieve OCS GE data from a remote FlatGeobuf*

Description

This function retrieves OCS GE (Land Cover) data for a specific Region of Interest (ROI) directly from a remote FlatGeobuf (.fgb) file hosted on a server (e.g., S3).

It leverages GDAL's virtual file system ('/vsicurl/') and the spatial indexing capabilities of FlatGeobuf to download only the data chunks intersecting the bounding box of the ROI, making it highly efficient for large datasets.

Usage

```
get_ocsge_data_fgb(roi, fgb_url)
```

Arguments

`roi`	An `sf` object defining the Region Of Interest. It can be in any projection, but will be transformed to EPSG:2154 (Lambert-93) internally.
`fgb_url`	Character string. The public URL to the remote '.fgb' file.

Details

The function performs the following steps:

1. Transforms the `roi` to Lambert-93 (EPSG:2154).
2. calculates the bounding box of the `roi`.
3. Uses `sf::st_read` with a WKT filter to fetch only relevant features from the remote file.
4. Applies a precise geometric intersection ('st_intersection') to clip the data to the exact shape of the `roi`.

Value

An `sf` object containing the OCS GE polygons intersected by the ROI, projected in Lambert-93 (EPSG:2154).

Note

This function requires a working internet connection and GDAL support for the FlatGeobuf driver and network capabilities (vsicurl).

Examples

```
## Not run:
  library(sf)

  # 1. Define a Region of Interest (ROI)
  # Example: A small bounding box in France
  my_roi <- st_as_sf(data.frame(
    lon = c(2.3, 2.4, 2.4, 2.3, 2.3),
    lat = c(48.8, 48.8, 48.9, 48.9, 48.8)
  ), coords = c("lon", "lat"), crs = 4326)

  # 2. URL to the remote FlatGeobuf file
  # (Replace with the actual URL of your OCS GE bucket)
  url_fgb <- "https://example.com/data/ocsge_grand_est.fgb"

  # 3. Fetch data
  ocsge_data <- get_ocsge_data_fgb(roi = my_roi, fgb_url = url_fgb)

  # 4. Check result
  print(ocsge_data)
  plot(st_geometry(ocsge_data))

## End(Not run)
```

`habitat` *Create a Habitat object*

Description

Create a spatial Habitat object based on an optional `sf` data.frame. If no geometry is provided, creates an empty Habitat object. The object has columns:

- `habitat`: logical, TRUE/FALSE
- `weight`: numeric
- `geometry`: sfc geometry

Usage

```
habitat(geometry = NULL, habitat = NULL, weight = NULL)
```

Arguments

`geometry`	An object of class `sf` or `sfc`. Optional, default is empty.
`habitat`	Logical vector indicating habitat presence. Default is logical(0).
`weight`	Numeric vector of weights. Default is numeric(0).

Value

An object of class `habitat`, inheriting from `sf` and `data.frame`.

Examples

```
library(sf)

# Empty habitat
h <- habitat()
h

# Habitat with geometries
geom <- st_sfc(
  st_point(c(0, 0)),
  st_point(c(1, 1)),
  crs = 4326
)

hab <- habitat(
  geometry = geom,
  habitat = c(TRUE, FALSE),
  weight = c(0.8, 0)
)
hab
```

`habitat_raster` *Create a raster from a habitat object*

Description

Create a raster from a habitat object

Usage

```
habitat_raster(ground_raster, habitat)
```

Arguments

`ground_raster`	SpatRaster (reference grid).
`habitat`	habitat object inherited from `sf` data.frame class.

Value

SpatRaster (weight and NA in nogo)

`intake` *Constructor for Intake Parameters*

Description

Creates and configures the trophic flux table with a simplified syntax.

Usage

```
intake(x, ..., default = NULL, normalize = TRUE)
```

Arguments

`x`	A ‘spacemodel‘ object or a ‘trophic_tbl‘.
`...`	Flux definitions. - Key ‘"Target"‘ (e.g., ‘"Fox" = 0.5‘): applies to all links pointing to Fox. - Key ‘"Source -> Target"‘ (e.g., ‘"Soil -> Worm" = 0.8‘): targets a specific link. Values can be numeric (linear coefficient), formulas, or functions.
`default`	The default function for unspecified links (default is identity).
`normalize`	Logical. Whether to normalize diet weights (default TRUE).

Value

A ‘trophic_tbl‘ with a configured ‘flux‘ column.

`is_cyclic` *Test if a directed graph is cyclic*

Description

Implements Kahn’s algorithm to detect cycles in a directed graph.

Usage

```
is_cyclic(df)
```

Arguments

`df`	A data.frame with columns `from` and `to`.

Value

Logical. TRUE if the graph contains at least one cycle.

Examples

```
df <- data.frame(from=c("A","B"), to=c("B","A"))
is_cyclic(df)
```

`load_raster_extdata` *load raster file from internal data*

Description

A raster of the (example).

Usage

```
load_raster_extdata(path_name)
```

Arguments

`path_name`	Path of the raster (.tiff) file to download.

Format

An object ‘SpatRaster‘ (package terra).

Value

A `SpatRaster` object

Source

Internal data package.

See Also

`rast`

`lower_neighbors` *Get resource layers for a given trophic layer*

Description

Returns the upstream neighbors (prey/resources) of a given layer in a trophic graph.

Usage

```
lower_neighbors(trophic_tbl, layer)
```

Arguments

`trophic_tbl`	A `trophic_tbl` object
`layer`	Name of the layer (string) in the spacemodel.

Value

A character vector of names of layers that are resources for `layer`.

`normalize_weights` *Normalize weights of a trophic table*

Description

Adds a new column `normalized_weight` to a `trophic_tbl` object so that, for each target node (`to`), the sum of incoming weights equals 1.

Usage

```
normalize_weights(tbl)
```

Arguments

`tbl`	A `trophic_tbl` object.

Details

For every unique value in the `to` elements of the `link` column, the function divides each corresponding weight by the total weight of all links pointing to that same node.

Nodes with no incoming links are left unchanged.

Value

A `trophic_tbl` object with an additional column `normalized_weight`.

Examples

```
net <- trophic() |>
  add_link("a", "b", weight = 2) |>
  add_link("c", "b", weight = 3)

net_norm <- normalize_weights(net)
```

`ocsge_metaleurop` *SF object defining very simplified OCS-GE soil cover metaleurop*

Description

Simple feature collection with 9 features and 11 fields. Projected CRS: RGF93 v1 / Lambert-93.

Usage

```
data(ocsge_metaleurop)
```

Format

An object of class `sf` (inherits from `data.frame`) with 9 rows and 12 columns.

Examples

```
data(ocsge_metaleurop)
```

`ocsge_species_dict` *Valued weight between OCSGE layer and species*

Description

Valued weight between OCSGE layer and species

Usage

```
data(ocsge_species_dict)
```

Format

An object of class `data.frame` with 13090 rows and 6 columns.

Examples

```
data(ocsge_species_dict)
```

`plot.trophic_tbl` *Plot a trophic table*

Description

Creates a simple graphical representation of a trophic network using ggplot2.

Usage

```
## S3 method for class 'trophic_tbl'
plot(x, shift = TRUE, ...)
```

Arguments

`x`	A `trophic_tbl` object.
`shift`	To shift x_axis between trophic level and avoid the potential overlapping of arrows.
`...`	Additional arguments (not used, for S3 consistency).

Details

Nodes are positioned according to their trophic level:

- The y-axis represents trophic levels
- Nodes of the same level are placed on the same horizontal line
- The x-axis positions are assigned sequentially (0, 1, 2, ...)

Directed links are drawn from lower to higher trophic levels using arrows.

Value

A ggplot object.

Examples

```
net <- trophic() |>
  add_link("a", "b") |>
  add_link("b", "c")

plot(net)
```

`raster_stack` *Create a RasterStack from a list of rasters and names*

Description

This function creates a ‘SpatRaster‘ stack from a list of rasters and assigns unique names to each layer.

Usage

```
raster_stack(raster_list, names = NULL)
```

Arguments

`raster_list`	A list of ‘SpatRaster‘ objects or file paths to raster files.
`names`	A character vector of unique names for each raster layer in the stack.

Details

The function checks that the length of ‘raster_list‘ matches the length of ‘names‘, and that all names are unique. If not, it stops with an error.

Value

A `SpatRaster` object with named layers.

Examples

```
# Example with terra rasters
library(terra)
r1 <- rast(nrows=10, ncols=10, vals=1:100)
r2 <- rast(nrows=10, ncols=10, vals=101:200)
raster_stack(list(r1, r2), c("layer1", "layer2"))
```

`ref_ocsge` *Nomenclature of OCS-GE soil cover*

Description

Nomenclature of OCS-GE soil cover

Usage

```
data(ref_ocsge)
```

Format

An object of class `data.frame` with 14 rows and 4 columns.

Examples

```
data(ref_ocsge)
```

`roi_metaleurop` *SF object defining ROI metaleurop*

Description

Simple feature collection with 1 feature and 1 field. Geodetic CRS: WGS 84.

Usage

```
data(roi_metaleurop)
```

Format

An object of class `sf` (inherits from `data.frame`) with 1 rows and 2 columns.

Examples

```
data(roi_metaleurop)
```

`sf_micromammals` *DataBase of collected MicroMammals species*

Description

DataBase of collected MicroMammals species

Usage

```
data(sf_micromammals)
```

Format

An object of class `sf` (inherits from `tbl_df`, `tbl`, `data.frame`) with 1426 rows and 27 columns.

Examples

```
data(sf_micromammals)
```

`spacemodel` *Create a spacemodel object*

Description

Constructor for the ‘spacemodel‘ class. This function combines spatial data (a raster stack) and ecological data (a trophic table) into a single object used for modelling.

Usage

```
spacemodel(raster_stack, trophic_tbl)
```

Arguments

`raster_stack`	A `SpatRaster` object (multi-layer stack) representing the spatial distribution of the species or groups.
`trophic_tbl`	An object of class `trophic_tbl` containing the ecological parameters and properties of the species.

Details

The function performs several checks to ensure data consistency:

- Verifies that `raster_stack` is a `SpatRaster`.
- Verifies that `trophic_tbl` is a `trophic_tbl` object.
- Ensures the number of raster layers matches the number of levels in the trophic table.
- Ensures that the names of the raster layers match the names in the trophic table.

Value

A `SpatRaster` object with the following additional attributes:

- `trophic_tbl`: The `trophic_tbl` object passed as input.
- `spacemodel`: A logical flag set to `TRUE`, indicating this raster is part of a spacemodel.

See Also

`rast`, `trophic_tbl`

`transfer` *Transfer (food, contaminant) across trophic levels*

Description

Computes the transfer through a trophic network from lower to higher trophic levels using spatial spreading and intake functions.

Usage

```
transfer(
  spacemodel,
  kernels,
  intakes = NULL,
  exposure_weighting = "local",
  verbose = FALSE
)
```

Arguments

`spacemodel`	A named list of spatial layers (e.g. `SpatRaster` objects). Must contain an attribute `trophic_tbl` of class `trophic_tbl`.
`kernels`	A list of kernel parameters for each layer.
`intakes`	A `trophic_tbl` object (or compatible table) containing normalized weights and flux functions for each trophic link.
`exposure_weighting`	Character. Defines how the realized exposure is calculated based on the predator’s presence. Options are: • `"local"` (Default): Weight exposure by the local habitat value (‘predator_habitat‘). Assumes the predator’s intake is strictly proportional to the habitat quality/density of the pixel where it resides. • `"diffuse"`: Weight exposure by a dispersed habitat kernel. Represents a "neighborhood" effect where the predator’s presence is smoothed over its home range. Useful to avoid edge effects where a predator on a poor pixel surrounded by good habitat would otherwise have 0 exposure. • `"potential"`: No weighting. Returns the pure environmental offer (potential exposure) regardless of the predator’s density. Useful for identifying risk hotspots.
`verbose`	Logical. If `TRUE`, prints progress information.

Details

The function processes layers in ascending trophic order, as defined by the `level` attribute of the trophic table.

For each layer:

1. Resources (lower neighbors) are identified.
2. Concentration from each resource is spatially spread using `spread()`.
3. Intake is computed using `intake()`.
4. Contributions from all resources are summed.

The function assumes that intake weights are already normalized so that, for each consumer, the sum of contributions from all resources equals 1.

Value

A named ‘spacemodel‘ object as a list of spatial layers representing values after transfer.

`trophic` *Create a trophic table*

Description

Creates a data.frame of class `trophic_tbl` designed to store trophic links. Can be initialized empty or from an existing data.frame.

Usage

```
trophic(data = NULL, from = NULL, to = NULL, weight = NULL)
```

Arguments

`data`	(Optional) A data.frame containing link information.
`from`	(Optional) Character string. Name of the column in `data` containing source nodes.
`to`	(Optional) Character string. Name of the column in `data` containing target nodes.
`weight`	(Optional) Character string. Name of the column in `data` containing weights. Default is 1 if not specified.

Value

An object of class `trophic_tbl`.

Examples

```
# 1. Empty initialization (pipe style)
net <- trophic() |>
  add_link("sol", "sp1")

# 2. Initialization from data.frame
df_raw <- data.frame(src = c("A", "A"), target = c("B", "C"), w = c(2, 5))
net_from_df <- trophic(df_raw, from = "src", to = "target", weight = "w")
```

`[.trophic_tbl` *Subset method for trophic_tbl*

Description

Ensures that any subsetting or modification preserves the validity of the trophic table.

Usage

```
## S3 method for class 'trophic_tbl'
x[...]
```

Arguments

`x`	A trophic_tbl object.
`...`	Additional arguments passed to the base method.

Value

A validated trophic_tbl object.

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