Package 'APAtree'

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Type Package

Title Computation of the 'Area Potentially Available' (APA) to Trees

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Description Maps of the 'area potentially available' (APA) of trees is calculated from mapped forest stands using the approach from Gspaltl et al. (2012) <doi:10.1093/forestry/cps052>. This is done by computing a rasterized version of 'weighted voronoi diagrams' using a an approximation of the trees competitive ability (e.g., crown radius, leaf area) as weight. The main output are 'Raster*'-objects from the 'raster' package that are stored together with the raw data in apa_list's, the main class of the 'APAtree' package. Aggregation functions are provided to calculate stand characteristics based on APA-maps such as relative proportions according to APA-size and the neighborhood diversity index NDiv (Glatthorn (2021) <doi:10.1016/j.ecolind.2021.108073>).

License GPL (>= 2)

URL https://github.com/JonasGlatthorn/APAtree/

BugReports https://github.com/JonasGlatthorn/APAtree/issues/

Imports Rcpp (>= 1.0.7), lwgeom, FD, parallel, units, stats, graphics, utils, methods

LinkingTo BH, Rcpp

Depends R (>= 4.0.0), raster, sf

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`APAtree-package` *Generation and analysis of maps of the area potentially available to trees (APA-maps) of forest stands*

Description

APA-maps are calculated from tree inventory data of forest stands. Tree coordinates, the competitive ability of trees and information about plot borders are used as inputs to derive APA-maps using multiplicatively weighted Voronoi diagrams. Functions to calculate important characteristics from APA-maps are provided (e.g., size of APA-patches of individual trees and tree species, neighborhood diversity).

Details

The core function of the `APAtree`-package is the `apa_list` function that creates APA-maps from tree inventory data and stores it together with the input data and APA-properties in an object of class `apa_list`.

For a more detailed description of the package see the vignette (`vignette("APAtree-vignette",package = "APAtree")`)

Additionally, the scripts to produce some of the Figures in Glatthorn (accepted) can be found in the folder `paste0(path.package("APAtree"),"/glatthorn_2021")`.

Author(s)

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References

Glatthorn, Jonas (accepted). A spatially explicit index for tree species or trait diversity at neighborhood and stand level. Ecological Indicators.

Gspaltl, M., Sterba, H., & O'hara, K. L. (2012). The relationship between available area efficiency and area exploitation index in an even-aged coast redwood (Sequoia sempervirens) stand. Forestry, 85(5), 567-577.

Römisch,K. (1995) Durchmesserwachstum und ebene Bestandesstruktur am Beispiel der Kiefernversuchsfläche Markersbach. In Deutscher Verband forstl. Forschungsanstalten, Sektion Biometrie und Informatik. Gottfried Hempel (ed.) Tagung Tharanth/Grillenburg, Vol. 8, pp. 84–103.

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apa_add_agg_class *Add aggregation classes to an* apa_list

Description

Additional grouping variables are added to an apa_list (for example tree species information). All APA-properties will be aggregated for these classes as well.

Usage

```
apa_add_agg_class(
  apa_list,
  agg_class_column = NULL,
  apa_polygon = attr(apa_list, "apa_config")$apa_polygon
)
```

Arguments

apa_list	A apa_list-object that was created with the [apa_list]-function.
agg_class_column	A vector of column names in apa_list$tree_dat that specify variables that are used as additional grouping variable.
apa_polygon	logical, specifies if POLYGONs of APA-patches be should be added.

apa_add_polygon *Add* POLYGON*-columns to an* apa_list

Description

Add POLYGON-columns to an apa_list

Usage

```
apa_add_polygon(apa_list)
```

Arguments

apa_list	A apa_list-object that was created with the [apa_list]-function.

apa_add_subplot_dat *Add subplots to datasets*

Description

If there are subplots within the plots for which APA-characteristics should be calculated, they may be added to the apa_list.

Usage

```
apa_add_subplot_dat(
  apa_list,
  subplot_dat,
  subplot_id_column,
  radius = NULL,
  apa_polygon = attr(apa_list, "apa_config")$apa_polygon
)
```

Arguments

apa_list	A apa_list-object that was created with the [apa_list]-function.
subplot_dat	A named list with datasets (sf-data.frames) about the subplots . Each data.frame in subplot_dat has to have a unique name, a column with the plot_id, an own id-column (specified via the subplot_id_column argument) and a geometry column. The geometry column either has to contain POLYGON-data or POINT-data (in which case APA-properties in circular neighborhoods around the points will be calculated.)
subplot_id_column	A named vector specifying the id-columns of the subplot datasets.
radius	If a geometry column in subplot_dat contains POINT-data, radius specifies the radius of the neighborhood analysis.
apa_polygon	Should polygons of the the APA-patches added to the dataset?

apa_border_tree *Assess which trees in APA-maps are border trees.*

Description

Border trees are trees whose APA-patches touch the plot-border.

Usage

```
apa_border_tree(apa_list)
```

Arguments

apa_list	A apa_list-object that was created with the [apa_list]-function.

Value

An apa_list where apa_list$tree_dat will have an additional column that specifies which trees are border trees.

Examples

```
library(APAtree)
data(tree_enrico, package = "APAtree")
data(plot_enrico, package = "APAtree")

# only calculate an apa_list for two plots and with a coarse resolution of 1 m
# to save time.
apa_list_enrico <-
  apa_list(plot_dat = subset(plot_enrico, id_plot %in% c("5.2", "8.2")),
           tree_dat = tree_enrico,
           plot_id_column = "id_plot",
           tree_id_column = "id_tree",
           weight_column = "crown_radius_95",
           res = 1,
           apa_polygon = TRUE)

apa_list_enrico <- apa_border_tree(apa_list_enrico)

# Information about which tree is a border tree is stored in the border_tree
# column
table(apa_list_enrico$tree_dat$border_tree)

# Plot border trees
plot(apa_list_enrico,
     color_map = data.frame(border_tree = c(TRUE, FALSE),
                            color = c("red", gray(.9))),
     critical = NA)
```

apa_drop_x *Remove elements from an apa_list*

Description

Depending on which function is chosen, either all APA-properties, all aggregation classes, all subplots or all polygons of APA-patches will be removed from all datasets in the apa_list.

Usage

```
apa_drop_properties(apa_list)

apa_drop_agg_class(apa_list)

apa_drop_subplot(apa_list)

apa_drop_polygon(apa_list)
```

Arguments

apa_list	A apa_list-object that was created with the [apa_list]-function.

Value

A apa_list where the respective elements were removed.

Examples

```
library(APAtree)
data(tree_enrico, package = "APAtree")
data(plot_enrico, package = "APAtree")
data(subplot_enrico, package = "APAtree")

# Only calculate an apa_list for two plots and with a coarse resolution of 10 m
# to save time.
apa_list_enrico <-
  APAtree::apa_list(plot_dat = subset(plot_enrico, id_plot %in% c("5.2", "8.2")),
                    tree_dat = tree_enrico,
                    plot_id_column = "id_plot",
                    tree_id_column = "id_tree",
                    weight_column = "crown_radius_95",
                    res = 10,
                    agg_class_column = "species",
                    subplot_dat = list(subplot = subplot_enrico),
                    subplot_id_column = c(subplot = "id_subplot"),
                    apa_properties = c("apa_size"),
                    apa_polygon = TRUE)

# removes all APA-properties
```

```
apa_list_enrico_1 <-
  apa_drop_properties(apa_list_enrico)

# removes all aggregation classes
apa_list_enrico_2 <-
  apa_drop_agg_class(apa_list_enrico)

# removes all subplots
apa_list_enrico_3 <-
  apa_drop_subplot(apa_list_enrico)

# removes all polygons of APA-patches
apa_list_enrico_4 <-
  apa_drop_polygon(apa_list_enrico)
```

`apa_list` *Calculating APA-maps*

Description

Calculate maps of the area potentially available to trees (APA-maps) out of tree inventory data. All vector data that is used or provided by the `APAtree`-package is stored in `data.frames` of the additional `sf` class of the `sf`-package (referred to as `sf-data.frame`). APA-maps are raster data that are stored in objects of the `raster`-package.

Usage

```
apa_list(
  plot_dat,
  tree_dat,
  plot_id_column,
  tree_id_column,
  weight_column,
  agg_class_column = NULL,
  core_column = attr(plot_dat, "sf_column"),
  buffer_column = core_column,
  res = 1,
  subplot_dat = NULL,
  subplot_id_column = NULL,
  radius = 10,
  apa_properties = NA,
  edge_correction = "none",
  dis_trait_column = NULL,
  dis_method = "gowdis",
  dis_transform = sqrt,
  scope = "global",
```

```
  apa_polygon = TRUE
)
```

Arguments

plot_dat	An sf-data.frame with plot-level data. plot.dat must contain a column that specifies the unique id of the plot. the column name of the plot id is specified with the plot_id_column-argument. The plot id is used to relate plot- and tree-data. A column with POLYGON-data that specify the outline of the plots has to be provided.
tree_dat	An sf-data.frame with tree data. tree.dat must contain a unique id of each tree. The column name of the tree id is specified with tree_id_column. Plot and tree-data are related by the id of the plot, which has to be a column in both datasets. The geometry type of tree_dat has to be POINT-data that specifies tree coordinates.
plot_id_column	Column name of plot_dat specifying unique plot id's.
tree_id_column	Column name of tree_dat specifying unique tree id's.
weight_column	Column name of tree_dat that specifies a variable to be used as weighting factor for the calculation of APA-maps.
agg_class_column	An optional vector of column names of tree_dat that specify variables that are used as additional grouping variable (for example tree species) to aggregate apa-properties (see apa_add_agg_class for more details).
core_column	Column name of plot_dat specifying a sfc-column with POLYGON-data of plot boundaries. Default is the active geometry of plot_dat.
buffer_column	Column name of plot_dat specifying a sfc-column with POLYGONs of boundaries of a buffer-zone around the core plot. To specify a buffer is only necessary if trees outside of the core area of a plot were sampled (plus-sampling) and the edge-correction method is "critical". Defaults to core_column.
res	single number specifying the resolution of the APA-maps (identical in x- and y-direction).
subplot_dat	A named list of sf-data.frames with additional data of subplots. If the active geometry column of plot_dat is POLYGON-data, calculation of apa-properties will be done for the area within these POLYGONs. For POINT-data, circular subplots are created around the point coordinates.
subplot_id_column	A named vector specifying the id columns of subplot_dat.
radius	The radius of circular subplots that should be used if a dataset in in subplot_dat contains POINT-data.
apa_properties	A vector specifying the apa-properties that will be calculated. May be any combination of "border_tree", "apa_size", "ndiv" and "pdiv".
edge_correction	which of the implemented edge correction method should be applied when calculating apa-properties ("none", "critical" or "border_tree_exclusion".

`dis_trait_column`
: A list containing combinations of traits that will be used to estimate dissimilarity between trees when calculating apa-properties. Refers to column names of `tree_dat`.

`dis_method`
: Which method should be used to estimate dissimilarity between trees. If `dis_method` is `gowdis`, `FD::gowdis()` will be used to calculate Gower dissimilarity. Alternatively, `dis_method` may be any `function` that calculates a dissimilarity matrix out of a `data.frame` with trait values.

`dis_transform`
: A `function` to transform dissimilarities. Defaults to `sqrt`.

`scope`
: Should scaling of the dissimilarity be done at `"global"` or at `"local"` level? If `dis_method` scales dissimilarity between trees according to the range of occurring values in the dataset (as done by `"gowdis"`), a `"global"` `scope` will use the range of all values in `tree_dat`. Any other `scope` will use the range of values at plot-level to scale dissimilarity.

`apa_polygon`
: logical, specifies if `POLYGON`s of APA-patches be should be added to the datasets. Defaults to `TRUE`.

Details

APA-maps are derived by calculating a rasterized version of weighted Voronoi-Diagrams of tree coordinates. To each tree a weight may be assigned that reflects the competitive ability of the tree.

Value

`apa_list` returns an object of class `"apa_list"`. An `apa_list` is a `list` of `data.frames` with at least two elements:

- `apa_list$plot_dat`: A `data.frame` with the original plot-level data is stored with an additional column `apa_map` that is a list containing all APA-maps. APA-maps of individual plots are represented by `RasterStack` objects. If additional APA-properties are calculated at stand-level, they are appended to this `data.frame` as well.
- `apa_list$tree_dat`: A `data.frame` with the original tree-level data Additional tree-level APA-characteristics are added to `tree_dat` as separate columns.
- aggregation classes (optional): if one or multiple aggregation classes (e.g., tree species) were added to the `apa_list`, additional `data.frames` at class-level will be added..
- `apa_list$subplot_dat` (optional): If subplots were specified, all data at subplot-level are stored here.

References

Glatthorn, Jonas (2021). A spatially explicit index for tree species or trait diversity at neighborhood and stand level. Ecological Indicators, 130, 108073. https://doi.org/10.1016/j.ecolind.2021.108073.

Römisch,K. (1995) Durchmesserwachstum und ebene Bestandesstruktur am Beispiel der Kiefernversuchsfläche Markersbach. In Deutscher Verband forstl. Forschungsanstalten, Sektion Biometrie und Informatik. Gottfried Hempel (ed.) Tagung Tharanth/Grillenburg, Vol. 8, pp. 84–103.

Gspaltl, M., Sterba, H., & O'hara, K. L. (2012). The relationship between available area efficiency and area exploitation index in an even-aged coast redwood (Sequoia sempervirens) stand. Forestry, 85(5), 567-577.

Examples

```
library(APAtree)
data(tree_enrico, package = "APAtree")
data(plot_enrico, package = "APAtree")

tree_enrico$height_class <- tree_enrico$height > 20

# only calculate an apa_list for two plots and with a coarse resolution of 1 m
# to save time.
apa_list_enrico <-
  apa_list(plot_dat = subset(plot_enrico, id_plot %in% c("5.2", "8.2")),
           tree_dat = tree_enrico,
           plot_id_column = "id_plot",
           tree_id_column = "id_tree",
           weight_column = "crown_radius_95",
           agg_class_column = c("species", "height_class"),
           res = 1,
           apa_polygon = TRUE)

apa_list_enrico
```

---

apa_ndiv *Calculate the index for neighborhood diversity NDiv for an apa_list*

Description

NDiv assesses the average dissimilarity between trees and their neighbors using APA-maps. Dissimilarity can be assessed using a species- or a trait-based approach. Upscaling of the tree-level NDiv to the species- or stand-level are provided.

Usage

```
apa_ndiv(
  apa_list,
  dis_trait_column,
  dis_method = "gowdis",
  dis_transform = sqrt,
  scope = "global",
  edge_correction = "none",
  pdiv = TRUE
)
```

Arguments

apa_list	A apa_list-object that was created with the [apa_list]-function.
dis_trait_column	A list containing combinations of traits that will be used to estimate dissimilarity between trees when calculating apa-properties. Refers to column names of tree_dat.

dis_method	Which method should be used to estimate dissimilarity between trees. If dis_method is gowdis, FD::gowdis() will be used to calculate Gower dissimilarity. Alternatively, dis_method may be any function that calculates a dissimilarity matrix out of a data.frame with trait values.
dis_transform	A function to transform dissimilarities. Defaults to sqrt.
scope	Should scaling of the dissimilarity be done at "global" or at "local" level? If dis_method scales dissimilarity between trees according to the range of occurring values in the dataset (as done by "gowdis"), a "global" scope will use the range of all values in tree_dat. Any other scope will use the range of values at plot-level to scale dissimilarity.
edge_correction	which of the implemented edge correction method should be applied when calculating apa-properties ("none", "critical" or "border_tree_exclusion".
pdiv	If TRUE (default), pdiv will be calculated (proportion-based diversity, average dissimilarity between a tree and all other trees in a stand, irrespective of the spatial configuration.)

Details

See Glatthorn (2021) for details.

References

Glatthorn, Jonas (2021). A spatially explicit index for tree species or trait diversity at neighborhood and stand level. Ecological Indicators, 130, 108073. https://doi.org/10.1016/j.ecolind.2021.108073.

Examples

```
library(APAtree)
data(tree_enrico, package = "APAtree")
data(plot_enrico, package = "APAtree")

tree_enrico$height_class <- tree_enrico$height > 20

# only calculate an apa_list for two plots and with a coarse resolution of 1 m
# to save time.
apa_list_enrico <-
  apa_list(plot_dat = subset(plot_enrico, id_plot %in% c("5.2", "8.2")),
           tree_dat = tree_enrico,
           buffer_column = "buffer_geometry",
           core_column = "border_geometry",
           plot_id_column = "id_plot",
           tree_id_column = "id_tree",
           agg_class_column = "species",
           weight_column = "crown_radius_95",
           res = 1,
           apa_polygon = FALSE)

# Calculate SpeciesNDiv
apa_list_enrico <-
```

```
  apa_ndiv(apa_list_enrico,
           dis_trait_column = "species")

# tree-level SpeciesNDiv:
head(apa_list_enrico$tree_dat[, c("id_tree", "species_ndiv")])

# stand-level SpeciesNDiv:
apa_list_enrico$plot_dat[, c("id_plot", "species_ndiv")]

# species-level SpeciesNDiv:
head(apa_list_enrico$species[, c("id_plot", "species", "species_ndiv")])
```

---

apa_seg *Calculate the segregation index of NDiv*

Description

The segregation index of NDiv assesses how much NDiv deviates from its random expectation using a randomization approach. Values close to zero indicate a random distribution of the traits that were used to calculate NDiv, values larger than zero indicate a regular distribution (stem-wise mixing) and values smaller than zero indicate a clustered configuration (patch-wise mixing).

Usage

```
apa_seg(
  apa_list,
  nsim = 1000,
  save_folder = NULL,
  save_simulations = TRUE,
  overwrite = FALSE,
  buffer_separate = TRUE,
  parallel = TRUE,
  cl = NULL,
  no_cores = 1,
  iseed = 42
)
```

Arguments

apa_list	A apa_list-object that was created with the [apa_list]-function.
nsim	Integer, how many simulation runs will be done.
save_folder	If specified, intermediate simulation results and processing report will be stored in this folder (defaults to NULL).
save_simulations	If TRUE (default) and if save_folder is specified, individual simulations will be stored (may consume large storage capacities).

`overwrite` If FALSE (default), `save_folder` needs to be empty. If TRUE, all content in `save_folder` will be deleted before the new simulations start.

`buffer_separate` Should tree locations in the buffer and cores zones be randomized separately? Defaults to TRUE.

`parallel` If TRUE (default), parallel processing will be used.

`cl` If `parallel` is TRUE, a Parallel Socket Cluster that was created with the [parallel::makeCluster()]-function is specified here. If NULL (default), `parallel::makeCluster(no_cores)` will be used.

`no_cores` The number of cores that will be used for parallel processing (default is 1). If NULL is specified, `parallel::detectCores() -1` will be used to automatically use one core less than available.

`iseed` A seed that will be passed to [parallel::clusterSetRNGStream] to make simulations reproducible when parallel processing is used (default is 42).

Details

See Glatthorn (2021) for details.

References

Glatthorn, Jonas (2021). A spatially explicit index for tree species or trait diversity at neighborhood and stand level. Ecological Indicators, 130, 108073. https://doi.org/10.1016/j.ecolind.2021.108073.

Examples

```
library(APAtree)
data(tree_enrico, package = "APAtree")
data(plot_enrico, package = "APAtree")

tree_enrico$height_class <- tree_enrico$height > 20

# only calculating an apa_list for two plots and with a coarse resolution of 1 m
# to save time.
apa_list_enrico <-
  apa_list(plot_dat = subset(plot_enrico, id_plot %in% c("5.2", "8.2")),
           tree_dat = tree_enrico,
           buffer_column = "buffer_geometry",
           core_column = "border_geometry",
           plot_id_column = "id_plot",
           tree_id_column = "id_tree",
           weight_column = "crown_radius_95",
           agg_class_column = c("species", "height_class"),
           res = 10,
           apa_polygon = FALSE)

apa_list_enrico <-
  apa_ndiv(apa_list_enrico, dis_trait_column = "species")

apa_list_enrico <-
```

```
  apa_seg(apa_list_enrico, nsim = 3, parallel = FALSE)

# stand-level segregation index of SpeciesNDiv
apa_list_enrico$plot_dat[, c("id_plot", "seg_species_ndiv")]
```

---

apa_size *Calculate the sizes of APA-patches in an* apa_list

Description

For Each dataset in an apa_list, the sizes of the respective APA-patches will be calculated (absolute and proportional).

Usage

```
apa_size(apa_list, edge_correction = "none")
```

Arguments

apa_list	A apa_list-object that was created with the [apa_list]-function.
edge_correction	which of the implemented edge correction method should be applied when calculating apa-properties ("none", "critical" or "border_tree_exclusion".

References

Glatthorn, Jonas (2021). A spatially explicit index for tree species or trait diversity at neighborhood and stand level. Ecological Indicators, 130, 108073. https://doi.org/10.1016/j.ecolind.2021.108073.

Gspaltl, M., Sterba, H., & O'hara, K. L. (2012). The relationship between available area efficiency and area exploitation index in an even-aged coast redwood (Sequoia sempervirens) stand. Forestry, 85(5), 567-577.

Examples

```
library(APAtree)
data(tree_enrico, package = "APAtree")
data(plot_enrico, package = "APAtree")

tree_enrico$height_class <- tree_enrico$height > 20

# only calculate an apa_list for two plots and with a coarse resolution of 1 m
# to save time.
apa_list_enrico <-
  apa_list(plot_dat = subset(plot_enrico, id_plot %in% c("5.2", "8.2")),
           tree_dat = tree_enrico,
           buffer_column = "buffer_geometry",
           core_column = "border_geometry",
```

```
            plot_id_column = "id_plot",
            tree_id_column = "id_tree",
            agg_class_column = "species",
            weight_column = "crown_radius_95",
            res = 1,
            apa_polygon = FALSE)

# Calculate SpeciesNDiv
apa_list_enrico <-
  apa_size(apa_list_enrico)

# tree-level APA-sizes:
head(apa_list_enrico$tree_dat[, c("id_tree", "apa_size_total", "apa_size_prop")])

# stand-level APA-sizes:
apa_list_enrico$plot_dat[, c("id_plot", "apa_size_total", "apa_size_prop")]

# species-level APA-sizes:
head(apa_list_enrico$species[, c("id_plot", "species", "apa_size_total", "apa_size_prop")])
```

`plot.apa_list` *plot APA-maps*

Description

APA-maps that are stored in an `APA-list`-object are being plotted.

Usage

```
## S3 method for class 'apa_list'
plot(
  x,
  subset = NULL,
  color_map = 1,
  tree_size_column = attr(x, "apa_config")$weight_column,
  tree_size_scale = 1,
  pal = sf::sf.colors,
  single_plots = FALSE,
  add_legend = TRUE,
  critical = "#FF000033",
  add = FALSE,
  cex = graphics::par("cex"),
  add_subplot = FALSE,
  add_plot_id_values = TRUE,
  ...
)
```

Arguments

x	A apa_list-object.
subset	The subset of APA-maps in apa_list that will be plotted (see subset.apa_list).
color_map	If numeric or character, this argument specifies which aggregation class should be used for coloring APA-patches (see apa_add_agg_class()). By supplying a data.frame, a custom color scheme can be specified. The first column of the data.frame needs to match with a categorical column in tree_dat and the second column specifies the colors.
tree_size_column	Column name in tree_dat that is used to adjust point sizes of tree locations. If this column is a metric units object, it is scaled to meters to match the units of the axes.
tree_size_scale	If tree_size_column is a metric units object, it is multiplied with tree_size_scale. Otherwise, tree_size_scale specifies the size of the largest point in meters.
pal	If no color_map is provided, this color palette function is used for coloring. specified here.
single_plots	Should the APA-maps be plotted as individual plots (TRUE) or should all APA-maps be plotted in a single diagram (FALSE, default)?
add_legend	If TRUE (default), a legend will be plotted.
critical	A color to shade the critical area close to the plot borders that may be influenced by an edge effect.
add	If FALSE (default), the plot will be standalone, otherwise it will be added to the currently active plot.
cex	Character expansion factor for labels (legend, titles)
add_subplot	If TRUE, subplots that were added via apa_add_subplot_dat will be added to the plot (default is FALSE).
add_plot_id_values	If TRUE (default), plot id's will be added as title.
...	not implemented.

Examples

```
library(APAtree)
data(tree_enrico, package = "APAtree")
data(plot_enrico, package = "APAtree")
data(subplot_enrico, package = "APAtree")

tree_enrico$height_class <- cut(tree_enrico$height, breaks = seq(0, 40, 4))

# only calculating an apa_list for two plots and with a coarse resolution of 1 m
# to save time.
apa_list_enrico <-
  apa_list(plot_dat = subset(plot_enrico, id_plot %in% c("5.2", "8.2")),
           tree_dat = tree_enrico,
           plot_id_column = "id_plot",
```

```
            tree_id_column = "id_tree",
            weight_column = "crown_radius_95",
            agg_class_column = c("species", "height_class"),
            res = 1,
            apa_polygon = TRUE)

# plot all APA-maps in an apa_list:
plot(apa_list_enrico)

# choose a different palette for plotting
plot(apa_list_enrico, pal = rainbow)

# choose a custom color scheme
color_map <-
  data.frame(species = c("Fagus sylvatica", "Pseudotsuga menziesii"),
             species_color = c("#7d5831", "#bcc746"))
plot(apa_list_enrico, color_map = color_map)
```

`plot_enrico` *Plot-level data of 16 forest stands in Lower Saxony, Germany*

Description

This dataset contains plot-level data from the Enrico-project from 16 mixed forest stands in Lower Saxony, Germany.

Usage

```
plot_enrico
```

Format

A `data.frame` of 16 plots. Plot coordinates are stored as 'simple feature column' (see the `sf`-package for more details):

id_plot Unique plot id's.

border_geometry A `sfc_POLYGON`-column specifying the coordinates of the plot border relative to the plot center.

buffer_geometry A `sfc_POLYGON`-column specifying the coordinates of the plot buffer (10 m distance from `boder_geometry`) relative to the plot center.

References

Ammer, Christian; Annighoefer, Peter; Balkenhol, Niko; Hertel, Dietrich; Leuschner, Christoph; Polle, Andrea; Lamersdorf, Norbert; Scheu, Stefan; Glatthorn, Jonas (2020): RTG 2300 - Enrichment of European beech forests with conifers. PANGAEA, https://doi.org/10.1594/PANGAEA.925228

subplot_enrico *Subplot-level data of 16 forest stands in Lower Saxony, Germany*

Description

This dataset contains subplot-level data from the Enrico-project from 16 mixed forest stands in Lower Saxony, Germany.

Usage

```
subplot_enrico
```

Format

A `data.frame` of 352 subplots on 16 plots. Plot coordinates are stored as 'simple feature column' (see the `sf`-package for more details):

id_subplot Unique subplot id's.

id_plot Plot id's.

object Name of the subplots ('plot', 'buffer', 'quadrant', 'sixteenth').

geometry A `sfc_POLYGON`-column specifying the coordinates of the subplots relative to the plot center.

References

Ammer, Christian; Annighoefer, Peter; Balkenhol, Niko; Hertel, Dietrich; Leuschner, Christoph; Polle, Andrea; Lamersdorf, Norbert; Scheu, Stefan; Glatthorn, Jonas (2020): RTG 2300 - Enrichment of European beech forests with conifers. PANGAEA, https://doi.org/10.1594/PANGAEA.925228

subset.apa_list *Subsetting of apa_lists*

Description

Select one or more APA-maps and related data from an `apa_list` object.

Usage

```
## S3 method for class 'apa_list'
subset(x, subset, ...)
```

Arguments

`x`	A /codeapa_list-object.
`subset`	Either a numeric or a character vector specifying the plots that shall be selected.
`...`	not implemented.

`tree_enrico` *Tree-level data of 16 forest stands in Lower Saxony, Germany*

Description

This dataset contains tree-level data from the Enrico-project from 16 mixed forest stands in Lower Saxony, Germany.

Usage

```
tree_enrico
```

Format

A `data.frame` of 2813 trees on 16 plots. Tree coordinates are stored as 'simple feature column' (see the `sf`-package for more details):

id_tree Unique tree id.

id_plot Plot id's

species Name of the tree species

position Does the tree stand in the core plot ('plot') or in the 10 m buffer zone around the core plot ('buffer').

dbh Diameter at breast height (1.3 m) in cm.

height Top height of the tree in m. Estimated with a stand height curve.

crown_radius_95 Expected 95 % quantile of the crown radius of a tree of this species and diameter. Estimated according to allometric equations (Pretzsch et al. 2015)

crown_radius_95 Expected median of the crown radius of a tree of this species and diameter. Estimated according to allometric equations (Pretzsch et al. 2015)

tree_geometry A `sfc_POINT`-column specifying tree coordinates relative to the plot center in meter.

References

Ammer, Christian; Annighoefer, Peter; Balkenhol, Niko; Hertel, Dietrich; Leuschner, Christoph; Polle, Andrea; Lamersdorf, Norbert; Scheu, Stefan; Glatthorn, Jonas (2020): RTG 2300 - Enrichment of European beech forests with conifers. PANGAEA, https://doi.org/10.1594/PANGAEA.925228

Pretzsch, H., Biber, P., Uhl, E., Dahlhausen, J., Roetzer, T., Caldentey, J., Koike, T., van Con, T., Chavanne, A., Seifert, T., Du Toit, B., Farnden, C., Pauleit, S., 2015. Crown size and growing space requirement of common tree species in urban centres, parks, and forests. Urban Forestry & Urban Greening 14 (3), 466-479.

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