Package ‘sharpshootR’

April 17, 2025

Type Package

Encoding UTF-8

Title A Soil Survey Toolkit

Description A collection of data processing, visualization, and export functions to support soil survey operations. Many of the functions build on the `SoilProfileCollection` S4 class provided by the aqp package, extending baseline visualization to more elaborate depictions in the context of spatial and taxonomic data. While this package is primarily developed by and for the USDA-NRCS, in support of the National Cooperative Soil Survey, the authors strive for generalization sufficient to support any soil survey operation. Many of the included functions are used by the SoilWeb suite of websites and movile applications. These functions are provided here, with additional documentation, to enable others to replicate high quality versions of these figures for their own purposes.

Version 2.3.3

Maintainer Dylan Beaudette <`dylan.beaudette@usda.gov`>

LazyLoad yes

LazyData true

License GPL (>= 3)

Repository CRAN

URL `https://github.com/ncss-tech/sharpshootR`

BugReports `https://github.com/ncss-tech/sharpshootR/issues`

Suggests MASS, spdep, circlize, rvest, xml2, terra, raster, exactextractr, httr, jsonlite, igraph, dendextend, testthat, hydromad (>= 0.9.27), latticeExtra, farver, venn, gower, daymetr, elevatr, Evapotranspiration, zoo, SoilTaxonomy, sf, Hmisc, knitr, rmarkdown, vegan

Depends R (>= 3.5.0)

Imports grDevices, graphics, methods, stats, utils, aqp, ape, soilDB, cluster, lattice, reshape2, scales, circular, RColorBrewer, plyr, digest, e1071, stringi, curl, grid

Additional_repositories `https://hydromad.github.io`

RoxygenNote 7.3.2

VignetteBuilder knitr

NeedsCompilation no

Author Dylan Beaudette [cre, aut],
Jay Skovlin [aut],
Stephen Roecker [aut],
Andrew Brown [aut],
USDA-NRCS Soil Survey Staff [ctb]

Date/Publication 2025-04-17 06:50:02 UTC

Contents

sharpshootR-package 3
amador 4
aspect.plot 4
CDEC.snow.courses 6
CDECquery 7
CDECsnowQuery 8
CDEC_StationInfo 9
colorMixtureVenn 10
component.adj.matrix 11
constantDensitySampling 12
dailyWB 13
dailyWB_SSURGO 14
diagnosticPropertyPlot 15
diagnosticPropertyPlot2 16
dist.along.grad 17
dueling.dendrograms 18
ESS_by_Moran_I 19
estimateSoilMoistureState 20
FFD 21
FFDplot 22
formatPLSS 23
generateLineHash 24
HenryTimeLine 26
HHM 26
huePositionPlot 27
hydOrder 28
isMineralSoilMaterial 29
iterateHydOrder 30
joinAdjacency 32
LL2PLSS 32
moistureStateProportions 33
moistureStateStats 34
moistureStateThreshold 34
monthlyWB 35

monthlyWB_summary 37
Moran_I_ByRaster 38
multinominal2logical 39
OSDexamples 40
PCP_plot 40
percentileDemo 41
plotAvailWater 42
plotGeomorphCrossSection 45
plotSoilRelationChordGraph 46
plotSoilRelationGraph 47
plotTransect 50
plotWB 53
plotWB_lines 55
PLSS2LL 57
polygonAdjacency 58
prepareDailyClimateData 58
prepare_SSURGO_hydro_data 59
reconcileOSDGeomorph 60
sample.by.poly 61
sampleRasterStackByMU 62
samplingStability 63
simpleWB 64
site_photos_kml 65
SoilTaxonomyDendrogram 66
table5.2 68
vizAnnualClimate 69
vizFlatsPosition 70
vizGeomorphicComponent 71
vizHillslopePosition 72
vizMountainPosition 73
vizSurfaceShape 74
vizTerracePosition 75

Index **76**

`sharpshootR-package` *A collection of functions to support soil survey*

Description

This package contains mish-mash of functionality and sample data related to the daily business of soil survey operations with the USDA-NRCS. Many of the functions are highly specialized and inherit default arguments from the names used by the various NCSS (National Cooperative Soil Survey) databases. A detailed description of this package with links to associated tutorials can be found at the project website.

`amador` *SSURGO Data Associated with the Amador Soil Series*

Description

SSURGO Data Associated with the Amador Soil Series

Usage

```
data(amador)
```

Format

A subset of data taken from the "component" table of SSURGO

`mukey`	map unit key
`compname`	component name
`comppct_r`	component percentage

Source

USDA-NRCS SSURGO Database

`aspect.plot` *Plot Aspect Data*

Description

Plot a graphical summary of multiple aspect measurements on a circular diagram.

Usage

```
aspect.plot(
  p,
  q = c(0.05, 0.5, 0.95),
  p.bins = 60,
  p.bw = 30,
  stack = TRUE,
  p.axis = seq(0, 350, by = 10),
  plot.title = NULL,
  line.col = "RoyalBlue",
  line.lwd = 1,
  line.lty = 2,
  arrow.col = line.col,
  arrow.lwd = 1,
```

```
  arrow.lty = 1,
  arrow.length = 0.15,
  ...
)
```

Arguments

`p`	a vector of aspect angles in degrees, measured clock-wise from North
`q`	a vector of desired quantiles
`p.bins`	number of bins to use for circular histogram
`p.bw`	bandwidth used for circular density estimation
`stack`	`logical`, should the individual points be stacked into `p.bins` number of bins and plotted
`p.axis`	a sequence of integers (degrees) describing the circular axis
`plot.title`	an informative title
`line.col`	density line color
`line.lwd`	density line width
`line.lty`	density line line style
`arrow.col`	arrow color
`arrow.lwd`	arrow line width
`arrow.lty`	arrow line style
`arrow.length`	arrow head length
`...`	further arguments passed to `circular::plot.circular`

Details

Spread and central tendency are depicted with a combination of circular histogram and kernel density estimate. The circular mean, and relative confidence in that mean are depicted with an arrow: longer arrow lengths correspond to greater confidence in the mean.

Value

This function is primarily called for graphical output, also invisibly returns circular stats.

Note

Manual adjustment of `p.bw` may be required in order to get an optimal circular density plot. This function requires the package `circular`, version 0.4-7 or later.

Author(s)

D.E. Beaudette

Examples

```
# simulate some data
p.narrow <- runif(n = 25, min = 215, max = 280)
p.wide <- runif(n = 25, min = 0, max = 270)

# set figure margins to 0, 2-column plot
op <- par(no.readonly = TRUE)
par(mar = c(0, 0, 0, 0), mfcol = c(1, 2))

# plot, save circular stats
x <- aspect.plot(p.narrow, p.bw = 10,
plot.title = 'Soil A', pch = 21, col = 'black', bg = 'RoyalBlue')

y <- aspect.plot(p.wide, p.bw = 10,
plot.title = 'Soil B', pch = 21, col = 'black', bg = 'RoyalBlue')

# reset output device options
par(op)

x
```

`CDEC.snow.courses` *CDEC Snow Course List*

Description

The CDEC snow course list, updated September 2019

Usage

```
data(CDEC.snow.courses)
```

Format

A data frame with 259 observations on the following 9 variables.

`course_number`	course number
`name`	connotative course label
`id`	course ID
`elev_feet`	course elevation in feet
`latitude`	latitude
`longitude`	longitude
`april.1.Avg.inches`	average inches of snow as of April 1st
`agency`	responsible agency
`watershed`	watershed label

Source

Data were scraped from `http://cdec.water.ca.gov/misc/SnowCourses.html`, 2019.

Examples

```
data(CDEC.snow.courses)
head(CDEC.snow.courses)
```

`CDECquery` *Easy Access to the CDEC API*

Description

A (relatively) simple interface to the CDEC website.

Usage

```
CDECquery(id, sensor, interval = "D", start, end)
```

Arguments

`id`	station ID (e.g. 'spw'), single value or vector of station IDs, see details
`sensor`	the sensor ID, single value or vector of sensor numbers, see details
`interval`	character, 'D' for daily, 'H' for hourly, 'M' for monthly, 'E' for event: see Details.
`start`	starting date, in the format 'YYYY-MM-DD'
`end`	ending date, in the format 'YYYY-MM-DD'

Details

Sensors that report data on an `interval other than monthly ('M'), daily ('D'), or hourly ('H') can be queried w` interval ('E'). Soil moisture and temperature sensors are an example of this type of reporting. See examples below.

1. Station IDs can be found here: `http://cdec.water.ca.gov/staInfo.html`

2a. Sensor IDs can be found using this URL: `http://cdec.water.ca.gov/dynamicapp/staMeta?station_id=`, followed by the station ID.

2b. Sensor details can be accessed using `CDEC_StationInfo with the station ID`.

3. Reservoir capacities can be found here: `http://cdec.water.ca.gov/misc/resinfo.html`

4. A new interactive map of CDEC stations can be found here: `http://cdec.water.ca.gov`

Value

A `data.frame` with the following fields: `datetime`, `year`, `month`, `value`.

Author(s)

D.E. Beaudette

References

`http://cdec.water.ca.gov/queryCSV.html`

See Also

`CDECsnowQuery()`, `CDEC_StationInfo()`

`CDECsnowQuery` *Get snow survey data (California only) from the CDEC website.*

Description

Get snow survey data (California only) from the CDEC website.

Usage

```
CDECsnowQuery(course, start_yr, end_yr)
```

Arguments

`course`	integer, course number (e.g. 129)
`start_yr`	integer, the starting year (e.g. 2010)
`end_yr`	integer, the ending year (e.g. 2013)

Details

This function downloads data from the CDEC website, therefore an internet connection is required. The `SWE` column contains adjusted SWE if available (`Adjusted` column), otherwise the reported SWE is used (`Water` column). See the tutorial for examples.

Value

A `data.frame` with results from CDEC.

Note

Snow course locations, ID numbers, and other information can be found here: `http://cdec.water.ca.gov/misc/SnowCourses.html`

Author(s)

D.E. Beaudette

References

http://cdec.water.ca.gov/cgi-progs/snowQuery

`CDEC_StationInfo` *CDEC Sensor Details (by Station)*

Description

Query CDEC Website for Sensor Details

Usage

```
CDEC_StationInfo(s)
```

Arguments

`s`	character, a single CDEC station ID (e.g. 'HHM')

Details

This function requires the `rvest` package.

Value

A `list` object containing site metadata, sensor metadata, and possibly comments about the site.

Author(s)

D.E. Beaudette

See Also

`[CDECquery]`

`colorMixtureVenn` *Create a Venn Diagram of Simulated Color Mixtures*

Description

Create a Venn Diagram of Simulated Color Mixtures

Usage

```
colorMixtureVenn(
  chips,
  w = rep(1, times = length(chips))/length(chips),
  mixingMethod = "exact",
  ellipse = FALSE,
  labels = TRUE,
  names = FALSE,
  sncs = 0.85
)
```

Arguments

`chips`	character vector of standard Munsell color notation (e.g. "10YR 3/4")
`w`	vector of proportions, can sum to any number, must be same length as `chips`
`mixingMethod`	approach used to simulate a mixture: see `aqp::mixMunsell()` for details
`ellipse`	logical, use alternative ellipse-style (4 or 5 colors only)
`labels`	logical, print mixture labels
`names`	logical, print names outside of the "sets"
`sncs`	scaling factor for set names

Value

This function is called to create graphical output, nothing returned.

Examples

```
if(requireNamespace("venn") & requireNamespace("gower")) {

chips <- c('10YR 8/1', '2.5YR 3/6', '10YR 2/2')
names(chips) <- c("tan", "dark red", "dark brown")

colorMixtureVenn(chips)
colorMixtureVenn(chips, names = TRUE)

colorMixtureVenn(chips, w = c(1, 1, 1), names = TRUE)
colorMixtureVenn(chips, w = c(10, 5, 1), names = TRUE)
```

```
}
```

`component.adj.matrix` *Create an adjacency matrix from a data.frame of component data*

Description

Create an adjacency matrix from SSURGO component data

Usage

```
component.adj.matrix(
  d,
  mu = "mukey",
  co = "compname",
  wt = "comppct_r",
  method = c("community.matrix", "occurrence"),
  standardization = "max",
  metric = "jaccard",
  rm.orphans = TRUE,
  similarity = TRUE,
  return.comm.matrix = FALSE
)
```

Arguments

`d`	`data.frame`, typically of SSURGO data
`mu`	name of the column containing the map unit ID (typically 'mukey')
`co`	name of the column containing the component ID (typically 'compname')
`wt`	name of the column containing the component weight percent (typically 'comppct_r')
`method`	one of either: `community.matrix`, or `occurrence`; see details
`standardization`	community matrix standardization method, passed to `vegan::decostand`
`metric`	community matrix dissimilarity metric, passed to `vegan::vegdist`
`rm.orphans`	`logical`, should map units with a single component be omitted? (typically yes)
`similarity`	logical, return a similarity matrix? (if `FALSE`, a distance matrix is returned)
`return.comm.matrix`	logical, return pseudo-community matrix? (if `TRUE` no adjacency matrix is created)

Value

A similarity or adjacency matrix suitable for use with `igraph` functions or anything else that can accommodate a *similarity* matrix.

Author(s)

D.E. Beaudette

Examples

```
if (requireNamespace("igraph") && requireNamespace("vegan")) {
  # load sample data set
  data(amador)

  # convert into adjacency matrix
  m <- component.adj.matrix(amador)

  # plot network diagram, with Amador soil highlighted
  plotSoilRelationGraph(m, s = 'amador')
}
```

`constantDensitySampling` *Sample Polygons at a Fixed Density*

Description

Perform constant-density sampling of polygons.

Usage

```
constantDensitySampling(
  x,
  polygon.id = "pID",
  n.pts.per.ac = 1,
  min.samples = 5,
  sampling.type = "regular"
)
```

Arguments

`x`	either `SpatVector` or object that can be coerced into one, should contain polygons registered to a planar coordinate reference system
`polygon.id`	character, name of column which contains a unique ID for each polygon
`n.pts.per.ac`	numeric, sampling density in "points per acre"
`min.samples`	integer, enforced minimum number of samples per polygon
`sampling.type`	character, sampling type passed to `terra::spatSample()`

Value

`SpatVector` of sample points

Author(s)

D.E. Beaudette

`dailyWB` *Simple Daily Water Balance*

Description

Simple interface to the hydromad "leaky bucket" soil moisture model, with accommodation for typical inputs from common soil data and climate sources. Critical points along the water retention curve are specified using volumetric water content (VWC): satiation (saturation), field capacity (typically 1/3 bar suction), and permanent wilting point (typically 15 bar suction).

Usage

```
dailyWB(x, daily.data, id, MS.style = "default", S_0 = 0.5, M = 0, etmult = 1)
```

Arguments

`x`	`data.frame`, required columns include: • `sat`: VWC at satiation • `fc`: VWC at field capacity • `pwp`: VWC at permanent wilting point • `thickness`: soil material thickness in cm • `a.ss`: recession coefficients for subsurface flow from saturated zone, should be > 0 (range: 0-1) • "id"
`daily.data`	`data.frame`, required columns include: • `date`: `Date` class representation of dates • `PPT`: daily total, precipitation in mm • `PET`: daily total, potential ET in mm
`id`	character, name of column in `x` that is used to identify records
`MS.style`	moisture state classification style, see `estimateSoilMoistureState`
`S_0`	fraction of water storage filled at time = 0 (range: 0-1)
`M`	fraction of area covered by deep-rooted vegetation
`etmult`	multiplier for PET

Value

a `data.frame`

References

Farmer, D., M. Sivapalan, Farmer, D. (2003). Climate, soil and vegetation controls upon the variability of water balance in temperate and semiarid landscapes: downward approach to water balance analysis. Water Resources Research 39(2), p 1035.

Bai, Y., T. Wagener, P. Reed (2009). A top-down framework for watershed model evaluation and selection under uncertainty. Environmental Modelling and Software 24(8), pp. 901-916.

`dailyWB_SSURGO` *Perform daily water balance modeling using SSURGO and DAYMET*

Description

Pending.

Usage

```
dailyWB_SSURGO(
  x,
  cokeys = NULL,
  start = 1988,
  end = 2018,
  modelDepth = 100,
  MS.style = "default",
  a.ss = 0.1,
  S_0 = 0.5,
  bufferRadiusMeters = 1
)
```

Arguments

`x`	`sf` object representing a single point
`cokeys`	vector of component keys to use
`start`	starting year (limited to DAYMET holdings)
`end`	ending year (limited to DAYMET holdings)
`modelDepth`	soil depth used for water balance, see details
`MS.style`	moisture state classification style, see `estimateSoilMoistureState`
`a.ss`	recession coefficients for subsurface flow from saturated zone, should be > 0 (range: 0-1)
`S_0`	fraction of water storage filled at time = 0 (range: 0-1)
`bufferRadiusMeters`	spatial buffer (meters) applied to `x` for the look-up of SSURGO data

Value

`data.frame` of daily water balance results

Author(s)

D.E. Beaudette

References

Farmer, D., M. Sivapalan, Farmer, D. (2003). Climate, soil and vegetation controls upon the variability of water balance in temperate and semiarid landscapes: downward approach to water balance analysis. Water Resources Research 39(2), p 1035.

`diagnosticPropertyPlot` *Diagnostic Property Plot (base graphics)*

Description

Generate a graphical description of the presence/absence of soil diagnostic properties.

Usage

```
diagnosticPropertyPlot(
  f,
  v,
  k,
  grid.label = "upedonid",
  dend.label = "upedonid",
  sort.vars = TRUE
)
```

Arguments

`f`	`SoilProfileCollection` object
`v`	character vector of site-level attribute names of `logical` type
`k`	an integer, number of groups to highlight
`grid.label`	the name of a site-level attribute (usually unique) annotating the y-axis of the grid
`dend.label`	the name of a site-level attribute (usually unique) annotating dendrogram terminal leaves
`sort.vars`	sort variables according to natural clustering (`TRUE`), or use supplied ordering in `v`

Details

This function attempts to display several pieces of information within a single figure. First, soil profiles are sorted according to the presence/absence of diagnostic features named in `v`. Second, these diagnostic features are sorted according to their distribution among soil profiles. Third, a binary grid is established with row-ordering of profiles based on step 1 and column-ordering based on step 2. Blue cells represent the presence of a diagnostic feature. Soils with similar diagnostic features should 'clump' together. See examples below.

Value

a `list` is silently returned by this function, containing:

`rd` a `data.frame` containing IDs and grouping code

`profile.order` a vector containing the order of soil profiles (row-order in figure), according to diagnostic property values

`var.order` a vector containing the order of variables (column-order in figure), according to their distribution among profiles

Author(s)

D.E. Beaudette and J.M. Skovlin

See Also

`multinominal2logical()`

`diagnosticPropertyPlot2`

Diagnostic Property Plot (lattice)

Description

Generate a graphical description of the presence/absence of soil diagnostic properties.

Usage

```
diagnosticPropertyPlot2(f, v, k, grid.label = "upedonid", sort.vars = TRUE)
```

Arguments

`f`	`SoilProfileCollection` object
`v`	character vector of site-level attribute names of `logical` type
`k`	an integer, number of groups to highlight
`grid.label`	the name of a site-level attribute (usually unique) annotating the y-axis of the grid
`sort.vars`	sort variables according to natural clustering (`TRUE`), or use supplied ordering in `v`

Details

This function attempts to display several pieces of information within a single figure. First, soil profiles are sorted according to the presence/absence of diagnostic features named in `v`. Second, these diagnostic features are sorted according to their distribution among soil profiles. Third, a binary grid is established with row-ordering of profiles based on step 1 and column-ordering based on step 2. Blue cells represent the presence of a diagnostic feature. Soils with similar diagnostic features should 'clump' together. See examples below.

Value

a `list` is silently returned by this function, containing:

`rd`	a `data.frame` containing IDs and grouping code
`profile.order`	a vector containing the order of soil profiles (row-order in figure), according to diagnostic property values
`var.order`	a vector containing the order of variables (column-order in figure), according to their distribution among profiles

Author(s)

D.E. Beaudette and J.M. Skovlin

See Also

`multinominal2logical`

`dist.along.grad` *Compute Euclidean distance along a gradient.*

Description

This function computes Euclidean distance along points aligned to a given gradient (e.g. elevation).

Usage

```
dist.along.grad(coords, var, grad.order, grad.scaled.min, grad.scaled.max)
```

Arguments

`coords`	a matrix of x and y coordinates in some projected coordinate system
`var`	a vector of the same length as `coords`, describing the gradient of interest
`grad.order`	vector of integers that define ordering of coordinates along gradient
`grad.scaled.min`	min value of rescaled gradient values
`grad.scaled.max`	max value of rescaled gradient values

Details

This function is primarily intended for use within `plotTransect`.

Value

A `data.frame` object:

scaled.grad scaled gradient values

scaled.distance cumulative distance, scaled to the interval of `0.5`, `nrow(coords) + 0.5`

distance cumulative distance computed along gradient, e.g. transect distance

variable sorted gradient values

x x coordinates, ordered by gradient values

y y coordinate, ordered by gradient values

grad.order a vector index describing the sort order defined by gradient values

Note

This function is very much a work in progress, ideas welcome.

Author(s)

D.E. Beaudette

See Also

`plotTransect`

`dueling.dendrograms` *Dueling Dendrograms*

Description

Graphically compare two related dendrograms

Usage

```
dueling.dendrograms(
  p.1,
  p.2,
  lab.1 = "D1",
  lab.2 = "D2",
  cex.nodelabels = 0.75,
  arrow.length = 0.05
)
```

Arguments

`p.1`	left-hand phylo-class dendrogram
`p.2`	right-hand phylo-class dendrogram
`lab.1`	left-hand title
`lab.2`	right-hand title
`cex.nodelabels`	character expansion size for node labels
`arrow.length`	arrow head size

Details

Connector arrows are used to link nodes from the left-hand dendrogram to the right-hand dendrogram.

Value

nothing is returned, function is called to generate graphical output

Author(s)

D.E. Beaudette

`ESS_by_Moran_I` *Estimate Effective Sample Size*

Description

Estimation of effective sample size (ESS). See Fortin & Dale 2005, p. 223, Equation 5.15 using global Moran's I as 'rho'.

Usage

```
ESS_by_Moran_I(n, rho)
```

Arguments

`n`	sample size
`rho`	Global Moran's I

Value

numeric; estimated Effective Sample Size

Author(s)

D.E. Beaudette

References

Fortin, M.J. and Dale, M.R.T. (2005) Spatial Analysis: A Guide for Ecologists. Cambridge University Press, Cambridge, 1-30.

`estimateSoilMoistureState`

A very simple estimation of soil moisture state based on volumetric water content

Description

This is a very simple classification of volumetric water content (VWC) into 5 "moisture states", based on an interpretation of water retention thresholds. Classification is performed using VWC at satiation, field capacity (typically 1/3 bar suction), permanent wilting point (typically 15 bar suction), and water surplus in mm. The inputs to this function are closely aligned with the assumptions and output from `hydromad::hydromad(sma = 'bucket', ...)`.

Soil moisture classification rules are as follows:

- VWC <= `pwp`: "very dry"
- VWC > `pwp` AND <= (mid-point between `fc` and `pwp`): "dry"
- VWC > (mid-point between `fc` and `pwp`) AND <= `fc`: "moist"
- VWC > `fc`: "very moist"
- VWC > `fc` AND `U` (surplus) > 4mm: "wet"

Usage

```
estimateSoilMoistureState(
  VWC,
  U,
  sat,
  fc,
  pwp,
  style = c("default", "newhall")
)
```

Arguments

`VWC`	vector of volumetric water content (VWC), range is 0-1
`U`	vector of surplus water (mm)
`sat`	satiation water content, range is 0-1
`fc`	field capacity water content, range is 0-1
`pwp`	permanent wilting point water content, range is 0-1
`style`	VWC classification style

Value

vector of moisture states (ordered factor)

Author(s)

D.E. Beaudette

Examples

```
# "very moist"
estimateSoilMoistureState(VWC = 0.3, U = 0, sat = 0.35, fc = 0.25, pwp = 0.15)
estimateSoilMoistureState(VWC = 0.3, U = 2, sat = 0.35, fc = 0.25, pwp = 0.15)

"wet"
estimateSoilMoistureState(VWC = 0.3, U = 5, sat = 0.35, fc = 0.25, pwp = 0.15)

# "very dry"
estimateSoilMoistureState(VWC = 0.15, U = 0, sat = 0.35, fc = 0.25, pwp = 0.15)

# "dry"
estimateSoilMoistureState(VWC = 0.18, U = 0, sat = 0.35, fc = 0.25, pwp = 0.15)
```

`FFD` *Frost-Free Day Evaluation*

Description

Evaluation frost-free days and related metrics from daily climate records.

Usage

```
FFD(
  d,
  returnDailyPr = TRUE,
  minDays = 165,
  frostTemp = 32,
  endSpringDOY = 182,
  startFallDOY = 213
)
```

Arguments

`d`	`data.frame` with columns 'datetime' 'year', and 'value'; 'value' being daily minimum temperature, see details
`returnDailyPr`	optionally return `list` with daily summaries
`minDays`	min number of days of non-NA data in spring | fall, required for a reasonable estimate of FFD

`frostTemp`	critical temperature that defines "frost" (same units as `d$value`)
`endSpringDOY`	day of year that marks end of "spring" (typically Jan 1 – June 30)
`startFallDOY`	day of year that marks start of "fall" (typically Aug 1 – Dec 31)

Details

The default `frostTemp=32` is suitable for use with minimum daily temperatures in degrees Fahrenheit. Use `frostTemp = 0` for temperatures in degrees Celsius.

FFD tutorial

Value

a `data.frame` when a `returnDailyPr = FALSE`, otherwise a `list` with the following elements:

- summary: FFD summary statistics as a `data.frame`
- fm: frost matrix
- Pr.frost: Pr(frost|day): daily probability of frost

Author(s)

D.E. Beaudette

Examples

```
# 11 years of data from highland meadows
data('HHM', package = 'sharpshootR')
x.ffd <- FFD(HHM, returnDailyPr = FALSE, frostTemp = 32)

str(x.ffd)
```

`FFDplot` *Plot output from FFD()*

Description

Plot output from FFD()

Usage

```
FFDplot(s, sub.title = NULL)
```

Arguments

`s`	output from `FFD`, with `returnDailyPr = TRUE`
`sub.title`	figure subtitle

Value

nothing, function is called to generate graphical output

Examples

```
# 11 years of data from highland meadows
data('HHM', package = 'sharpshootR')
x.ffd <- FFD(HHM, returnDailyPr = TRUE, frostTemp=32)

FFDplot(x.ffd)
```

`formatPLSS` *formatPLSS*

Description

Format PLSS information into a coded format that can be digested by PLSS web service.

Usage

```
formatPLSS(p, type = "SN")
```

Arguments

`p`	data.frame with chunks of PLSS coordinates
`type`	an option to format protracted blocks 'PB', unprotracted blocks 'UP', or standard section number 'SN' (default).

Details

This function is typically accessed as a helper function to prepare data for use within `PLSS2LL()` function.

Value

A vector of PLSS codes.

Note

This function expects that the `Polygon` object has coordinates associated with a projected CRS– e.g. units of meters.

This function requires the following packages: stringi.

Author(s)

D.E. Beaudette, Jay Skovlin, A.G. Brown

See Also

PLSS2LL()

Examples

```
# create some data
d <- data.frame(
  id = 1:3,
  qq = c('SW', 'SW', 'SE'),
  q = c('NE', 'NW', 'SE'),
  s = c(17, 32, 30),
  t = c('T36N', 'T35N', 'T35N'),
  r = c('R29W', 'R28W', 'R28W'),
  type = 'SN',
  m = 'MT20',
  stringsAsFactors = FALSE
)
# add column names

names(d) <- c('id', 'qq', 'q', 's', 't', 'r', 'type', 'm')
# generate formatted PLSS codes
formatPLSS(d, type='SN')
```

`generateLineHash` *Generate a unique ID for line segments*

Description

Generate a unique ID for a line segment, based on the non-cryptographic murmur32 hash.

Usage

```
generateLineHash(x, precision = -1, algo = "murmur32")
```

Arguments

x	an `sf` object, with 1 line segment per feature
precision	digits are rounded to this many places to the right (negative) or left (positive) of the decimal place
algo	hash function algorithm, passed to digest::digest()

Details

The input `sf` object must NOT contain multi-part features. The precision specified should be tailored to the coordinate system in use and the snapping tolerance used to create join decision line segments. A `precision` of 4 is reasonable for geographic coordinates (snapping tolerance of 0.0001 degrees or ~ 10 meters). A `precision` of -1 (snapping tolerance of 10 meters) is reasonable for projected coordinate systems with units in meters.

Value

A vector of unique IDs created from the hash of line segment start and end vertex coordinates. Unique IDs are returned in the order of records of `x` and can therefore be saved into a new column of the associated attribute table. `NA` is returned for empty geometries.

Note

An error is issued if any non-unique IDs are generated. This could be caused by using coordinates that do not contain enough precision for unique hashing.

Author(s)

D.E. Beaudette

Examples

```
if(requireNamespace("sf")) {

# 10 random line segments
# shared end vertices
.x <- runif(n = 11, min = 0, max = 100)
.y <- runif(n = 11, min = 0, max = 100)
m <- matrix(c(.x, .y), ncol = 2, byrow = TRUE)

# init LINESTRING geometries
a <- lapply(1:(nrow(m) - 1), function(i) {
  .idx <- c(i, i+1)
  geom <- sf::st_sfc(sf::st_linestring(m[.idx, ]))
  a <- sf::st_sf(geom)

})

# flatten list -> 10 feature sf object
a <- do.call('rbind', a)

# line hashes
a$id <- generateLineHash(a, precision = 0)

# graphical check
plot(a, lwd = 2, key.width = lcm(4), axes = TRUE, las = 1)


# simulate empty geometry
a$geom[2] <- sf::st_sfc(sf::st_linestring())

# NA returned for empty geometry
generateLineHash(a, precision = 0)

}
```

`HenryTimeLine` *Sensor Data Timeline from Henry Mount Soil and Water DB*

Description

This function generates a simple chart of start/end dates for non-NA sensor data returned by `soilDB::fetchHenry()`. Data are organized according to sensor name + sensor depth.

Usage

```
HenryTimeLine(sensor_data, ...)
```

Arguments

`sensor_data`	`soiltemp`, `soilVWC`, or related data returned by `soilDB::fetchHenry()`
`...`	additional arguments to `latticeExtra::segplot`

Value

a `lattice` graphics object

Author(s)

D.E. Beaudette

`HHM` *Highland Meadows*

Description

11 years of climate data from the Highland Meadows weather station, as maintained by CA DWR.

Usage

```
data("HHM")
```

Format

A data frame with 3469 observations on the following 12 variables.

`station_id` a character vector

`dur_code` a character vector

`sensor_num` a numeric vector

`sensor_type` a character vector

`value` a numeric vector

`flag` a character vector

`units` a character vector

`datetime` a POSIXct

`year` a numeric vector

`month` a factor with levels `January` `February` `March` `April` `May` `June` `July` `August` `September` `October` `November` `December`

`water_year` a numeric vector

`water_day` a numeric vector

`huePositionPlot` *Hue Position Chart*

Description

A simple visualization of the hue positions for a given Munsell value/chroma according to Soil Survey Technical Note 2.

Usage

```
huePositionPlot(
  value = 6,
  chroma = 6,
  chip.cex = 4.5,
  label.cex = 0.75,
  contour.dE00 = FALSE,
  origin = NULL,
  origin.cex = 0.75,
  grid.res = 2,
  ...
)
```

Arguments

`value`	a single Munsell value
`chroma`	a single Munsell chroma
`chip.cex`	scaling for color chip rectangle
`label.cex`	scaling for color chip
`contour.dE00`	logical, add dE00 contours from `origin`, imlpicitly `TRUE` when `origin` is not `NULL`
`origin`	point used for distance comparisons can be either single row matrix of CIELAB coordinates, a character vector specifying a Munsell color. By default (`NULL`) represents CIELAB coordinates (L,0,0), where L is a constant value determined by `value` and `chroma`. See examples.
`origin.cex`	scaling for origin point

`grid.res`	grid resolution for contours, units are CIELAB A/B coordinates. Caution, small values result in many pair-wise distances which could take a very long time.
`...`	additional arguments to `contour()`

Value

nothing, function is called to generate graphical output

Examples

```
huePositionPlot(value = 4, chroma = 4)

huePositionPlot(value = 6, chroma = 6)

huePositionPlot(value = 8, chroma = 8)

huePositionPlot(value = 6, chroma = 6, contour.dE00 = TRUE, grid.res = 2)

# shift origin to arbitrary CIELAB coordinates or Munsell color
huePositionPlot(origin = cbind(40, 5, 15), origin.cex = 0.5)

huePositionPlot(origin = '5G 6/4', origin.cex = 0.5)

huePositionPlot(origin = '10YR 3/4', origin.cex = 0.5)

huePositionPlot(value = 3, chroma = 4, origin = '10YR 3/4', origin.cex = 0.5)
```

`hydOrder` *Hydrologic Ordering of a Geomorphic Proportion Matrix*

Description

Hydrologic Ordering of a Geomorphic Proportion Matrix

Usage

```
hydOrder(x, g, clust = TRUE, j.amount = 0)
```

Arguments

`x`	x `data.frame`, geomorphic proportion matrix, as created by `soilDB::fetchOSD(..., extended=TRUE)`
`g`	character, name of geomorphic summary table, one of: `c('geomcomp', 'hillpos', 'flats', 'terrace', 'mtnpos', 'shape')`

`clust`	logical, perform clustering of geomorphic proportion matrix
`j.amount`	amount of noise applied to rows having a duplicate proportion vector, passed to `jitter()`

Value

when `clust` = `FALSE` a vector of series names, in hydrologic ordering, otherwise a `list` with the following elements:

- `clust`: rotated `hclust` object
- `hyd.order`: vector of series names, in hydrologic ordering
- `clust.hyd.order`: vector of series names, after clustering + rotation, approximate hydrologic ordering
- `match.rate`: fraction of series matching target hydrologic ordering, after clustering + rotation
- `obj`: objective function value (sum of squared rank differences), used by `iterateHydOrder()`

Author(s)

D.E. Beaudette

Examples

```
# example data, similar to results from soilDB::fetchOSD(..., extended = TRUE)
data("OSDexamples")

# no clustering of the geomorphic proportion matrix
h <- hydOrder(OSDexamples$hillpos, g = 'hillpos', clust = FALSE)

# compare with original order

data.frame(
original = OSDexamples$hillpos$series,
ordered = h
)

# cluster results
h <- hydOrder(OSDexamples$hillpos, g = 'hillpos', clust = TRUE)
str(h)
```

`isMineralSoilMaterial` *Mineral Soil Material Criteria from 12th Ed. of KST*

Description

Evaluate mineral soil material criteria based on soil organic carbon, clay content, and length of saturation.

Usage

```
isMineralSoilMaterial(soc, clay, saturation = TRUE)
```

Arguments

`soc`	soil organic carbon percent by mass
`clay`	clay content percent by mass
`saturation`	logical, cumulative saturation 30+ days

Value

`data.frame` of criteria test results

`iterateHydOrder` *Iteratively Attempt Hydrologic Ordering of Geomorphic Proportion Matrix*

Description

Iteratively Attempt Hydrologic Ordering of Geomorphic Proportion Matrix

Usage

```
iterateHydOrder(
  x,
  g,
  target = 0.9,
  maxIter = 20,
  j.amount = 0.05,
  verbose = FALSE,
  trace = FALSE
)
```

Arguments

`x`	`data.frame` geomorphic proportion matrix, as created by `soilDB::fetchOSD(..., extended=TRUE)`
`g`	name of geomorphic summary table, one of: `c('geomcomp', 'hillpos', 'flats', 'terrace', 'mtnpos', 'shape')`
`target`	numeric, target match rate
`maxIter`	integer, maximum number of perturbations of geomorphic probability matrix
`j.amount`	numeric, amount of noise applied to rows with too few unique values, passed to `jitter()`
`verbose`	logical, additional output printed via message
`trace`	logical, additional list of results for each iteration

Details

This function is used by the suite of geomorphic proportion visualization functions (`viz*`) to attempt rotation of a dendrogram according to "hydrologic ordering" rules. A perfect rotation is not always possible, and reported as a match rate in the returned `score` value

Value

A `list` with the following elements:

- `clust`: rotated `hclust` object
- `hyd.order`: vector of series names, in hydrologic ordering
- `clust.hyd.order`: vector of series names, after clustering + rotation, approximate hydrologic ordering
- `match.rate`: fraction of series matching target hydrologic ordering, after clustering + rotation
- `obj`: objective function value (sum of squared rank differences), used by `iterateHydOrder()`
- `niter`: number of iterations
- `trace`: list of results by iteration, only when `trace = TRUE`

Author(s)

D.E. Beaudette

Examples

```
# example data, similar to results from soilDB::fetchOSD(..., extended = TRUE)
data("OSDexamples")

# single iteration of hydrologic ordering
h1 <- hydOrder(OSDexamples$hillpos, g = 'hillpos', clust = TRUE)

# perform several iterations, keep the best one
h2 <- iterateHydOrder(OSDexamples$hillpos, 'hillpos', verbose = TRUE)

# compare: only slightly better match rate achieved
h1$match.rate
h2$match.rate

# return trace log for eval of objective function
# increase max iterations
h2 <- iterateHydOrder(OSDexamples$hillpos, 'hillpos', maxIter = 100, verbose = TRUE, trace = TRUE)

# inspect objective function evolution
tr <- h2$trace
obj <- sapply(tr, '[[', 'obj')

plot(obj, type = 'b')
hist(obj)
```

```
# in this case the clustering of hillpos proportions has only two possible configurations
```

`joinAdjacency` *Join Document Adjacency*

Description

Convert a set of line segment "join decisions" into a weighted adjacency matrix describing which map unit symbols touch.

Usage

```
joinAdjacency(x, vars = c("l_musym", "r_musym"))
```

Arguments

`x`	`data.frame` or similar object, each row represents a single shared edge (typically `sf` LINESTRING feature)
`vars`	a vector of two characters naming columns containing "left", and "right" map unit symbols

Value

A weighted adjacency matrix is returned, suitable for plotting directly with `plotSoilRelationGraph()`.

Author(s)

D.E. Beaudette

See Also

`plotSoilRelationGraph()`

`LL2PLSS` *LL2PLSS*

Description

Uses latitude and longitude coordinates to return the PLSS section geometry from the BLM PLSS web service.

Usage

```
LL2PLSS(x, y, returnlevel = c("I", "S"))
```

Arguments

`x`	longitude coordinates (WGS84)
`y`	latitude coordinates (WGS84)
`returnlevel`	’S’ for "Section" or ’I’ for "Intersection" (subsections)

Details

This function accepts geographic coordinates and returns the PLSS fabric geometry to the quarter-quarter section. `returnlevel` defaults to ’I’ which returns smallest intersected sectional aliquot geometry, ’S’ will return the section geometry of the coordinates. See https://gis.blm.gov/arcgis/rest/services/Cadastral/BLM_N for details.

Value

`sf` object with geometry and PLSS definition.

Note

This function requires the following packages: httr, jsonlite, and sf.

Author(s)

D.E. Beaudette, Jay Skovlin, A.G. Brown

See Also

`PLSS2LL()`, `formatPLSS()`

`moistureStateProportions`

Compute moisture state proportions

Description

Compute moisture state proportions

Usage

```
moistureStateProportions(x, id = "compname", step = c("month", "week", "doy"))
```

Arguments

`x`	`data.frame` created by `dailyWB()` or `dailyWB_SSURGO()`
`id`	character, column name identifying sites, components, or soil series
`step`	time step, one of ’month’, ’week’, or ’doy’

Value

`data.frame`

`moistureStateStats` *Statistics on Soil Moisture State*

Description

Statistics on Soil Moisture State

Usage

```
moistureStateStats(x, id = "compname")
```

Arguments

`x`	`data.frame`, created by `moistureStateProportions()`
`id`	name of ID column

Value

`data.frame` containing the most-likely moisture state and Shannon entropy.

`moistureStateThreshold` *Apply a threshold to soil moisture states*

Description

Apply a threshold to soil moisture states

Usage

```
moistureStateThreshold(
  x,
  id = "compname",
  threshold = "moist",
  operator = c("<", ">", "==", "<=", ">=")
)
```

Arguments

`x`	a `data.frame` created by `dailyWB()` or `dailyWB_SSURGO()`
`id`	character, column name identifying sites, soils, or soil series
`threshold`	moisture state threshold, see `estimateSoilMoistureState`
`operator`	one of "<", ">", "==", "<=", or ">="

Value

`data.frame`

Author(s)

D.E. Beaudette

`monthlyWB` *Monthly Water Balances*

Description

Perform a monthly water balance by "leaky bucket" model, inspired by code from `bucket.sim` of `hydromad` package, as defined in Bai et al., (2009) (model "SMA_S1"). The plant available water-holding storage (soil thickness * awc) is used as the "bucket capacity". All water in excess of this capacity is lumped into a single "surplus" term.

Usage

```
monthlyWB(
  AWC,
  PPT,
  PET,
  S_init = 1,
  starting_month = 1,
  rep = 1,
  keep_last = FALSE,
  distribute = FALSE,
  method = c("equal", "random", "gaussian"),
  k = 10
)
```

Arguments

`AWC`	numeric, available water-holding capacity (mm), typically thickness (mm) * awc (fraction)
`PPT`	numeric, time-series of monthly PPT (mm), calendar year ordering
`PET`	numeric, time-series of monthly PET (mm), calendar year ordering
`S_init`	numeric, initial fraction of `AWC` filled with water (values 0-1)
`starting_month`	integer, starting month index, 1=January, 9=September
`rep`	integer, number of cycles to run water balance
`keep_last`	logical, keep only the last iteration of the water balance
`distribute`	logical, distribute monthly data into `k` divisions within each month
`method`	method for distributing PPT and PET into `k` divisions:

- 'equal' divides PPT and PET into `k` equal amounts
- 'random' divides PPT and PET into random proportions generated via multinominal simulation
- 'gaussian' divides PPT and PET according to a bell-shaped curve centered in the middle of each month

`k`	integer, number of divisions

Details

See the monthly water balance tutorial for further examples and discussion.

A number of important assumptions are made by this style of water balance modeling:

- the concept of field capacity is built into the specified bucket size
- the influence of aquitards or local terrain cannot be integrated into this model
- interception is not used in this model

Value

a `data.frame` with the following elements:

- PPT: monthly PPT (mm)
- PET: monthly PET (mm)
- U: monthly surplus (mm)
- S: monthly soil moisture storage (mm)
- ET: monthly AET (mm)
- D: monthly deficit (mm)
- month: month number
- mo: month label

References

Arkley R, Ulrich R. 1962. The use of calculated actual and potential evapotranspiration for estimating potential plant growth. Hilgardia 32(10):443-469.

Bai, Y., T. Wagener, P. Reed (2009). A top-down framework for watershed model evaluation and selection under uncertainty. Environmental Modelling and Software 24(8), pp. 901-916.

Farmer, D., M. Sivapalan, Farmer, D. (2003). Climate, soil and vegetation controls upon the variability of water balance in temperate and semiarid landscapes: downward approach to water balance analysis. Water Resources Research 39(2), p 1035.

`monthlyWB_summary` *Water Balance Summaries*

Description

A summary of a monthly water balance, including estimates of total and consecutive "dry", "moist", "wet" conditions, total surplus, deficit, and AET, and annual AET/PET ratio.

Usage

```
monthlyWB_summary(w, AWC = NULL, PWP = NULL, FC = NULL, SAT = NULL)
```

Arguments

`w`	used for for `monthlyWB_summary()`: a data.frame, such as result of `monthlyWB()`;
`AWC`	numeric, optional plant-available water storage (mm)
`PWP`	numeric, optional permanent wilting point (volumetric water content)
`FC`	numeric, optional field capacity (volumetric water content)
`SAT`	numeric, optional saturation capacity (volumetric water content)

Value

`monthlyWB_summary()`: a `data.frame` containing:

- cumulative (`dry`, `moist`, `wet`) days
- consecutive (`dry_con`, `moist_con`, `wet_con`) days
- total deficit (`total_deficit`) in mm
- total surplus (`total_surplus`) in mm
- total actual evapotranspiration (`total_AET`) in mm
- annual actual evapotranspiration to potential evapotranspiration ratio (`annual_AET_PET_ratio`)

Note

Work in progress: AWC, PWP, FC, and SAT arguments are currently ignored!

`Moran_I_ByRaster` *Compute Moran's I for a raster sampled from a mapunit extent*

Description

Compute Moran's I using a subset of sample collected within the extent of a mapunit. This is likely an under-estimate of SA because we are including pixels both inside/outside MU delineations

Usage

```
Moran_I_ByRaster(
  r,
  mu.extent = NULL,
  n = NULL,
  k = NULL,
  do.correlogram = FALSE,
  cor.order = 5,
  crop.raster = TRUE
)
```

Arguments

`r`	single `SpatRaster`
`mu.extent`	`SpatVector` representation of mapunit polygons bounding box (via `terra::ext()`)
`n`	number of regular samples (what is a reasonable value?)
`k`	number of neighbors used for weights matrix
`do.correlogram`	compute correlogram?
`cor.order`	order of correlogram
`crop.raster`	optionally disable cropping of the raster layer

Details

This function uses the `spdep::moran.test()` function

Value

If `do.correlogram` is `TRUE` a list with estimated Moran's I (`$I`) and the correlogram (`$correlogram`), otherwise the estimated Moran's I value.

Author(s)

D.E. Beaudette

`multinominal2logical` *Convert Multinominal to Logical Matrix*

Description

Convert a single multinominal, site-level attribute from a `SoilProfileCollection` into a matrix of corresponding logical values. The result contains IDs from the `SoilProfileCollection` and can easily be joined to the original site-level data.

Usage

```
multinominal2logical(x, v)
```

Arguments

`x`	a `SoilProfileCollection` object
`v`	the name of a site-level attribute that is a factor, or can be coerced to a factor, with more than 2 levels

Value

A `data.frame` with IDs in the first column, and as many columns of logical vectors as there were levels in `v`. See examples.

Author(s)

D.E. Beaudette

See Also

`diagnosticPropertyPlot()`

Examples

```


if(require(soilDB) &
   require(aqp) &
   require(latticeExtra)) {


  # sample data, an SPC
  data(loafercreek, package='soilDB')

  # convert to logical matrix
  hp <- multinominal2logical(loafercreek, 'hillslopeprof')

  # join-in to site data
  site(loafercreek) <- hp
```

```
  # variable names
  v <- c('lithic.contact', 'paralithic.contact',
         'argillic.horizon', 'toeslope', 'footslope',
         'backslope', 'shoulder', 'summit')

  # visualize with some other diagnostic features
  x <- diagnosticPropertyPlot(loafercreek, v, k = 5,
                              grid.label = 'bedrckkind', dend.label = 'upedonid')
}
```

`OSDexamples` *Example output from soilDB::fetchOSD()*

Description

These example data are used to test various functions in this package when network access may be limited.

Usage

```
data(OSDexamples)
```

Format

An object of class `list` of length 18.

`PCP_plot` *Percentiles of Cumulative Precipitation*

Description

Generate a plot representing percentiles of cumulative precipitation, given a historic record, and criteria for selecting a year of data for comparison.

Usage

```
PCP_plot(
  x,
  this.year,
  this.day = NULL,
  method = "exemplar",
  q.color = "RoyalBlue",
  c.color = "firebrick",
  ...
)
```

Arguments

`x`	result from `CDECquery` for now, will need to generalize to other sources
`this.year`	a single water year, e.g. 2020
`this.day`	optional integer representing days since start of selected water year
`method`	'exemplar' or 'daily', currently 'exemplar' is the only method available
`q.color`	color of percentiles cumulative precipitation
`c.color`	color of selected year
`...`	additional arguments to `plot`

Details

This is very much a work in progress. Further examples at `https://ncss-tech.github.io/AQP/sharpshootR/CDEC.html`, and `https://ncss-tech.github.io/AQP/sharpshootR/cumulative-PPT.html`.

Value

nothing, this function is called to create graphical output

Author(s)

D.E. Beaudette

See Also

`soilDB::waterDayYear()`

`percentileDemo` *Demonstration of Percentiles vs. Mean / SD*

Description

This function can be used to graphically demonstrate the relationship between distribution shape, an idealized normal distribution (based on sample mean and sd) shape, and measures of central tendency / spread.

Usage

```
percentileDemo(x, labels.signif = 3, pctile.color = "RoyalBlue",
mean.color = "Orange", range.color = "DarkRed",
hist.breaks = 30, boxp = FALSE, ...)
```

Arguments

`x`	vector of values to summarize
`labels.signif`	integer, number of significant digits to be used in figure annotation
`pctile.color`	color used to demonstrate range from 10th to 90th percentiles
`mean.color`	color used to specify mean +/- 2SD
`range.color`	color used to specify data range
`hist.breaks`	integer, number of suggested breaks to `hist`
`boxp`	logical, add a box and whisker plot?
`...`	further arguments to `plot`

Value

A 1-row matrix of summary stats is invisibly returned.

Note

This function is mainly for educational purposes.

Author(s)

D.E. Beaudette

References

https://ncss-tech.github.io/soil-range-in-characteristics/why-percentiles.html

Examples

```
if (requireNamespace("Hmisc")) {
  x <- rnorm(100)
  percentileDemo(x)

  x <- rlnorm(100)
  percentileDemo(x)
}
```

`plotAvailWater` *Visual Demonstration of Available Soil Water*

Description

Generate a simplistic diagram of the various fractions of water held within soil pore-space. Largely inspired by Figure 2 from O'Geen (2013).

Usage

```
plotAvailWater(
  x,
  width = 0.25,
  cols = c(grey(0.5), "DarkGreen", "LightBlue", "RoyalBlue"),
  name.cex = 0.8,
  annotate = TRUE
)
```

Arguments

`x`	a `data.frame` containing sample names and water retention data, see examples below
`width`	vertical width of each bar graph
`cols`	a vector of colors used to symbolize 'solid phase', 'unavailable water', 'available water', and 'gravitational water'
`name.cex`	character scaling of horizon names, printed on left-hand side of figure
`annotate`	logical, annotate AWC

Value

nothing, function is called to generate graphical output

Author(s)

D.E. Beaudette

References

O'Geen, A. T. (2013) Soil Water Dynamics. Nature Education Knowledge 4(5):9.

Examples

```
# demonstration
s <- data.frame(
  name = c('loamy sand', 'sandy loam', 'silt loam', 'clay loam'),
  pwp = c(0.05, 0.1, 0.18, 0.2),
  fc = c(0.1, 0.2, 0.38, 0.35),
  sat = c(0.25, 0.3, 0.45, 0.4))
s$solid <- with(s, 1-sat)

par(mar=c(5, 6, 0.5, 0.5))
plotAvailWater(s, name.cex=1.25)




  if(requireNamespace("aqp")) {
```

```
    # demonstration using idealized AWC by soil texture
    data("ROSETTA.centroids", package = "aqp")

    # subset columns
    x <- ROSETTA.centroids[, c('texture', 'pwp', 'fc', 'sat', 'awc')]

    # adjust to expected names / additional data required by plotAvailWater
    names(x)[1] <- 'name'
    x$solid <- with(x, 1 - sat)

    # re-order based on approximate AWC
    x <- x[order(x$awc), ]

    op <- par(no.readonly = TRUE)

    par(mar=c(5, 6.5, 0.5, 0.5))
    plotAvailWater(x, name.cex = 1)

    par(op)

  }


  # use some real data from SSURGO
  if(requireNamespace("curl") &&
     requireNamespace("httr") &&
     curl::has_internet() &&
     require("soilDB")) {

    q <- "SELECT hzdept_r as hztop, hzdepb_r as hzbottom,
hzname as name, wsatiated_r/100.0 as sat,
wthirdbar_r/100.0 as fc, wfifteenbar_r/100.0 as pwp, awc_r as awc
FROM chorizon
WHERE cokey IN (SELECT cokey from component where compname = 'dunstone')
AND wsatiated_r IS NOT NULL
ORDER BY cokey, hzdept_r ASC;"

    x <- SDA_query(q)
    x <- unique(x)
    x <- x[order(x$name), ]
    x$solid <- with(x, 1-sat)

    op <- par(no.readonly = TRUE)

    par(mar=c(5, 5, 0.5, 0.5))
    plotAvailWater(x)

    par(op)
  }
```

`plotGeomorphCrossSection` *Present a* `SoilProfileCollection` *aligned to a geomorphic summary as cross-section.*

Description

Present a `SoilProfileCollection` aligned to a geomorphic summary as cross-section.

Usage

```
plotGeomorphCrossSection(
  x,
  type = c("line", "bar"),
  g = "hillpos",
  clust = TRUE,
  col = c("#377EB8", "#4DAF4A", "#984EA3", "#FF7F00", "#E41A1C"),
  ...
)
```

Arguments

`x`	resulting list from `soilDB::fetchOSD(..., extended = TRUE)`
`type`	character, 'line' for line plot or 'bar' for barplot of geomorphic proportions
`g`	character, select a geomorphic summary. Currently 'hillpos' (2D hillslope position) is the only supported choice.
`clust`	logical, use clustering order of geomorphic proportions (`TRUE`) or exact hydrologic ordering (`FALSE`), see `hydOrder()`
`col`	character vector of colors
`...`	additional arguments to `iterateHydOrder()`

Details

Additional arguments to `aqp::plotSPC()` can be provided using `options(.aqp.plotSPC.args = list(...))`. For example, adjustments to maximum depth and profile width can be set via: `options(.aqp.plotSPC.args = list(max.depth = 150, width = 0.35))`. Default arguments can be reset with `options(.aqp.plotSPC.args = NULL)`.

When `clust = TRUE`, especially for `SoilProfileCollections` with a wide range in depth, it may be necessary to adjust the `scaling.factor` argument to `aqp::plotSPC()` via: `options(.aqp.plotSPC.args = list(scaling.factor = 0.01))`. Larger values will increase the height of profile sketches.

Value

nothing, function is called to generate graphical output

Author(s)

D.E. Beaudette

`plotSoilRelationChordGraph`

Visualize Soil Relationships via Chord Diagram

Description

Visualize Soil Relationships via Chord Diagram

Usage

```
plotSoilRelationChordGraph(
  m,
  s,
  mult = 2,
  base.color = "grey",
  highlight.colors = c("RoyalBlue", "DarkOrange", "DarkGreen"),
  add.legend = TRUE,
  ...
)
```

Arguments

`m`	an adjacency matrix, no `NA` allowed
`s`	soil of interest, must exist in the column or row names of `m`
`mult`	multiplier used to re-scale data in `m` associated with `s`
`base.color`	color for all soils other than `s` and 1st and 2nd most commonly co-occurring soils
`highlight.colors`	vector of 3 colors: soil of interest, 1st most common, 2nd most common
`add.legend`	`logical`, add a legend
`...`	additional arguments passed to `circlize::chordDiagramFromMatrix`

Details

This function is experimental. Documentation pending. See `http://jokergoo.github.io/circlize/` for ideas.

Value

nothing, function is called to generate graphical output

Author(s)

D.E. Beaudette

`plotSoilRelationGraph` *Plot a component relation graph*

Description

Plot a component relation graph based on an adjacency or similarity matrix.

Usage

```
plotSoilRelationGraph(
  m,
  s = "",
  plot.style = c("network", "dendrogram", "none"),
  graph.mode = "upper",
  spanning.tree = NULL,
  del.edges = NULL,
  vertex.scaling.method = "degree",
  vertex.scaling.factor = 2,
  edge.scaling.factor = 1,
  vertex.alpha = 0.65,
  edge.transparency = 1,
  edge.col = grey(0.5),
  edge.highlight.col = "royalblue",
  g.layout = igraph::layout_with_fr,
  vertex.label.color = "black",
  delete.singletons = FALSE,
  ...
)
```

Arguments

`m`	adjacency matrix
`s`	central component; an empty character string is interpreted as no central component
`plot.style`	plot style ('network', or 'dendrogram'), or 'none' for no graphical output
`graph.mode`	interpretation of adjacency matrix: 'upper' or 'directed', see details
`spanning.tree`	plot the minimum or maximum spanning tree ('min', 'max'), or, max spanning tree plus edges with weight greater than the n-th quantile specified in `spanning.tree`. See details and examples.
`del.edges`	optionally delete edges with weights less than the specified quantile (0-1)
`vertex.scaling.method`	'degree' (default) or 'distance', see details
`vertex.scaling.factor`	scaling factor applied to vertex size

`edge.scaling.factor`	optional scaling factor applied to edge width
`vertex.alpha`	optional transparency setting for vertices (0-1)
`edge.transparency`	optional transparency setting for edges (0-1)
`edge.col`	edge color, applied to all edges
`edge.highlight.col`	edge color applied to all edges connecting to component named in `s`
`g.layout`	an igraph layout function, defaults to `igraph::layout_with_fr`
`vertex.label.color`	vertex label color
`delete.singletons`	optionally delete vertices with no edges (`degree == 0`)
`...`	further arguments passed to plotting function

Details

Vertex size is based on a normalized index of connectivity:

- "degree" size = `sqrt(igraph::degree(g) / max(igraph::degree(g))) * scaling.factor`
- "distance" size = `sqrt(igraph::distance(V -> s) / max(igraph::distance(V -> s))) * scaling.factor`, where distance(V->s) is the distance from all nodes to the named series, `s`.

Edge width can be optionally scaled by edge weight by specifying an `edge.scaling.factor` value. The maximum spanning tree represents a sub-graph where the sum of edge weights are maximized. The minimum spanning tree represents a sub-graph where the sum of edge weights are minimized. The maximum spanning tree is likely a more useful simplification of the full graph, in which only the strongest relationships (e.g. most common co-occurrences) are preserved.

The maximum spanning tree + edges with weights > n-th quantile is an experimental hybrid. The 'backbone' of the graph is created by the maximum spanning tree, and augmented by 'strong' auxiliary edges–defined by a value between 0 and 1.

The `graph.mode` argument is passed to `igraph::graph_from_adjacency_matrix()` and determines how vertex relationships are coded in the adjacency matrix `m`. Typically, the default value of 'upper' (the upper triangle of `m` contains adjacency information) is the desired mode. If `m` contains directional information, set `graph.mode` to 'directed'. This has the side-effect of altering the default community detection algorithm from `igraph::cluster_fast_greedy` to `igraph::cluster_walktrap`.

Value

an igraph `graph` object is invisibly returned

Note

The default output for `plot.style=network` is nondeterministic when using most igraph layouts, including the default `igraph::layour_with_fr`. Previous versions of sharpshootR hard-coded a random seed via `set.seed(1010101)`. Consider adding this if you are trying to recreate previous output.

Author(s)

D.E. Beaudette

Examples

```
# consider setting a random seed for consistent output from run to run
# prior releases of sharpshootR used:
# set.seed(1010101)

if (requireNamespace("igraph") && requireNamespace("vegan")) {
  # load sample data set
  data(amador)

  # create weighted adjacency matrix (see ?component.adj.matrix for details)
  m <- component.adj.matrix(amador)

  # plot network diagram, with Amador soil highlighted
  plotSoilRelationGraph(m, s='amador')

  # dendrogram representation
  plotSoilRelationGraph(m, s='amador', plot.style='dendrogram')

  # compare methods
  m.o <- component.adj.matrix(amador, method='occurrence')

  op <- par(no.readonly = TRUE)

  par(mfcol=c(1,2))
  plotSoilRelationGraph(m, s='amador', plot.style='dendrogram')
  title('community matrix')
  plotSoilRelationGraph(m.o, s='amador', plot.style='dendrogram')
  title('occurence')

  # investigate max spanning tree
  plotSoilRelationGraph(m, spanning.tree='max')

  # investigate max spanning tree + edges with weights > 75-th pctile
  plotSoilRelationGraph(m, spanning.tree=0.75)

  par(op)



    if(requireNamespace("curl") &
       curl::has_internet() &
       require(soilDB)) {

      # get similar data from soilweb, for the Pardee series
      s <- 'pardee'
      d <- siblings(s, component.data = TRUE)

      # normalize component names
```

```
    d$sib.data$compname <- tolower(d$sib.data$compname)

    # keep only major components
    d$sib.data <- subset(d$sib.data, subset=compkind == 'Series')

    # build adj. matrix and plot
    m <- component.adj.matrix(d$sib.data)
    plotSoilRelationGraph(m, s=s, plot.style='dendrogram')

    # alter plotting style, see ?plot.phylo
    plotSoilRelationGraph(m, s=s, plot.style='dendrogram', type='fan')
    plotSoilRelationGraph(m, s=s, plot.style='dendrogram',
                          type='unrooted', use.edge.length=FALSE)

  }

}
```

---

plotTransect *Arrange Profiles along a Transect*

Description

Plot a collection of Soil Profiles linked to their position along some gradient (e.g. transect).

Usage

```
plotTransect(
  s,
  xy,
  grad.var.name,
  grad.var.order = order(site(s)[[grad.var.name]]),
  transect.col = "RoyalBlue",
  tick.number = 7,
  y.offset = 100,
  scaling.factor = 0.5,
  distance.axis.title = "Distance Along Transect (km)",
  grad.axis.title = NULL,
  dist.scaling.factor = 1000,
  spacing = c("regular", "relative"),
  fix.relative.pos = list(thresh = 0.6, maxIter = 5000),
  ...
)
```

Arguments

s	`SoilProfileCollection` object
xy	`sf` object, defining point coordinates of soil profiles, must be in same order as `s`, must be a projected coordinate reference system (UTM, AEA, etc.)

`grad.var.name`	the name of a site-level attribute containing gradient values
`grad.var.order`	optional indexing vector used to override sorting along `grad.var.name`
`transect.col`	color used to plot gradient (transect) values
`tick.number`	number of desired ticks and labels on the gradient axis
`y.offset`	vertical offset used to position profile sketches
`scaling.factor`	scaling factor applied to profile sketches
`distance.axis.title`	a title for the along-transect distances
`grad.axis.title`	a title for the gradient axis
`dist.scaling.factor`	scaling factor (divisor) applied to linear distance units, default is conversion from m to km (1000)
`spacing`	profile sketch spacing style: "regular" (profiles aligned to an integer grid) or "relative" (relative distance along transect)
`fix.relative.pos`	adjust relative positions in the presence of overlap, `FALSE` to suppress, otherwise list of arguments to `aqp::fixOverlap`
`...`	further arguments passed to `aqp::plotSPC`.

Details

Depending on the nature of your `SoilProfileCollection` and associated gradient values, it may be necessary to tinker with figure margins, `y.offset` and `scaling.factor`.

Value

An invisibly-returned `data.frame` object:

- scaled.grad: scaled gradient values
- scaled.distance: cumulative distance, scaled to the interval of `0.5, nrow(coords) + 0.5`
- distance: cumulative distance computed along gradient, e.g. transect distance
- variable: sorted gradient values
- x: x coordinates, ordered by gradient values
- y: y coordinate, ordered by gradient values
- grad.order: a vector index describing the sort order defined by gradient values

Note

This function is very much a work in progress, ideas welcome!

Author(s)

D.E. Beaudette

Examples

```
if(require(aqp) &
require(sf) &
  require(soilDB)
) {

library(aqp)
library(soilDB)
library(sf)


# sample data
data("mineralKing", package = "soilDB")

# device options are modified locally, reset when done
op <- par(no.readonly = TRUE)

# quick overview
par(mar=c(1,1,2,1))
groupedProfilePlot(mineralKing, groups='taxonname', print.id=FALSE)

# setup point locations
s <- site(mineralKing)
xy <- st_as_sf(s, coords = c('longstddecimaldegrees', 'latstddecimaldegrees'))
st_crs(xy) <- 4326

# convert to suitable projected cRS
# projected CRS, UTM z11 NAD83 (https://epsg.io/26911)
xy <- st_transform(xy, 26911)

# adjust margins
par(mar = c(4.5, 4, 4, 1))

# standard transect plot, profile sketches arranged along integer sequence
plotTransect(mineralKing, xy, grad.var.name = 'elev_field',
             grad.axis.title = 'Elevation (m)', label = 'upedonid', name = 'hzname')

# default behavior, attempt adjustments to prevent over-plot and preserve relative spacing
# use set.seed() to fix outcome
plotTransect(mineralKing, xy, grad.var.name = 'elev_field',
             grad.axis.title = 'Elevation (m)', label = 'upedonid',
             name = 'hzname', width = 0.15, spacing = 'relative')

# attempt relative positioning based on scaled distances, no corrections for overlap
# profiles are clustered in space and therefore over-plot
plotTransect(mineralKing, xy, grad.var.name = 'elev_field',
             grad.axis.title = 'Elevation (m)', label = 'upedonid', name = 'hzname',
             width = 0.15, spacing = 'relative', fix.relative.pos = FALSE)

# customize arguments to aqp::fixOverlap()
```

```
plotTransect(mineralKing, xy, grad.var.name = 'elev_field', crs = crs.utm,
             grad.axis.title = 'Elevation (m)', label = 'upedonid', name = 'hzname',
             width = 0.15, spacing = 'relative',
             fix.relative.pos = list(maxIter=6000, adj=0.2, thresh=0.7))

plotTransect(mineralKing, xy, grad.var.name = 'elev_field', crs = crs.utm,
             grad.axis.title = 'Elevation (m)', label = 'upedonid', name = 'hzname',
             width = 0.2, spacing = 'relative',
             fix.relative.pos = list(maxIter = 6000, adj = 0.2, thresh = 0.6),
             name.style = 'center-center')

par(op)

}
```

`plotWB` *Visualize Monthly Water Balance*

Description

This function offers one possible visualization for the results of `monthlyWB()`. Note that "surplus" water is stacked on top of "actual ET", and "deficit" water is stacked below "storage". Calculate actual values for "surplus" and "deficit" from the figure like this:

- surplus value = surplus - AET
- deficit value = deficit - storage

Usage

```
plotWB(
  WB,
  AWC = attr(WB, "AWC"),
  sw.col = "#377EB8",
  surplus.col = "#4DAF4A",
  et.col = "#E41A1C",
  deficit.col = "#FF7F00",
  pch = c(21, 21),
  pt.cex = 1,
  pt.col = par("bg"),
  pt.bg = par("fg"),
  lty = c(1, 2),
  lwd = 2,
  n.ticks = 8,
  grid.col = grey(0.65),
  month.cex = 1,
```

```
  legend.cex = 0.9,
  ylim
)
```

Arguments

`WB`	output from `monthlyWB()`
`AWC`	available water-holding capacity (mm), typically the value used in `monthlyWB()` and stored as an attribute of `WB`
`sw.col`	color for soil water ("storage)
`surplus.col`	color for surplus water
`et.col`	color for ET
`deficit.col`	color for deficit
`pch`	plotting character for PPT and PET points
`pt.cex`	character expansion factor for PPT and PET points
`pt.col`	point symbol color for PPT and PET points
`pt.bg`	point symbol background color for PPT and PET points
`lty`	line type for PPT and PET lines (`c(1, 2)`)
`lwd`	line width for PPT and PET curves
`n.ticks`	approximate number of tick marks on positive and negative y-axis
`grid.col`	horizontal grid line color
`month.cex`	scaling factor for month labels (x-axis)
`legend.cex`	scaling factor for legend
`ylim`	optional vector of y-axis limits, `c(-min, max)`, typically used when comparing drastically different water balances in the same figure. Default limits are usually best for a single water balance plot.

Value

nothing, function is called to generate graphical output

Note

You may have to adjust figure margins and size to get all of the elements to "look right".

Author(s)

D.E. Beaudette and J.M. Skovlin

Examples

```
if(requireNamespace('hydromad')) {

## A shallow / droughty soil near Sonora CA
# 100mm (4") AWC
AWC <- 100
PPT <- c(171, 151, 138, 71, 36, 7, 1, 2, 11, 48, 102, 145)
PET <- c(15.17, 18.26, 30.57, 42.95, 75.37, 108.05, 139.74, 128.9, 93.99, 59.84, 26.95, 14.2)

# water-year
# three years
x.wb <- monthlyWB(AWC, PPT, PET, S_init = 0, starting_month = 9, rep = 3)
x.wb[x.wb$mo == 'Sep', ]

# plot all three years
plotWB(x.wb)

# water-year / last iteration
x.wb <- monthlyWB(AWC, PPT, PET, S_init = 0,
                  starting_month = 9, rep = 3,
                  keep_last = TRUE
)

# plot
plotWB(x.wb)


## Drummer series (Fine-silty, mixed, superactive, mesic Typic Endoaquolls), southern IL

AWC <- 244
PPT <- c(36, 37, 54, 82, 98, 96, 92, 75, 69, 70, 65, 50)
PET <- c(0, 0, 12, 46, 90, 130, 145, 128, 88, 46, 14, 0)

# using calendar year
x.wb <- monthlyWB(AWC, PPT, PET, S_init = 0,
                  starting_month = 1, rep = 3,
                  keep_last = TRUE
)

plotWB(x.wb)

}
```

`plotWB_lines` *Visualization of a monthly water balance using lines and areas*

Description

This function creates a graphical summary of a monthly water balance, typically estimated via `monthlyWB()`.

Usage

```
plotWB_lines(
  WB,
  cols = c("#759CC9", "#EB6D6E", "#7FC47D"),
  line.col = "black",
  line.lty = c(1, 2, 3),
  interpolator = c("spline", "linear"),
  spline.method = c("natural", "periodic"),
  month.cex = 1,
  legend.cex = 0.9
)
```

Arguments

`WB`	output from `monthlyWB()`
`cols`	vector of three colors used for area under PPT, PET, and AET curves
`line.col`	single color used for PPT, PET, and AET lines
`line.lty`	vector of three line styles used for PPT, PET, AET curves
`interpolator`	spline or linear interpolation of monthly values, use of `spline` may lead to minor smoothing artifacts in shaded areas
`spline.method`	when `interpolator = 'spline'`, argument passed to `splinefun(..., method = spline.method)`
`month.cex`	scaling factor for month labels
`legend.cex`	scaling factor for legend

Value

nothing, function is called to generate graphical output

Author(s)

J.M. Skovlin and D.E. Beaudette

Examples

```
if(requireNamespace('hydromad')) {

## A shallow / droughty soil near Sonora CA
# 100mm (4") AWC
AWC <- 100
PPT <- c(171, 151, 138, 71, 36, 7, 1, 2, 11, 48, 102, 145)
PET <- c(15.17, 18.26, 30.57, 42.95, 75.37, 108.05, 139.74, 128.9, 93.99, 59.84, 26.95, 14.2)

# calendar-year
# three year warm-up
x.wb <- monthlyWB(AWC, PPT, PET, S_init = 0, starting_month = 1, rep = 3, keep_last = TRUE)

# plot
```

```
plotWB_lines(x.wb)

}
```

`PLSS2LL` *PLSS2LL*

Description

Fetch latitude and longitude (centroid) coordinates for coded PLSS information from the BLM PLSS web service.

Usage

```
PLSS2LL(p, plssid = "plssid")
```

Arguments

`p`	`data.frame` with chunks of PLSS definition
`plssid`	column name containing PLSS ID

Value

A `data.frame` of PLSS codes and coordinates.

Note

This function expects that the input `p` will have a 'plssid' column generated by the `formatPLSS()` function. Requires the following packages: httr, and jsonlite.

Author(s)

D.E. Beaudette, Jay Skovlin, A.G. Brown

See Also

`LL2PLSS()`, `formatPLSS()`

`polygonAdjacency` *Summarize Spatial Adjacency of Polygon Fabric*

Description

This function utilizes the `spdep` and `igraph` packages to evaluate several measures of spatial connectivity.

Usage

```
polygonAdjacency(x, v = "MUSYM", ...)
```

Arguments

`x`	`sf` object containing simple polygon features, some of which should share edges
`v`	character, name of column in attribute table describing map unit labels
`...`	additional arguments passed to `spdep::poly2nb()`

Details

Examples are presented in this tutorial.

Value

a `list` containing:

- `commonLines`: an integer vector of feature IDs, describing polygons sharing edges and values of `v` (map unit labels)
- `adjMat`: weighted adjacency matrix, suitable for visualization with `plotSoilRelationGraph()`

Author(s)

D.E. Beaudette

`prepareDailyClimateData` *Prepare daily climate data (DAYMET) for a single point*

Description

This function returns daily climate data required for a simple water balance (and more), using three packages:

- `elevatr`: elevation data at `x`
- `daymetr`: DAYMET data at `x` for years `start` through `end`
- `Evapotranspiration`: Makkink formulation for estimating reference crop evapotranspiration

Usage

```
prepareDailyClimateData(x, start, end, onlyWB = TRUE)
```

Arguments

`x`	`sf` object representing a single point
`start`	start year (1998)
`end`	end year (2018)
`onlyWB`	logical, return just those date required by `dailyWB`

Value

a `data.frame`

`prepare_SSURGO_hydro_data` *Get and prepare basic soil hydraulic parameters from SSURGO via SDA*

Description

Get and prepare basic soil hydraulic parameters from SSURGO via SDA

Usage

```
prepare_SSURGO_hydro_data(cokeys, max.depth)
```

Arguments

`cokeys`	vector of component keys (cokey) in current SSURGO snapshot
`max.depth`	target depth of aggregation (cm), corrected later by real soil depth as reported by `slab()`

Details

Weighted mean soil hydraulic parameters are returned over the interval of `0-max.depth`, calculated by `aqp::slab()`.

Value

a `list` containing:

- SPC: `SoilProfileCollection`
- agg: aggregate representation of hydraulic parameters, by cokey

The following soil hydraulic properties are included:

variable	description
cokey	component key
hzname	horizon name
hz_top	horizon top depth (cm)
hz_bottom	horizon bottom depth (cm)
thick	horizon thickness (cm)
sat	VWC at saturation (cm/cm)
fc	VWC at field capacity defined by 1/3rd bar tension (cm/cm)
fc_tenthbar	VWC at field capacity defined by 1/3rd bar tension (cm/cm)
pwp	VWC at permanent wilting point or 15 bar tension (cm/cm)
awc	total sand content (<2mm fraction, mass %)
sand	total silt content (<2mm fraction, mass %)
silt	total clay content (<2mm fraction, mass %)
clay	total sand content (<2mm fraction, mass %)
dbthirdbar	bulk density at 1/3 bar tension (g/cm^3)
dbovendry	bulk density oven-dry basis (g/cm^3)
ksat	Ksat (um/second)
soil_fraction	volume fraction of soil (1 - coarse fragment volume fraction)

Author(s)

D.E. Beaudette

`reconcileOSDGeomorph` *Reconcile IDs between a SPC and associated geomorphic proportion table*

Description

This function can assist with linked visualizations that include soil morphology data stored in a `SoilProfileCollection` and geomorphic proportions stored in a `data.frame`, as returned by `soilDB::fetchOSD()`.

Usage

```
reconcileOSDGeomorph(
  x,
 selection = c("hillpos", "geomcomp", "flats", "mtnpos", "terrace", "shape_across",
    "shape_down")
)
```

Arguments

`x`	resulting list from `soilDB::fetchOSD(..., extended = TRUE)`
`selection`	character, name of geomorphic proportion table

Value

a `list` with subset `SoilProfileCollection` and `data.frame` of geomorphic proportions, `selection` is preserved as an attribute.

Author(s)

D.E. Beaudette

`sample.by.poly` *Sample a Single Polygon at a Target Density*

Description

Sample a single `SpatVector` polygon at a target density in "samples / acre".

Usage

```
sample.by.poly(
  p,
  n.pts.per.ac = 1,
  min.samples = 5,
  sampling.type = "regular",
  p4s = NULL
)
```

Arguments

`p`	`SpatVector` containing a single polygon feature
`n.pts.per.ac`	numeric, sampling density in "points per acre"
`min.samples`	integer, enforced minimum number of samples per polygon
`sampling.type`	sampling.type character, sampling type passed to `terra::spatSample()`
`p4s`	output from `terra::crs()`

Value

`SpatVector` of sample points

Author(s)

D.E. Beaudette

`sampleRasterStackByMU` *Sample a Raster Stack*

Description

Sample a raster stack by map unit polygons, at a constant density.

Usage

```
sampleRasterStackByMU(
  mu,
  mu.set,
  mu.col,
  raster.list,
  pts.per.acre,
  p = c(0, 0.05, 0.25, 0.5, 0.75, 0.95, 1),
  progress = TRUE,
  estimateEffectiveSampleSize = TRUE,
  polygon.id = "pID"
)
```

Arguments

`mu`	a `SpatialPolygonsDataFrame` object in a projected coordinate reference system (CRS)
`mu.set`	character vector of map unit labels to be sampled
`mu.col`	column name in attribute table containing map unit labels
`raster.list`	a `list` containing raster names and paths, see details below
`pts.per.acre`	target sampling density in `points per acre`
`p`	percentiles for polygon area stats, e.g. `c(0.05, 0.25, 0.5, 0.75, 0.95)`
`progress`	logical, print a progress bar while sampling?
`estimateEffectiveSampleSize`	estimate an effective sample size via Moran's I?
`polygon.id`	Column name containing unique polygon IDs; default: `"pID"`; calculated if missing

Details

This function is used by various NRCS reports that summarize or compare concepts defined by collections of polygons using raster data sampled from within each polygon, at a constant sampling density. Even though the function name includes "RasterStack", this function doesn't actually operate on the "stack" object as defined in the raster package. The collection of raster data defined in `raster.list` do not have to share a common coordinate reference system, grid spacing, or extent. Point samples generated from `mu` are automatically converted to the CRS of each raster before extracting values. The extent of each raster in `raster.list` must completely contain the extent of `mu`.

Value

A `list` containing:

`raster.samples`	a `data.frame` containing samples from all rasters in the stack
`area.stats`	a `data.frame` containing area statistics for all map units in the collection
`unsampled.ids`	an index to rows in the original SPDF associated with polygons not sampled
`raster.summary`	a `data.frame` containing information on sampled rasters
`Moran_I`	a `data.frame` containing estimates Moran's I (index of spatial autocorrelation)

Author(s)

D.E. Beaudette

See Also

`constantDensitySampling()`, `sample.by.poly()`

`samplingStability` *Estimate Sampling Stability*

Description

Stability is defined as the width of the 5th-95th percentile range, over n.reps replications of median estimates associated with sampling events. The resulting width is scaled by the population median and returned as a fraction.

Usage

```
samplingStability(
  mu,
  r,
  n.set = c(0.01, 0.1, 0.5, 1, 2),
  n.reps = 10,
  p.id = "pID"
)
```

Arguments

`mu`	map unit polygons, must have polygon ID, must be in CRS with units of meters
`r`	SpatRaster
`n.set`	set of sampling density values to try
`n.reps`	number of replications
`p.id`	polygon ID column name

Value

data.frame with median stability values as percentage of population median, range: `[0,1]`

Author(s)

D.E. Beaudette

`simpleWB` *Simple interface to the hydromad "leaky bucket" soil moisture model*

Description

Simple interface to the hydromad "leaky bucket" soil moisture model.

Usage

```
simpleWB(
  PPT,
  PET,
  D,
  thickness,
  sat,
  fc,
  pwp,
  S_0 = 0.5,
  a.ss = 0.05,
  M = 0,
  etmult = 1
)
```

Arguments

`PPT`	precipitation series (mm)
`PET`	potential ET series (mm)
`D`	dates
`thickness`	soil thickness (cm)
`sat`	volumetric water content at saturation (satiated water content)
`fc`	volumetric water content at field capacity (typically 1/3 bar suction)
`pwp`	volumetric water content at permanent wilting point (typically 15 bar suction)
`S_0`	initial soil moisture as a fraction of total water storage (mm)
`a.ss`	recession coefficients for subsurface flow from saturated zone, should be > 0
`M`	fraction of area covered by deep-rooted vegetation
`etmult`	multiplier for PET

Details

Adjustments for coarse fragments should be made by reducing `thickness`.

Value

a `data.frame`

References

Farmer, D., M. Sivapalan, Farmer, D. (2003). Climate, soil and vegetation controls upon the variability of water balance in temperate and semiarid landscapes: downward approach to water balance analysis. Water Resources Research 39(2), p 1035.

Bai, Y., T. Wagener, P. Reed (2009). A top-down framework for watershed model evaluation and selection under uncertainty. Environmental Modelling and Software 24(8), pp. 901-916.

`site_photos_kml` *site_photos_kml*

Description

Generates a KML file of site locations with associated site photos and a link to a pedon description report.

Usage

```
site_photos_kml(data,
filename='photos.kml', make.image.grid=FALSE,
file.source = c('local', 'relative')
)
```

Arguments

`data`	a dataframe
`filename`	full file path and name with .kml extension
`make.image.grid`	logical, include linked site images, default is FALSE
`file.source`	'local' sources the image files to a specific system path, 'relative' sources the image files to files folder that can be included and referenced within a .kmz file

Details

This function simplifies writing a kml file of site and/or sites with linked photos. Further documentation is provided in this tutorial.

Value

A KML file of of sites with embedded associated site photos.

Author(s)

Jay Skovlin, D.E. Beaudette

`SoilTaxonomyDendrogram` *Soil Taxonomy Dendrogram*

Description

Plot a dendrogram based on the first 4 levels of Soil Taxonomy, with soil profiles hanging below. A dissimilarity matrix is computed using Gower's distance metric for nominal (`KST.order = FALSE`) or ordinal (`KST.order = TRUE`) scale variables, based on soil order, suborder, greatgroup, and subgroup taxa.

Usage

```
SoilTaxonomyDendrogram(
  spc,
  KST.order = TRUE,
  rotationOrder = NULL,
 level = c(soilorder = "soilorder", suborder = "suborder", greatgroup = "greatgroup",
    subgroup = "subgroup"),
  cluster.method = c("divisive", "agglomerative"),
  cluster.args = list(),
  name = "hzname",
  name.style = "center-center",
  id.style = "side",
  n.depth.ticks = 6,
  scaling.factor = 0.015,
  cex.names = 0.75,
  cex.id = 0.75,
  width = 0.25,
  y.offset = 0.5,
  shrink = FALSE,
  font.id = 2,
  cex.taxon.labels = 0.66,
  font.taxon.labels = 3,
  dend.color = par("fg"),
  dend.width = 1,
  dend.type = c("phylogram", "cladogram"),
  max.depth = ifelse(is.infinite(max(spc)), 200, max(spc)),
  ...
)
```

Arguments

`spc`	a `SoilProfileCollection` object, typically returned by `soilDB::fetchOSD`
`KST.order`	logical, encode / cluster taxa via ordinal factors, based on ordering within Keys to Soil Taxonomy
`rotationOrder`	character vector of profile IDs with desired ordering of leaves in the dendrogram from left to right; exact ordering is not always possible
`level`	character. One or more site-level columns in `spc`. Default: `"soilorder"`, `"suborder"`, `"greatgroup"` and `"subgroup"`
`cluster.method`	Either "divisive" (`cluster::diana()`; default) or "agglomerative" (`cluster::agnes()`)
`cluster.args`	Optional: additional arguments for `cluster::diana()` or `cluster::agnes()` cluster methods
`name`	column name containing horizon names
`name.style`	passed to `aqp::plotSPC`
`id.style`	passed to `aqp::plotSPC`
`n.depth.ticks`	suggested number of ticks on the depth axis
`scaling.factor`	scaling factor used to convert depth units into plotting units
`cex.names`	character scaling for horizon names
`cex.id`	character scaling for profile IDs
`width`	width of profiles
`y.offset`	vertical offset between dendrogram and profiles
`shrink`	logical, should long horizon names be shrunk by 80% ?
`font.id`	integer, font style applied to profile id, default is 2 (bold)
`cex.taxon.labels`	numeric, character scaling for taxonomic information
`font.taxon.labels`	integer, font style applied to taxa labels, default is 3 (italic)
`dend.color`	dendrogram line color
`dend.width`	dendrogram line width
`dend.type`	dendrogram type, passed to `plot.phylo()`, either "phylogram" or "cladogram"
`max.depth`	depth at which profiles are truncated for plotting
`...`	additional arguments to `aqp::plotSPC`

Details

This function looks for specific site-level attributes named: `"soilorder"`, `"suborder"`, `"greatgroup"`, and `"subgroup"`, or their NASIS physical column name analogues `"taxorder"`, `"taxsuborder"`, `"taxgrtgroup"`, and `"taxsubgrp"`. See `https://github.com/ncss-tech/sharpshootR/blob/master/misc/soilTaxonomyDendrogram-examples.R` for some examples.

The `rotationOrder` argument uses `ape::rotateConstr()` to reorder leaves within the `hclust` representation of the ST hierarchy. Perfect sorting is not always possible.

Value

An invisibly-returned list containing:

- `dist`: pair-wise dissimilarity matrix
- `order`: final ordering of `hclust` leaves

Author(s)

D.E. Beaudette

`table5.2` *Table 5.2 from Hole and Campbell, 1985.*

Description

An adjacency matrix describing shared soil map boundary segments from the Soil Survey of Shawnee county, KS. This is table 5.2 from Hole and Campbell, 1985.

Usage

```
data(table5.2)
```

Format

An object of class `matrix` (inherits from `array`) with 18 rows and 18 columns.

References

Hole, F.D. and J.B. Campbell. Soil Landscape Analysis. Rowman and Allanheld, 1985.

Examples

```
data("table5.2")

if(requireNamespace("igraph")) {

  # note special incantation to get the "correct" graph structure
 g <- igraph::graph_from_adjacency_matrix(table5.2, mode = 'upper', diag = FALSE, weighted = TRUE)

  # visualize
  op <- par(no.readonly = TRUE)

  par(mar = c(0,0,0,0))
  plot(g)

  plot(g, vertex.size = sqrt(igraph::degree(g) * 25), vertex.label.family = 'sans')

  # find communities
  cm <- igraph::cluster_walktrap(g)
```

```
  plot(cm, g, vertex.label.family = 'sans')

  par(op)
}
```

`vizAnnualClimate` *Annual Climate Summaries for Soil Series Data*

Description

Annual climate summaries for soil series, based on `latticeExtra::segplot`, based on 5th, 25th, 50th, 75th, and 95th percentiles. Input data should be from `soilDB::fetchOSD`.

Usage

```
vizAnnualClimate(climate.data, IQR.cex = 1, s = NULL, s.col = "firebrick", ...)
```

Arguments

`climate.data`	Annual climate summaries, as returned from `soilDB::fetchOSD(..., extended=TRUE)`
`IQR.cex`	scaling factor for bar representing interquartile range
`s`	a soil series name, e.g. "LUCY", to highlight
`s.col`	color for highlighted soil series
`...`	further arguments passed to `latticeExtra::segplot`

Details

This function was designed for use with `soilDB::fetchOSD`. It might be possible to use with other sources of data but your mileage may vary. See the Soil Series Query Functions tutorial for more information.

Value

A `list` with the following elements:

- `fig`: lattice object (the figure)
- `clust`: clustering object returned by `cluster::diana`

Author(s)

D.E. Beaudette

See Also

`vizHillslopePosition()`

`vizFlatsPosition` *Visual Summary of Flat Landform Positions*

Description

A unique display of landform position probability.

Usage

```
vizFlatsPosition(
  x,
  s = NULL,
  annotations = TRUE,
  annotation.cex = 0.75,
  cols = c("#2B83BA", "#ABDDA4", "#FFFFBF", "#FDAE61", "#D7191C"),
  ...
)
```

Arguments

`x`	`data.frame` as created by `soilDB::fetchOSD(..., extended = TRUE)`, see details
`s`	an optional soil series name, highlighted in the figure
`annotations`	logical, add number of record and normalized Shannon entropy values
`annotation.cex`	annotation label scaling factor
`cols`	vector of colors
`...`	additional arguments to `iterateHydOrder()`: `target = 0.9, maxIter = 20, j.amount = 0.05, verbo`

Details

See the Soil Series Query Functions tutorial for more information.

Value

A `list` with the following elements:

- `fig`: lattice object (the figure)
- `order`: 1D ordering from `cluster::diana`
- `clust`: `hclust` object
- `match.rate`: fraction of series matching target hydrologic ordering, after clustering + rotation

Author(s)

D.E. Beaudette

`vizGeomorphicComponent`

Visual Summary of Hill Landform Positions

Description

A unique display of landform position probability.

Usage

```
vizGeomorphicComponent(
  x,
  s = NULL,
  annotations = TRUE,
  annotation.cex = 0.75,
  cols = c("#D53E4F", "#FC8D59", "#FEE08B", "#E6F598", "#99D594", "#3288BD"),
  ...
)
```

Arguments

`x`	`data.frame` as created by `soilDB::fetchOSD(..., extended = TRUE)`, see details
`s`	an optional soil series name, highlighted in the figure
`annotations`	logical, add number of record and normalized Shannon entropy values
`annotation.cex`	annotation label scaling factor
`cols`	vector of colors
`...`	additional arguments to `iterateHydOrder()`: `target = 0.9, maxIter = 20, j.amount = 0.05, verbo`

Details

See the Soil Series Query Functions tutorial for more information.

Value

A `list` with the following elements:

- `fig`: lattice object (the figure)
- `order`: 1D ordering from `cluster::diana`
- `clust`: `hclust` object
- `match.rate`: fraction of series matching target hydrologic ordering, after clustering + rotation

Author(s)

D.E. Beaudette

`vizHillslopePosition` *Visual Summary of Hillslope Position*

Description

A unique display of hillslope position probability.

Usage

```
vizHillslopePosition(
  x,
  s = NULL,
  annotations = TRUE,
  annotation.cex = 0.75,
  cols = c("#2B83BA", "#ABDDA4", "#FFFFBF", "#FDAE61", "#D7191C"),
  ...
)
```

Arguments

`x`	`data.frame` as created by `soilDB::fetchOSD(..., extended = TRUE)`
`s`	an optional soil series name, highlighted in the figure
`annotations`	logical, add number of record and normalized Shannon entropy values
`annotation.cex`	annotation label scaling factor
`cols`	vector of colors
`...`	additional arguments to `iterateHydOrder()`: `target = 0.9, maxIter = 20, j.amount = 0.05, verbo`

Details

See the Soil Series Query Functions tutorial for more information.

Value

A `list` with the following elements:

- `fig`: lattice object (the figure)
- `order`: 1D ordering from `cluster::diana`
- `clust`: `hclust` object
- `match.rate`: fraction of series matching target hydrologic ordering, after clustering + rotation

Author(s)

D.E. Beaudette

`vizMountainPosition` *Visual Summary of Mountain Slope Positions*

Description

A unique display of mountain slope position probability.

Usage

```
vizMountainPosition(
  x,
  s = NULL,
  annotations = TRUE,
  annotation.cex = 0.75,
  cols = c("#D53E4F", "#FC8D59", "#FEE08B", "#E6F598", "#99D594", "#3288BD"),
  ...
)
```

Arguments

`x`	`data.frame` as created by `soilDB::fetchOSD(..., extended=TRUE)`, see details
`s`	an optional soil series name, highlighted in the figure
`annotations`	logical, add number of record and normalized Shannon entropy values
`annotation.cex`	annotation label scaling factor
`cols`	vector of colors
`...`	additional arguments to `iterateHydOrder()`: `target = 0.9, maxIter = 20, j.amount = 0.05, verbo`

Details

See the Soil Series Query Functions tutorial for more information.

Value

A `list` with the following elements:

- `fig`: lattice object (the figure)
- `order`: 1D ordering from `cluster::diana`
- `clust`: `hclust` object
- `match.rate`: fraction of series matching target hydrologic ordering, after clustering + rotation

Author(s)

D.E. Beaudette

`vizSurfaceShape` *Visual Summary of Surface Shape*

Description

A unique display of surface shape (typically curvature) probability, suitable for across-slope or down-slope shape. Use the `title` argument to make this clear.

Usage

```
vizSurfaceShape(
  x,
  title = "Surface Shape",
  s = NULL,
  annotations = TRUE,
  annotation.cex = 0.75,
  cols = c("#2B83BA", "#FFFFBF", "#D7191C", "#808080", "darkgreen"),
  ...
)
```

Arguments

`x`	`data.frame` as created by `soilDB::fetchOSD(..., extended = TRUE)`, see details
`title`	a reasonable title for the figure
`s`	an optional soil series name, highlighted in the figure
`annotations`	logical, add number of record and normalized Shannon entropy values
`annotation.cex`	annotation label scaling factor
`cols`	vector of colors
`...`	additional arguments to `iterateHydOrder()`: `target = 0.9, maxIter = 20, j.amount = 0.05, verbo`

Details

See the Soil Series Query Functions tutorial for more information.

Value

A `list` with the following elements:

- `fig`: lattice object (the figure)
- `order`: 1D ordering from `cluster::diana`
- `clust`: `hclust` object
- `match.rate`: fraction of series matching target hydrologic ordering, after clustering + rotation

Author(s)

D.E. Beaudette

`vizTerracePosition` *Visual Summary of Terraced Landform Positions*

Description

A unique display of terraced landform position probability.

Usage

```
vizTerracePosition(
  x,
  s = NULL,
  annotations = TRUE,
  annotation.cex = 0.75,
  cols = c("#2B83BA", "#FDAE61"),
  ...
)
```

Arguments

`x`	`data.frame` as created by `soilDB::fetchOSD(..., extended = TRUE)`, see details
`s`	an optional soil series name, highlighted in the figure
`annotations`	logical, add number of record and normalized Shannon entropy values
`annotation.cex`	annotation label scaling factor
`cols`	vector of colors
`...`	additional arguments to `iterateHydOrder()`: `target = 0.9, maxIter = 20, j.amount = 0.05, verbo`

Details

See the Soil Series Query Functions tutorial for more information.

Value

A `list` with the following elements:

- `fig`: lattice object (the figure)
- `order`: 1D ordering from `cluster::diana`
- `clust`: `hclust` object
- `match.rate`: fraction of series matching target hydrologic ordering, after clustering + rotation

Author(s)

D.E. Beaudette

Index

∗ **datasets**
  amador, 4
  CDEC.snow.courses, 6
  HHM, 26
  OSDexamples, 40
  table5.2, 68
∗ **hplots**
  aspect.plot, 4
  diagnosticPropertyPlot, 15
  diagnosticPropertyPlot2, 16
  dueling.dendrograms, 18
  PCP_plot, 40
  percentileDemo, 41
  plotSoilRelationChordGraph, 46
  plotWB, 53
∗ **hplot**
  plotSoilRelationGraph, 47
∗ **manip**
  component.adj.matrix, 11
  constantDensitySampling, 12
  dist.along.grad, 17
  multinominal2logical, 39
  sample.by.poly, 61
  sampleRasterStackByMU, 62
  site_photos_kml, 65

amador, 4
aqp::mixMunsell(), *10*
aqp::plotSPC(), *45*
aspect.plot, 4

CDEC.snow.courses, 6
CDEC_StationInfo, *7*, 9
CDEC_StationInfo(), *8*
CDECquery, 7
CDECsnowQuery, 8
CDECsnowQuery(), *8*
colorMixtureVenn, 10
component.adj.matrix, 11
constantDensitySampling, 12
constantDensitySampling(), *63*
contour(), *28*

dailyWB, 13
dailyWB(), *33, 34*
dailyWB_SSURGO, 14
dailyWB_SSURGO(), *33, 34*
diagnosticPropertyPlot, 15
diagnosticPropertyPlot(), *39*
diagnosticPropertyPlot2, 16
digest::digest(), *24*
dist.along.grad, 17
dueling.dendrograms, 18

ESS_by_Moran_I, 19
estimateSoilMoistureState, *13, 14*, 20, *34*

FFD, 21, *22*
FFDplot, 22
formatPLSS, 23
formatPLSS(), *33*, *57*

generateLineHash, 24

HenryTimeLine, 26
HHM, 26
huePositionPlot, 27
hydOrder, 28
hydOrder(), *45*

isMineralSoilMaterial, 29
iterateHydOrder, 30
iterateHydOrder(), *29*, *31*, *45*, *70–75*

joinAdjacency, 32

LL2PLSS, 32
LL2PLSS(), *57*

moistureStateProportions, 33
moistureStateProportions(), *34*

`moistureStateStats`, 34
`moistureStateThreshold`, 34
`monthlyWB`, 35
`monthlyWB()`, *53–56*
`monthlyWB_summary`, 37
`Moran_I_ByRaster`, 38
`multinominal2logical`, *17*, 39
`multinominal2logical()`, *16*

`OSDexamples`, 40

`PCP_plot`, 40
`percentileDemo`, 41
`plotAvailWater`, 42
`plotGeomorphCrossSection`, 45
`plotSoilRelationChordGraph`, 46
`plotSoilRelationGraph`, 47
`plotSoilRelationGraph()`, *32*, *58*
`plotTransect`, *17, 18*, 50
`plotWB`, 53
`plotWB_lines`, 55
`PLSS2LL`, 57
`PLSS2LL()`, *24*, *33*
`plssMeridians` *(*`LL2PLSS`*)*, 32
`polygonAdjacency`, 58
`prepare_SSURGO_hydro_data`, 59
`prepareDailyClimateData`, 58

`reconcileOSDGeomorph`, 60

`sample.by.poly`, 61
`sample.by.poly()`, *63*
`sampleRasterStackByMU`, 62
`samplingStability`, 63
`sharpshootR` *(*`sharpshootR-package`*)*, 3
`sharpshootR-package`, 3
`simpleWB`, 64
`site_photos_kml`, 65
`soilDB::waterDayYear()`, *41*
`SoilTaxonomyDendrogram`, 66
`spdep::poly2nb()`, *58*

`table5.2`, 68
`terra::crs()`, *61*
`terra::spatSample()`, *12*, *61*

`vizAnnualClimate`, 69
`vizFlatsPosition`, 70
`vizGeomorphicComponent`, 71
`vizHillslopePosition`, 72
`vizHillslopePosition()`, *69*
`vizMountainPosition`, 73
`vizSurfaceShape`, 74
`vizTerracePosition`, 75