Package 'wrv'

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Title Wood River Valley Groundwater Flow Model

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Depends R (>= 3.1.0), sp, rgdal, rgeos, raster

Imports igraph, dplyr

Suggests RCurl, knitr, xtable, sfsmisc

SystemRequirements MODFLOW-USG (>= 1.2)

Description Pre- and post-processing program for the groundwater-flow model of the Wood River Valley aquifer system, south-central Idaho.

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URL https://github.com/jfisher-usgs/wrv

BugReports https://github.com/jfisher-usgs/wrv/issues

ByteCompile yes

LazyData yes

LazyDataCompression xz

VignetteBuilder knitr

R topics documented:

`alluvium.extent` *Extent of Alluvium Unit*

Description

The estimated extent of alluvium unit in the Wood River Valley, south-central Idaho.

Usage

```
alluvium.extent
```

Format

An object of `SpatialPolygonsDataFrame-class` containing 1 `Polygons`. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

Extent defined by Bartollino and Adkins (2012, Plate 1).

References

Bartolino, J.R., and Adkins, C.B., 2012, Hydrogeologic framework of the Wood River Valley aquifer system, south-central Idaho: U.S. Geological Survey Scientific Investigations Report 2012-5053, 46 p., available at `http://pubs.usgs.gov/sir/2012/5053/`.

Examples

```
plot(alluvium.extent)
str(alluvium.extent)
```

alluvium.thickness *Thickness of the Quaternary Sediment*

Description

Estimated thickness of the Quaternary sediment in the Wood River Valley aquifer system, South-Central Idaho.

Usage

```
alluvium.thickness
```

Format

An object of class RasterLayer. Each cell on the surface grid represents a depth measured from land surface in meters. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM). The spatial grid is composed of 565 rows and 429 columns, and has cell sizes that are constant at 100 meters by 100 meters.

Source

This dataset is a revised version of Plate 1 in Bartolino and Adkins (2012).

References

Bartolino, J.R., and Adkins, C.B., 2012, Hydrogeologic framework of the Wood River Valley aquifer system, south-central Idaho: U.S. Geological Survey Scientific Investigations Report 2012-5053, 46 p., available at http://pubs.usgs.gov/sir/2012/5053/.

Examples

```
plot(alluvium.thickness)
summary(alluvium.thickness)
```

basalt.extent *Extent of Basalt Unit*

Description

The estimated extent of the basalt unit underlying the alluvial Wood River Valley aquifer system.

Usage

```
basalt.extent
```

Format

An object of SpatialPolygonsDataFrame-class containing 1 Polygons. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

Extent defined by Bartollino and Adkins (2012, Plate 1).

References

Bartolino, J.R., and Adkins, C.B., 2012, Hydrogeologic framework of the Wood River Valley aquifer system, south-central Idaho: U.S. Geological Survey Scientific Investigations Report 2012-5053, 46 p., available at http://pubs.usgs.gov/sir/2012/5053/.

Examples

```
plot(basalt.extent)
str(basalt.extent)
```

---

bellevue.wwtp.ponds   *Bellevue Waste Water Treatment Plant Ponds*

Description

Location of the Bellevue Waste Water Treatment Plant ponds.

Usage

```
bellevue.wwtp.ponds
```

Format

An object of `SpatialPolygons` class containing 1 `Polygons`. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources

Examples

```
plot(bellevue.wwtp.ponds)
```

BumpDisconnectedCells *Adjustment for Vertically Disconnected Cells*

Description

Decrease model cell values in the lower raster layer if they violate a minimum vertical overlap between adjacent cells.

Usage

```
BumpDisconnectedCells(rs, min.overlap = 2, bump.by = 0.1, max.itr = 1e+04)
```

Arguments

`rs`	`RasterStack`; a collection of two raster layers, the first and second layers represent the top and bottom of a model layer.
`min.overlap`	`numeric`; the minimum vertical overlap between adjacent cells.
`bump.by`	`numeric`; the amount to decrease a cell value by during each iteration of the algorithm.
`max.itr`	`numeric`; the maximum number of iterations.

Details

During each iteration of the algorithm: (1) Cells are identified that violate the minimum vertical overlap between adjacent cells; that is, the bottom of cell `i` is greater than or equal to the top of an adjacent cell `j` minus the minimum overlap specified by the `min.overlap` argument. (2) For cells violating the minimum vertical overlap, lower raster layer (`rs[[2]]`) values are decreased by the value specified in the `bump.by` argument.

Value

Returns a `RasterLayer` that can be added to `rs[[2]]` to ensure connectivity between cells. Cell values in the returned raster grid represent vertical adjustments.

Author(s)

J.C. Fisher

Examples

```
set.seed(0)
r.top <- raster(ncols = 10, nrows = 10)
r.bot <- raster(ncols = 10, nrows = 10)
r.top[] <- rnorm(ncell(r.top), mean = 12)
r.bot[] <- rnorm(ncell(r.bot), mean = 10)
summary(r.top - r.bot)

r <- BumpDisconnectedCells(stack(r.top, r.bot), min.overlap = 0.1)
plot(r.bot + r)
```

BumpRiverStage *Adjustment for Implausible River Stage*

Description

Decrease stage values in river cells if they violate the laws of physics; that is, water always flows downhill.

Usage

```
BumpRiverStage(r, outlets, min.drop = 1e-06)
```

Arguments

r	RasterLayer; each cell on the surface grid represents a river stage.
outlets	SpatialPoints*, SpatialLines*, SpatialPolygons* or Extent; the location of discharge outlets. The rasterize function is used to locate outlet cells in the raster grid r.
min.drop	numeric; the minimum drop in stage between adjacent river cells.

Details

The Lee algorithm is used to identify flow paths among the modeled river cells. An analysis of river cell stage values along a flow path identifies any problematic cells that are obstructing downhill surface-water flow. Stage values for these problematic cells are then lowered to an acceptable elevation.

Value

Returns a RasterLayer with cell values representing the vertical change in stream stage. These changes can be added to r to ensure that water always flows downhill.

Author(s)

J.C. Fisher

Examples

```
## Not run: # see wrv-model vignette
```

`bypass.canal` *Bypass Canal*

Description

Location of the Bypass Canal, used to divert water from the Big Wood River.

Usage

```
bypass.canal
```

Format

An object of `SpatialLines-class` containing 4 `Lines`. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources

Examples

```
plot(bypass.canal)
```

`canal.seep` *Canal Seepage*

Description

Canal seepage as a fraction of diversions for irrigation entities in the Wood River Valley.

Usage

```
canal.seep
```

Format

A `data.frame` object with 19 records and the following variables:

EntityName is the name of the irrigation entity served by the canal system.

SeepFrac is the estimated canal seepage as a fraction of diversions.

Source

Idaho Department of Water Resources

See Also

`canals`

Examples

```
str(canal.seep)
```

---

canals *Canals*

Description

Canal systems in the Wood River Valley and surrounding areas.

Usage

```
canals
```

Format

An object of `SpatialLinesDataFrame-class` containing 113 `Lines` and a `data.frame` with the following variable:

EntityName the name of the irrigation entity served by the canal system.

Source

Idaho Department of Water Resources (IDWR)

See Also

`r.canals`, `canal.seep`

Examples

```
plot(canals)
str(canals@data)
```

---

cities *Cities and Towns*

Description

Cities and towns in the Wood River Valley and surrounding areas.

Usage

```
cities
```

Format

An object of `SpatialPointsDataFrame-class` containing 9 points. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources (IDWR)

Examples

```
spplot(cities)
str(cities)
```

---

clay.extent *Extent of Clay Unit*

Description

The estimated extent of the confining clay unit (aquitard) separating the unconfined aquifer from the underlying confined aquifer in the Wood River Valley.

Usage

```
clay.extent
```

Format

An object of `SpatialPolygonsDataFrame-class` containing 2 `Polygons`. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

Extent defined by Moreland (1977, fig. 3 in USGS Open-File report). Moreland shows an outlier by Picabo that is assumed to indicate confined conditions in the basalt and not the lake sediments.

References

Moreland, J.A., 1977, Ground water-surface water relations in the Silver Creek area, Blaine County, Idaho: Boise, Idaho Department of Water Resources, Water Information Bulletin 44, 42 p., 5 plates in pocket, accessed January 31, 2012. Also published as U.S. Geological Survey Open-File report 77-456, 66 p., available at `http://pubs.er.usgs.gov/pubs/ofr/ofr77456`.

Examples

```
plot(clay.extent)
str(clay.extent)
```

`comb.sw.irr` *Combined Surface Water Irrigation Diversions*

Description

Supplemental groundwater rights and associated surface water rights.

Usage

```
comb.sw.irr
```

Format

A `data.frame` object with 1,213 records and the following variables:

WaterRight is the name of the supplemental groundwater right.

CombWaterRight is the name of the surface water right that shares a combined limit with the groundwater right.

Source is the river or stream source name for the surface water right.

WaterUse is the authorized beneficial use for the surface water right.

MaxDivRate is the authorized maximum diversion rate for the surface water right, in cubic meters per day.

Pdate is the priority date of the surface water right.

Source

Idaho Department of Water Resources (IDWR); derived from combined limit comments in IDWR water rights database.

Examples

```
str(comb.sw.irr)
```

`div.gw` *Groundwater Diversions*

Description

Groundwater diversions recorded by Water District 37 or municipal water providers.

Usage

```
div.gw
```

Format

A `data.frame` object with 7,292 records and the following variables:

YearMonth is the year and month during which diversions were recorded, with a required date format of `YYYYMM`.

Diversion is the name of the well.

Reach is the name of the river subreach into which the well water is discharged; only applicable to exchange wells.

BigReach is the name of the river reach into which the well water is discharged; only applicable to exchange wells.

EntityName is the name of the irrigation entity which the well supplies water.

WMISNumber is the well number in the Idaho Department of Water Resources (IDWR) Water Measurement Information System.

GWDiv is the volume of water diverted during the month, in cubic meters.

Source

IDWR; compiled data records from Water District 37 and 37M, City of Ketchum, Sun Valley Water and Sewer District, City of Hailey, and City of Bellevue.

Examples

```
str(div.gw)
```

`div.sw` *Surface Water Diversions*

Description

Surface water diversions recorded by Water District 37 or municipal water providers.

Usage

```
div.sw
```

Format

A `data.frame` object with 15,550 records and the following variables:

YearMonth is the year and month during which diversions were recorded, with a required date format of `YYYYMM`.

Diversion is the name of the surface-water diversion.

Reach is the river subreach from which the water is diverted.

BigReach is the river reach from which the water is diverted.

EntityName is the name of the irrigation entity which the diversion supplies water.

SWDiv is the volume of water diverted during the month, in cubic meters.

Source

Idaho Department of Water Resources; compiled data records from Water District 37 and 37M, City of Hailey, and City of Bellevue.

Examples

```
str(div.sw)
```

`div.ww` *Wastewater Treatment Plant Diversions*

Description

Recorded discharge from wastewater treatment plants.

Usage

```
div.ww
```

Format

A `data.frame` object with 1,182 records and the following variables:

YearMonth is the year and month during which diversions were recorded, with a required date format of `YYYYMM`.

Return is the name of the wastewater treatment plant.

Reach is the name of the river subreach to which treated effluent is discharged; only applicable to wastewater treatment plants that discharge to the river.

BigReach is the name of the river reach to which treated effluent is discharged; only applicable to wastewater treatment plants that discharge to the river.

EntityName is the name of the irrigation entity served by the wastewater treatment plant.

WWDiv is the volume of wastewater discharged during the month, in cubic meters.

Source

Idaho Department of Water Resources and U.S. Geological Survey; compiled data records from the U.S. Environmental Protection Agency for plants that discharge to the river, and from records of the Idaho Department of Environmental Quality for plants that discharge to land application.

Examples

```
str(div.ww)
```

`DownloadFile` *Download File from the Internet*

Description

This function downloads a file from the Internet.

Usage

```
DownloadFile(url, dest.dir = tempdir(), mode = NULL, extract = TRUE,
             max.attempts = 10L, wait.time = 30)
```

Arguments

`url`	`character`; the URL (or FTP) of a resource to be downloaded.
`dest.dir`	`character`; the directory where the downloaded file is saved.
`mode`	`character`; the mode with which to write the file, such as `"w"`, `"wb"` (binary), `"a"` (append) and `"ab"`.
`extract`	`logical`; if `TRUE`, an attempt is made to extract files from the file archive.
`max.attempts`	`integer`; the maximum number of attempts to download a file.
`wait.time`	`numeric`; the time to wait between download attempts, in seconds.

Details

This function requires the suggested package **RCurl**.

Value

Returns the file path(s) to the downloaded file (or uncompressed files).

Author(s)

J.C. Fisher

See Also

`CFILE`, `curlPerform`

Examples

```
url <- paste0("https://raw.githubusercontent.com/jfisher-usgs/",
              "wrv/master/inst/extdata/alluvium.extent.zip")
files <- DownloadFile(url)
unlink(files)
```

`drains` *Drain Locations*

Description

Polygons used to define the locations of drain boundaries in the model domain. The polygons clip the line segments along the aquifer boundary (see `alluvium.extent`), and model cells intersecting these clipped-line segments are defined as boundary cells.

Usage

```
drains
```

Format

An object of `SpatialPolygonsDataFrame-class` containing a set of 2 `Polygons` and a `data.frame` with the following variable:

Name is an identifier for the polygon.

cond is the drain conductance in square meters per day.

elev is the drain threshold elevation in meters above the North American Vertical Datum of 1988 (NAVD 88).

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

A Keyhole Markup Language (KML) file created in Google Earth with polygons drawn by hand in areas of known drains.

Examples

```
plot(drains)
str(drains)
```

`drybed` *Summary of Dry River Bed Conditions*

Description

A summary of dry river bed conditions in the Wood River Valley, Idaho. Stream reaches between Glendale and Wood River Ranch are episodically dry; these dry periods are based on records of dates when all water was turned into the Bypass Canal.

Usage

```
drybed
```

Format

A `data.frame` object with 12 records and the following variables:

Reach is the stream reach name.

199501, ..., 201012 are logical values indicating whether the stream reach exhibits dry-bed conditions during a stress period.

Source

Idaho Department of Water Resources; partially calculated from `drybed.bwr` dataset.

Examples

```
str(drybed)
```

`drybed.bwr` *Periods of Dry River Bed Conditions in the Big Wood River*

Description

Something...

Usage

```
drybed.bwr
```

Format

A `data.frame` object with 16 records and the following variables:

StartDate, EndDate something...

Comment something...

Source

Idaho Department of Water Resources; written communication with Kevin Lakey.

Examples

```
str(drybed.bwr)
```

efficiency — *Irrigation Efficiency*

Description

Irrigation efficiency for each irrigation entity.

Usage

```
efficiency
```

Format

A `data.frame` object with 88 records and the following variables:

EntityName is the name of the irrigation entity which the irrigation efficiency is applied.

Eff is the estimated irrigation efficiency, the ratio of the amount of water consumed by the crop to the amount of water supplied through irrigation.

Source

Idaho Department of Water Resources

Examples

```
str(efficiency)
```

entity.components — *Irrigation Entity Components*

Description

Irrigation entities and their components in the Wood River Valley and surrounding areas. An irrigation entity is defined as an area served by a group of surface water and/or groundwater diversion(s).

Usage

```
entity.components
```

Format

A `list` object with components of `SpatialPolygonsDataFrame-class`. There are a total of 192 components, one `SpatialPolygonsDataFrame` for each month in the 1995-2010 time period. Linked `data.frame` objects have the following variables:

EntitySrce a concatenation of the `EntityName` and `Source` character strings.

mean.et the mean evapotranspiration (ET) on irrigated and semi-irrigated lands in meters.

area the area of irrigated and semi-irrigated lands in square meters.

PrecipZone the name of the precipitation zone. See `precip.zones` dataset for details.

et.vol the volume of ET on irrigated and semi-irrigated lands in cubic meters.

precip.vol the volume of precipitation on irrigated and semi-irrigated lands in cubic meters.

cir.vol the volume of crop irrigation requirement (ET minus precipitation).

EntityName is the name of the irrigation entity.

Source is the water source: "Mixed" for a mixture of surface water and groundwater, "SW Only" for surface water only, and "GW Only" for groundwater only.

Source

Idaho Department of Water Resources

Examples

```
names(entity.components)
plot(entity.components[["199506"]])
print(entity.components[["199506"]])
```

`et` *Evapotranspiration*

Description

Evapotranspiration (ET) in the Wood River Valley and surrounding areas. Defined as the amount of water lost to the atmosphere via direct evaporation, transpiration by vegetation, or sublimation from snow covered areas.

Usage

```
et
```

Format

An object of class `RasterStack`, a collection of `RasterLayer` objects. There are a total of 192 raster layers, one layer for each month in the 1995-2010 time period. Each cell on a layers surface grid represents the monthly depth of ET in meters. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources

See Also

`et.method`

Examples

```
print(et)
plot(et[["199505"]])
```

`et.method` *Method Used to Calculate Evapotranspiration*

Description

The methods used to estimate evapotranspiration (ET) values.

Usage

```
et.method
```

Format

A `data.frame` object with 122 records with the following variables:

YearMonth The year and month during which the method was applied, with a required date format of `YYYYMM`.

ETMethod An identifier that indicates the method used to estimate ET values. Identifiers include: “MET”, the Mapping Evapotranspiration at high Resolution and with Internalized Calibration (METRIC) evapotranspiration model. “NET”, the correlation between Normalized Difference Vegetation Index (NDVI) and historic ET values. “INT”, interpolating form historic ET values. “ADJ”, interpolating form historic ET values and adjusted to remove outliers. “WNT”, the Allen and Robison method.

Source

Idaho Department of Water Resources

References

Allen, R., Robison, C.W., 2007, Evapotranspiration and consumptive water requirements for Idaho, University of Idaho, Kimberly, Idaho.

Allen, R., Robison, C.W., Garcia, M., Trezza, R., Tasumi, M., and Kjaersgaard, J., 2010, ETrF vs NDVI relationships for southern Idaho for rapid estimation of evapotranspiration, University of Idaho, Kimberly, ID.

Allen, R., Tasumi, M., Trezza, R., and Kjaersgaard, J., 2010, METRIC mapping evapotranspiration at high resolution applications manual for Landsat satellite imagery version 2.07, University of Idaho, Kimberly, ID.

ET Idaho: http://data.kimberly.uidaho.edu/ETIdaho/

Examples

```
str(et.method)
```

ExcludeSmallCellChunks *Exclude Small Cell Chunks*

Description

A cell chunk is defined as a group of connected cells with non-missing values. This function identifies cell chunks in a single raster grid layer. The chunk with the largest surface area is preserved and all others removed.

Usage

```
ExcludeSmallCellChunks(r)
```

Arguments

r	RasterLayer; a raster grid layer with cell values.

Value

The raster grid layer `r` with cell values in the smaller cell chunks set to `NA`.

Author(s)

J.C. Fisher

See Also

clump

Examples

```
set.seed(0)
r <- raster(ncols = 10, nrows = 10)
r[] <- round(runif(ncell(r)) * 0.7)
r <- clump(r)
plot(r)

r.new <- ExcludeSmallCellChunks(r)
plot(r.new, zlim = range(r[], na.rm = TRUE))
```

ExportRasterStack *Export Raster Stack*

Description

Write raster-stack, a collection of raster layers, to local directories using multiple file formats.

Usage

```
ExportRasterStack(rs, path, zip = "")
```

Arguments

rs	RasterStack; a collection of RasterLayer objects with the same extent and resolution.
path	character; path name to write raster stack.
zip	character; if there is no zip program on your path (on windows), you can supply the full path to a 'zip.exe' here, in order to make a KMZ file.

Details

Five local directories are created under path and named after their intended file formats: Comma-Separated Values ('CSV'), Portable Network Graphics ('PNG'), georeferenced TIFF ('TIF'), R Data ('RDA'), and Keyhole Markup Language ('KML'). Note that the KML file format requires a data conversion to latitude and longitude in a WGS 84 coordinate system; therefore, KML data is similar to model data but not identical.

To install 'zip.exe' on windows, download the latest binary version from the Info-ZIP website: select one of the given FTP locations, enter directory 'win32', download 'zip300xn.zip', and extract.

Value

None. Used for the side-effect files written to disk.

Author(s)

J.C. Fisher

See Also

writeRaster, KML

Examples

```
## Not run:
load(file = file.path(getwd(), "20130926130613", "Data", "raster.stack.rda"))
ExportRasterStack(rs, tempdir())
## End(Not run)
```

ExtractAlongTransect *Extract Raster Values Along Transect*

Description

Extract values from raster layer(s) along a user defined transect line.

Usage

```
ExtractAlongTransect(r, v, rtn.polygon = FALSE)
```

Arguments

r	RasterLayer or RasterStack; the raster layer(s).
v	SpatialPoints; vertices along the transect line.
rtn.polygon	logical; if TRUE, a polygon is returned. See 'Value' for additional information.

Details

The transect line is described using a simple polygonal chain. Transect line vertices and raster layer(s) must be specified in a coordinate reference system.

Value

If r is a RasterLayer or rtn.polygon is FALSE, a list is returned with components of class SpatialPointsDataFrame. These components represent continuous line segments along the transect line. The following variables are specified for each coordinate point in the line segment:

d	numeric; the distance along the transect line.
z1	numeric; the value of raster layer r1.
z2	numeric; the value of raster layer r2.

Alternatively, if r is a RasterStack and rtn.polygon is TRUE, a polygon of class gpc.poly is returned. Georeferencing is absent from the polygon with *x* representing the distance along the transect line and *y* representing the raster layer value.

Author(s)

J.C. Fisher

Examples

```
coords <- rbind(c(-100, -90), c(80, 90), c(80, 0), c(40, -40))
crs <- CRS("+proj=longlat +datum=WGS84")
v <- SpatialPoints(coords, proj4string = crs)
r1 <- raster(nrows = 10, ncols = 10, ymn = -80, ymx = 80)
set.seed(0)
r1[] <- runif(ncell(r1))
r1[4, 6] <- NA
plot(r1, xlab = "x", ylab = "y")
lines(SpatialLines(list(Lines(list(Line(coords)), ID = "Transect")), proj4string = crs))
points(v, pch = 21, bg = "grey")
segs <- ExtractAlongTransect(r1, v = v)
for (i in 1:length(segs))
  points(segs[[i]], col = "blue")

xlab <- "Distance along transect"
ylab <- "Value"
xlim <- range(vapply(segs, function(seg) range(seg@data[, "d"]), c(0, 0)))
ylim <- range(vapply(segs, function(seg) range(seg@data[, "z1"]), c(0, 0)))
dev.new()
plot(NA, type = "n", xlab = xlab, ylab = ylab, xlim = xlim, ylim = ylim)
for (i in 1:length(segs))
  lines(segs[[i]]@data[, c("d", "z1")], col = rainbow(length(segs))[i])
n <- length(v)
d <- cumsum(c(0, as.matrix(dist((coordinates(v))))[cbind(1:(n - 1), 2:n)]))
```

```
abline(v = d, col = "grey", lty = 2)
mtext(paste0("(", paste(head(coordinates(v), 1), collapse = ", "), ")"), adj = 0)
mtext(paste0("(", paste(tail(coordinates(v), 1), collapse = ", "), ")"), adj = 1)

r2 <- sum(r1, 2.0, na.rm = TRUE)
ply <- ExtractAlongTransect(stack(r1, r2), v = v, rtn.polygon = TRUE)
dev.new()
plot(ply, asp = 100, xlab = xlab, ylab = ylab, poly.args = list(col = "lightblue"))
abline(v = d, col = "grey", lty = 2)
mtext(paste("Cross sectional area =", format(area.poly(ply))))
```

---

gage.disch *Daily Mean Discharge at Gaging Stations*

Description

Daily mean discharge at gaging stations in the Big Wood River Valley, Idaho. Discharge records bracket the 1992-2014 time period and are based on records with quality assurance code of approved (‘A’).

Usage

```
gage.disch
```

Format

A `data.frame` object with 8,315 records and the following variables:

Date is the date during which discharge was averaged.

13135500 is the daily mean discharge in cubic meters per day, recorded at the USGS 13135500 Big Wood River near Ketchum gaging station.

13139510 is the daily mean discharge in cubic meters per day, recorded at the USGS 13139510 Big Wood River at Hailey gaging station.

13140800 is the daily mean discharge in cubic meters per day, recorded at the USGS 13140800 Big Wood River at Stanton Crossing near Bellevue gaging station.

Source

National Water Information System (NWIS), accessed on January 8, 2015.

Examples

```
str(gage.disch)
```

gage.height *Daily Mean Gage Height at Gaging Stations*

Description

Daily mean gage height at gaging stations in the Big Wood River Valley, Idaho. Gage height records bracket the 1987-2014 time period and are based on records with quality assurance codes of working ('W'), in review ('R'), and approved ('A').

Usage

```
gage.height
```

Format

A `data.frame` object with 9,980 records and the following variables:

Date is the date during which gage height was averaged.

13135500 is the daily mean gage height in meters, recorded at the USGS 13135500 Big Wood River near Ketchum gaging station.

13139510 is the daily mean gage height in meters, recorded at the USGS 13139510 Big Wood River at Hailey gaging station.

13140800 is the daily mean gage height in meters, recorded at the USGS 13140800 Big Wood River at Stanton Crossing near Bellevue gaging station.

Source

Data queried from the National Water Information System (NWIS) database on December 15, 2014, by Ross Dickinson (USGS). Records recorded on May 26-28, 1991 and March 15-22, 1995 were reassigned quality assurance codes of 'I' because of assumed ice build-up.

Examples

```
str(gage.height)
```

gage.usgs *USGS Gaging Stations*

Description

United State Geological Survey (USGS) gaging stations in the Wood River Valley and surrounding areas.

Usage

```
gage.usgs
```

Format

An object of `SpatialPointsDataFrame-class` containing 3 points. Something... Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

Something...

Examples

```
str(gage.usgs)
```

`GetDaysInMonth` *Get Number of Days in a Year and Month*

Description

Determine the number of days in a year and month.

Usage

```
GetDaysInMonth(x)
```

Arguments

`x`	`character` or `integer`; a vector of year and month values, with a required date format of `YYYYMM`.

Value

Returns an integer vector indicating the number of days in each year and month value specified in `x`.

Author(s)

J.C. Fisher

Examples

```
GetDaysInMonth(c("199802", "199804", "200412"))
```

GetSeasonalMultiplier *Get Seasonal Multiplier*

Description

This function determines the seasonal fraction of the mean.

Usage

```
GetSeasonalMultiplier(x, reduction, d.in.mv.ave, tr.stress.periods)
```

Arguments

x	data.frame; a time series with Date and numeric components.
reduction	numeric; a factor in the signal amplitude reduction algorithm. Its magnitude should be greater than or equal to 1, where a value of 1 indicates no reduction in the signal amplitude.
d.in.mv.ave	numeric; the number of days in the moving average subset.
tr.stress.periods	Date; a vector giving the start and end dates for each model stress period.

Details

A simple moving average is first calculated for each month using the previous data. The seasonal average of the monthly moving average is then passed through a signal amplitude reduction algorithm. The reduced values are then divided by the mean of the seasonal reduced data to give the seasonal fraction of the mean (seasonal multiplier).

Value

An object of class data.frame with Date and numeric components; that is, the starting date and multiplier for each season.

Author(s)

J.C. Fisher, A. Wylie, J.R. Bartolino, and J. Sukow

Examples

```
tr.interval <- as.Date(c("1995-01-01", "2011-01-01"))
tr.stress.periods <- seq(tr.interval[1] , tr.interval[2], "1 month")
m <- GetSeasonalMultiplier(gage.disch[, c("Date", "13139510")], 2, 273.932,
                           tr.stress.periods)
f <- vapply(tributaries$Flow, function(i) m$multiplier * i, rep(0, nrow(m)))
colnames(f) <- tributaries$ID
d <- cbind(m, f)
str(d)
```

GetWellConfig *Get Well Completion and Pumping Rate in Model Space*

Description

This function determines well completions and pumping rates in model space as a function of transmissivity.

Usage

```
GetWellConfig(pod.rech, rs.model, lay2.hk.tol = 1e-02)
```

Arguments

pod.rech	data.frame; is the average pumping rate for each well (WMISNumber) and model stress period (ss, 199501, ..., 201012).
rs.model	RasterStack; is composed of raster layers describing the model grid and hydraulic conductivity distribution: lay1.top, lay1.bot, lay2.bot, lay3.bot, lay1.top, lay1.hk, lay2.hk, and lay3.hk.
lay2.hk.tol	numeric; is the hydraulic conductivity tolerance for model cells in layer 2. Used to prevent pumping in the aquitard layer of the aquifer system. Pumping is prohibited in model layer 2 cells with hydraulic conductivity values less than lay2.hk.tol and a well opening isolated to layer 2; for these cases, pumping is allocated to the adjacent layer 1 cell.

Value

An object of class data.frame with the following components:

WMISNumber	numeric; a unique number assigned to a well.
lay, row, col	integer; is the layer, row, and column number of a model cell, respectively.
hk	numeric; is the hydraulic conductivity of the model cell, in meters per day.
thk	numeric; is the vertical length of the well opening (open borehole or screen) in the model cell, in meters. A value of zero indicates that the well opening is unknown or below the modeled bedrock surface.
frac	numeric; is the transmissivity fraction for a model cell, where transmissivity is expressed as hk multiplied by thk. The fraction is calculated by dividing the transmissivity of the model cell by the sum of all transmissivity values for cells belonging to the same well. Note that the transmissivity fraction calculation assumes that the cell is saturated.
ss, 199501, ..., 201012	numeric; is the pumping rate allocated to the model cell for each model stress period, in cubic meters per day. The pumping rate is calculated by multiplying the average pumping rate for a well (specified in pod.rech) by frac.

Author(s)

J.C. Fisher, and A. Wylie

Examples

```
## Not run: # see wrv-model vignette
```

hill.shading — *Land Surface Hill Shading*

Description

Hill shading of the Wood River Valley and surrounding area.

Usage

```
hill.shading
```

Format

An object of class `RasterLayer`. Each cell on the surface grid represents the hill shade. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM). The spatial grid is composed of 3,108 rows and 2,360 columns, and has cell sizes that are constant at 20 meters by 20 meters.

Source

Calculated from the slope and aspect of the `land.surface` dataset using the `terrain` and `hillShade` functions; see the 'wrv-datasets' vignette for the R code used in this calculation.

Examples

```
plot(hill.shading)
```

irr.entities — *Irrigation Entities*

Description

Delineation of areas served by a group of surface water and (or) groundwater diversions.

Usage

```
irr.entities
```

Format

An object of `SpatialPolygonsDataFrame-class` containing 235 `Polygons` and a `data.frame` with the following variables:

EntityName is the name of the irrigation entity served by a group of diversions.

Source is the water source: "Mixed" for a mixture of surface water and groundwater, "SW Only" for surface water only, and "GW Only" for groundwater only.

EntitySrce is a concatenation of the `EntityName` and `Source` character strings.

PrecipZone is the name of the precipitation zone. See `precip.zones` dataset for details.

Source

Idaho Department of Water Resources (IDWR); derived from IDWR water rights database, Blaine County tax lot data, and IDWR irrigated land classification files.

Examples

```
plot(irr.entities)
print(irr.entities)
```

`irr.lands` *Irrigated Lands*

Description

Irrigation classification of land area; available for years 1996, 2000, 2002, 2006, 2008, 2009, and 2010.

Usage

```
irr.lands
```

Format

A `list object` of length 7 with components of `SpatialPolygonsDataFrame-class`. The `data.frame` associated with each of the `SpatialPolygons` objects has the following variable:

Status is the status of land during the year reviewed, may be “irrigated”, “semi-irrigated”, or “non-irrigated”.

Source

Idaho Department of Water Resources; polygons derived from U.S. Department of Agriculture Common Land Unit polygons with some refinement of polygons. Irrigation status interpreted using satellite imagery and aerial photography.

See Also

`irr.lands.year`

Examples

```
spplot(irr.lands[["2010"]], "Status")
print(irr.lands)
```

`irr.lands.year` *Irrigation Lands for Year*

Description

Land classification specifying irrigation practices is not available for all years. For missing years, this dataset provides substitute years when land-classification was available (see `irr.lands`).

Usage

```
irr.lands.year
```

Format

A `data.frame` object with 16 records and the following variables:

Year is the year with a required date format of `YYYY`.

IL_Year is the substitute year with a required date format of `YYYY`.

Source

Idaho Department of Water Resources

Examples

```
str(irr.lands.year)
```

`lakes` *Lakes and Reservoirs*

Description

Lakes and reservoirs of the Wood River Valley and surrounding areas.

Usage

```
lakes
```

Format

An object of `SpatialPolygonsDataFrame-class` containing 55 `Polygons`. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources (IDWR)

Examples

```
plot(lakes)
str(lakes)
```

land.surface *Topography of Land Surface*

Description

The Wood River Valley (WRV) is a geologic feature located in south-central Idaho. This dataset gives the topography of the land surface in the WRV and vicinity.

Usage

```
land.surface
```

Format

An object of class `SpatialGridDataFrame-class`. Each cell on the surface grid represents an elevation in meters above the North American Vertical Datum of 1988 (NAVD 88). Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM). The spatial grid is composed of 565 rows and 429 columns, and has cell sizes that are constant at 100 meters by 100 meters.

Source

The National Elevation Dataset (NED) 1/3-arc-second raster (Gesch, 2007; Gesch and others, 2002). This dataset was downloaded on September 22, 2013 in a Esri ArcGRID format using the National Map Viewer. NED data are distributed in geographic coordinates in units of decimal degrees, and in conformance with the NAD 83. Elevation values are in meters above the NAVD 88. The west, east, south, and north bounding coordinates for this dataset are -115, -114, 43, and 44 decimal degrees, respectively. Post-processing includes: (1) project the values of the NED dataset into the `alluvium.thickness` spatial grid using bilinear interpolation, and (2) set values in cells where the elevation of the alluvium bottom is missing to `NA`.

References

Gesch, D.B., 2007, The National Elevation Dataset, in Maune, D., ed., Digital Elevation Model Technologies and Applications: The DEM Users Manual, 2nd Edition: Bethesda, Maryland, American Society for Photogrammetry and Remote Sensing, p. 99-118.

Gesch, D., Oimoen, M., Greenlee, S., Nelson, C., Steuck, M., and Tyler, D., 2002, The National Elevation Dataset: Photogrammetric Engineering and Remote Sensing, v. 68, no. 1, p. 5-11.

Examples

```
image(land.surface)
summary(land.surface)
```

map.labels *Map Labels*

Description

Map labels in the Wood River Valley and surrounding areas.

Usage

```
map.labels
```

Format

An object of SpatialPointsDataFrame-class containing 29 points. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

Best estimates of label locations.

Examples

```
plot(map.labels, col = "red")
lab <- cbind(map.labels@coords, map.labels@data)
for (i in seq_len(nrow(lab))) {
  text(lab$x[i], lab$y[i], labels = lab$label[i], cex = lab$cex[i],
       col = lab$col[i], font = lab$font[i], srt = lab$srt[i])
}
```

misc.seepage *Recharge from Miscellaneous Seepage Sites*

Description

Recharge from miscellaneous seepage sites in the Wood River Valley, Idaho.

Usage

```
misc.seepage
```

Format

A `data.frame` object with 2 records and the following variables:

RechSite is the name of the recharge site, see `bellevue.wwtp.ponds` and `bypass.canal` datasets.

199501, ..., 201012 is the monthly volume of recharge during a stress period, in cubic meters. The variable name is specified as year and month.

Source

Idaho Department of Water Resources

Examples

```
str(misc.seepage)
```

PlotGraph *Plot Method for Point or Line Data*

Description

This function draws a sequence of points or lines using specified coordinates.

Usage

```
PlotGraph(x, y, xlab, ylab, type = "s", lty = 1, pch = NULL, col = rainbow,
          pt.cex = 1, seq.date.by = "year", scientific = TRUE)
```

Arguments

`x, y`	`Date`, `numeric`, `matrix`, or `data.frame`; vectors or matrices of data for plotting. The vector length or number of rows should match. If `y` is missing, then `x = x[, 1]` and `y = x[, 2:n]`.
`xlab, ylab`	`character`; titles for x and y axes.
`type`	`character`; is the type of plot for each column of `y`, see `plot` for all possible types.
`lty`	`integer`; is the line type, see `par` for all possible types. Line types are used cyclically.
`pch`	`integer`; is the point type, see `points` for all possible types. Point types are used cyclically.
`col`	`integer`, `character`, or `function`; is the point or line color, see `par` for all possible ways this can be specified. Colors are used cyclically.
`pt.cex`	`numeric`; expansion factor for the points.
`seq.date.by`	`character`, `numeric`, or `difftime`; is the increment of the date sequence, see `seq.Date` for all possible ways this can be specified.
`scientific`	`logical`; indicates if axes labels should be encoded in scientific format.

Details

This function requires the suggested package **sfsmisc**.

Value

Used for the side-effect of a new plot generated.

Author(s)

J.C. Fisher

See Also

matplot

Examples

```
n <- 50

x <- as.Date("2008-07-12") + 1:n
y <- sample(1:100, n)
PlotGraph(x, y, ylab = "Random number", type = "p", pch = 16, seq.date.by = "weeks")

y <- data.frame(lapply(1:3, function(i) sample(1:100, n)))
PlotGraph(x, y, ylab = "Random number", type = "s", pch = 1, seq.date.by = "days")

y <- sapply(1:3, function(i) sample((1:100) + i * 100, n))
m <- cbind(as.numeric(x), y)
col <- c("red", "gold", "green")
PlotGraph(m, xlab = "Number", ylab = "Random number", type = "b", pch = 15:17,
          col = col, pt.cex = 0.9)
legend("topright", LETTERS[1:3], inset = 0.05, col = col, lty = 1, pch = 15:17,
       pt.cex = 0.9, cex = 0.8, bg = "white")
```

PlotMap *Plot Method for Spatial Data*

Description

Map values of a raster layer. A key showing how the colors map to raster values is shown below the map.

Usage

```
PlotMap(r, layer = 1, att = NULL, n, breaks, xlim = NULL, ylim = NULL,
        zlim = NULL, asp = 1, extend.xy = FALSE, extend.z = FALSE,
        reg.axs = TRUE, trim.r = TRUE, dms.tick = FALSE, bg.lines = FALSE,
        bg.image = NULL, bg.image.alpha = 1, pal = rainbow, col = NULL,
        max.dev.dim = c(43, 56), labels = NULL, bw = NULL,
        scale.loc = "bottomleft", arrow.loc = NULL, explanation = NULL,
        credit = proj4string(r), shade = NULL, contour.lines = NULL,
        rivers = NULL, lakes = NULL, dev.type = c("cur", "new", "pdf", "png"),
        file = "Rplot", useRaster)
```

Arguments

`r`	`RasterLayer`, `SpatialGridDataFrame`, or `CRS`; a raster layer with values to be plotted or a coordinate reference system (CRS).
`layer`	`integer`; the column to use in the `SpatialGridDataFrame`.
`att`	`numeric` or `character`; the variable identifying the levels attribute to use in the Raster Attribute Table (RAT). This argument requires `r` values that are of class `factor`.
`n`	`integer`; the desired number of intervals to partition the range of raster values (or `zlim` if specified) (optional).

breaks
: numeric; a vector of break points used to partition the colors representing numeric raster values (optional).

xlim
: numeric; a vector of length 2 giving the minimum and maximum values for the *x*-axis.

ylim
: numeric; a vector of length 2 giving the minimum and maximum values for the *y*-axis.

zlim
: numeric; a vector of length 2 giving the minimum and maximum raster values for which colors should be plotted.

asp
: numeric; the *y/x* aspect ratio for spatial axes.

extend.xy
: logical; if TRUE, the spatial limits will be extended to the next tick mark on the axes beyond the grid extent.

extend.z
: logical; if TRUE, the raster value limits will be extended to the next tick mark on the color key beyond the measured range.

reg.axs
: logical; if TRUE, the spatial data range is extended.

trim.r
: logical; if TRUE, the outer rows and columns that consist of all NA values will be removed.

dms.tick
: logical; if TRUE, the axes tickmarks are specified in degrees, minutes, and decimal seconds.

bg.lines
: logical; if TRUE, the graticule is drawn in back of the raster layer using white lines and a grey background.

bg.image
: RasterLayer; an image to drawn in back of the main raster layer r.

bg.image.alpha
: numeric; the opacity of the background image from 0 to 1.

pal
: function; a color palette to be used to assign colors in the plot.

col
: character; a vector of colors to be used in the plot. This argument requires breaks specification for numeric values of r and overrides any palette function specification. For numeric values there should be one less color than breaks. Factors require a color for each level.

max.dev.dim
: numeric; a vector of length 2 giving the maximum width and height for the graphics device in picas, respectively. Suggested dimensions for single-column, double-column, and sidetitle figures are c(21, 56), c(43, 56), and c(56, 43), respectively.

labels
: list; describes the location and values of labels in the color key. This list may include components at and labels.

bw
: numeric; the width of the color key box in picas. This argument requires r values that are of class factor.

scale.loc
: character; the position of the scale bar: "bottomleft", "topleft", "topright", or "bottomright" to denote scale location.

arrow.loc
: character; the position of the north arrow: "bottomleft", "topleft", "topright", or "bottomright" to denote arrow location.

explanation
: character; a label explaining the raster value.

credit
: character; a label crediting the base map.

shade
: list; if specified, a semi-transparent shade layer is drawn on top of the raster layer. This layer is described using a list of arguments supplied to hillShade. Passed arguments include "angle" and "direction". Additional arguments may also be passed that control the vertical aspect ratio ("z.factor") and color opacity ("alpha").

contour.lines	list; if specified, contour lines are drawn. The contours are described using a list of arguments supplied to contour. Passed arguments include "drawlables", "method", and "col".
rivers	list; if specified, lines are drawn. The lines are described using a list of arguments supplied to the plot method for SpatialLines. Passed arguments include "x", "col", and "lwd".
lakes	list; if specified, polygons are drawn. The polygons are described using a list of arguments supplied to the plot method for SpatialPolygons. Passed arguments include "x", "col", "border", and "lwd". Bitmap images require a regular grid.
dev.type	character; the graphics device type. Defaults to the 'active' device ("cur") and if it is unavailable a new device ("new") is opened based on getOption("device"). Specification of a file argument is required to open a new graphic device for a PDF formatted file ("pdf") or PNG formatted bitmap file ("png").
file	character; the name of the output file. Requires a dev.type of "pdf" or "png".
useRaster	logical; if TRUE, a bitmap raster is used to plot r instead of polygons. If UseRaster is not specified, raster images are used when the getOption("preferRaster") is true.

Details

The dimensions of a new graphics device is dependent on the argument values of max.dev.dim and asp.

Value

Returns a list object with graphical parameters "din" and "usr". See par for details.

Author(s)

J.C. Fisher

Examples

```
r <- raster(system.file("external/test.grd", package="raster"))
PlotMap(r, scale.loc = "topleft", dms.tick = TRUE, trim.r = TRUE)

graphics.off()
r <- raster(nrow = 10, ncol = 10)
r[] <- 1L
r[51:100] <- 2L
r[3:6, 1:5] <- 8L
r <- ratify(r)
rat <- levels(r)[[1]]
rat$land.cover <- c("Pine", "Oak", "Meadow")
rat$code <- c(12, 25, 30)
levels(r) <- rat
PlotMap(r, att = "land.cover", col = c("grey", "orange", "purple"))
PlotMap(r, att = "code")

graphics.off()
r <- alluvium.thickness
```

```
PlotMap(r@crs, bg.image = hill.shading, reg.axs = FALSE)
plot(alluvium.extent, border = "red", add = TRUE)
PlotMap(r, bg.image = hill.shading, bg.image.alpha = 0.6, dev.type = "new")
PlotMap(r, n = 10, extend.xy = TRUE, dev.type = "new")

graphics.off()
PlotMap(r, ylim = c(NA, 1360000), max.dev.dim = c(56, 43), n = 10, extend.z = TRUE,
        contour.lines = list(col = "#A9A9A9"))
plot(alluvium.extent, add = TRUE)
shade <- list(z.factor = 15, alpha = 0.4)
txt <- "Land surface elevation in meters above National Geodetic Vertical Datum of 1929."
ans <- PlotMap(r, ylim = c(NA, 1360000), max.dev.dim = c(56, 43), bg.lines = TRUE,
               shade = shade, arrow.loc = "topright", explanation = txt)

## Not run:
pdf("Rplot.pdf", width = ans$din[1], height = ans$din[2], version = "1.6",
    colormodel = "cmyk", useDingbats = FALSE)
PlotMap(r, ylim = c(NA, 1360000), max.dev.dim = c(56, 43), bg.lines = TRUE,
        shade = shade, arrow.loc = "topright", explanation = txt,
        useRaster = TRUE)
dev.off()
PlotMap(r, ylim = c(NA, 1360000), max.dev.dim = c(56, 43), bg.lines = TRUE,
        shade = shade, arrow.loc = "topright", explanation = txt,
        dev.type = "png")
## End(Not run)

graphics.off()
```

---

pod.gw *Points of Diversion for Groundwater*

Description

Points of diversion for groundwater within the Wood River Valley model study area.

Usage

```
pod.gw
```

Format

A `data.frame` object with 1,755 records and the following variables:

WMISNumber is a unique number assigned to a water right point of diversion.

WaterRight is a number identifying a specific authorization to use water in a prescribed manner.

EntityName is the name of the irrigation entity the point of diversion is assigned to.

EntitySrce is the source of water for an irrigation entity. Possible sources of water include surface water, groundwater and mixed. Mixed source entities derive water from both groundwater and surface water.

Pdate is the priority date, the date the water right was established.

IrrRate is the irrigation rate in cubic meters per day, the maximum permitted water use rate associated with a water right.

Source

Idaho Department of Water Resources water rights database.

See Also

`pod.wells`

Examples

```
summary(pod.gw)
```

---

pod.wells *Well Completions*

Description

Well completions for pumping wells in the Wood River Valley model study area.

Usage

```
pod.wells
```

Format

An object of `SpatialPointsDataFrame-class` containing 1,243 points with the following variables:

WMISNumber is a unique number assigned to a water right point of diversion.

WellUse is the permitted use(s) for a groundwater well.

TopOpen1 is the depth to the top of the first open interval in a groundwater well, in meters below land surface.

BotOpen1 is the depth to the bottom of the first open interval in a groundwater well, in meters below land surface.

TopOpen2 is the depth to the top of the second open interval in a groundwater well, in meters below land surface.

BotOpen2 is the depth to the bottom of the second open interval in a groundwater well, in meters below land surface.

Source

Idaho Department of Water Resources water rights database.

See Also

`pod.gw`

Examples

```
plot(pod.wells)
str(pod.wells@data)
```

`precip.zones` *Precipitation Zones*

Description

Precipitation zones specified for the Wood River Valley and surrounding areas. There are three precipitation zones, each containing a single weather station. Precipitation zones were distributed to maintain the geographic similarity between weather stations and zones.

Usage

```
precip.zones
```

Format

An object of `SpatialPolygonsDataFrame-class` containing 3 `Polygons` and a `data.frame` with the following variables:

ID a numeric identifier assigned to the polygon.

PrecipZone the name of the precipitation zone: "Ketchum", the northernmost zone with data from the Ketchum National Weather Service coop weather station. "Hailey", the central zone with data from the Hailey 3NNW National Weather Service coop weather station. "Picabo", the southernmost zone with data from the Picabo AgriMet weather station.

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources

See Also

`precipitation`

Examples

```
spplot(precip.zones, "PrecipZone")
print(precip.zones)
```

`precipitation` *Precipitation*

Description

Precipitation data recorded at three weather stations in the Wood River Valley and surrounding areas.

Usage

```
precipitation
```

Format

A `data.frame` object with 576 records and the following variables:

YearMonth is the year and month during which precipitation were recorded, with a required date format of `YYYYMM`.

PrecipZone the name of the precipitation zone, see `precip.zones` dataset for details.

Precip is the monthly precipitation in meters.

Source

Idaho Department of Water Resources

References

National Oceanic and Atmospheric Administration's National Weather Service (NWS) Cooperative Observer Program

U.S. Bureau of Reclamation's Cooperative Agricultural Weather Network (AgriMet)

Examples

```
str(precipitation)
```

`priority.cuts` *Priority Cuts*

Description

Priority cut dates applied to Big Wood River above Magic Reservoir and Silver Creek by Water District 37 and 37M on the 16th of each month.

Usage

```
priority.cuts
```

Format

A `data.frame` object with 112 records and the following variables:

YearMonth is the year and month during of the priority cut date, with a required date format of `YYYYMM`.

Pdate_BWR is the date of the priority cut applied to Big Wood River above Magic Reservoir by Water District 37.

Pdate_SC is the date of the priority cut applied to Silver Creek by Water District 37M.

Source

Idaho Department of Water Resources compiled priority cut dates in effect on the 16th of each month from Water District 37 and 37M records.

Examples

```
str(priority.cuts)
```

ProcessRecharge *Process Recharge*

Description

This function determines the areal recharge on irrigated and non-irrigated lands, and well pumping at points of diversion. A water-balance approach is used to calculate recharge.

Usage

```
ProcessRecharge(tr.stress.periods, r.grid, eff, seep, ss.stress.periods = NULL,
                dir.summary = NULL)
```

Arguments

`tr.stress.periods`	`Date`; a unique vector of start and end dates for each stress period in the simulation.
`r.grid`	`RasterLayer`; a raster of numeric values where `NA` indicates an 'inactive' cell in the top layer of the model.
`eff`	`data.frame`; see `efficiency` dataset for details.
`seep`	`data.frame`; see `canal.seep` dataset for details.
`ss.stress.periods`	`Date`; a unique vector of start and end dates for each stress period in the simulation; values from these stress periods are averaged for steady-state conditions.
`dir.summary`	`character`; path name to write summary tables for calculated recharge values. Data in the summary tables are converted to the english unit system to facilitate with quality assurance of the recharge calculation.

Value

Returns a `list` object with two components: (1) `areal.rech`, an object of class `RasterStack` composed of raster layers, one for each model stress period, with cell values representing the areal recharge in cubic meters per day. (2) `pod.rech`, an object of class `data.frame` with the following components:

`WMISNumber`	`numeric`; a unique number assigned to a water right point of diversion.
`ss, 199501, ..., 201012`	`numeric`; is the volumetric rate of well pumping at point locations in cubic meters per day, specified for each stress period.

Author(s)

J.C. Fisher, J. Sukow, and M. McVay

Examples

```
## Not run: # see wrv-model vignette
```

`public.parcels` *Public Land Parcels*

Description

Public land parcels in the Wood River Valley and surrounding areas.

Usage

```
public.parcels
```

Format

An object of `SpatialPolygons-class` containing 669 `Polygons`.

Source

Idaho Department of Water Resources; derived from Blaine County tax lots.

Examples

```
plot(public.parcels)
print(public.parcels)
```

`r.canals` *Rasterized Canals*

Description

Canal systems of the Wood River Valley and surrounding areas transferred to raster cells.

Usage

```
r.canals
```

Format

An object of class `RasterLayer` with indexed cell values linked to a raster attribute table (RAT). The RAT is a `data.frame` with the following components:

ID the integer cell index.

COUNT the frequency of the cell index in the raster grid.

EntityName the name of the irrigation entity served by the canal system.

Source

Calculated by transferring the `canals` dataset to grid cells in the `land.surface` dataset using the `rasterize` function; see the 'wrv-datasets' vignette for the R code used in this calculation.

Examples

```
plot(r.canals)
print(levels(r.canals)[[1]])
```

ReadModflowBinaryFile *Read MODFLOW Binary File*

Description

Read binary output data from a MODFLOW run.

Usage

```
ReadModflowBinaryFile(f, data.type = c("array", "flow"))
```

Arguments

`f`	`character`; the name of the binary file.
`data.type`	`character`; a description of how the data is saved.

Details

This function reads binary head ('`.hds`'), drawdown ('`.ddn`'), and budget ('`.bud`') files generated from a MODFLOW run.

Value

Returns a `list` object of length equal to the number of times the data type is written to the binary file. List components are `list` objects with the following components:

`d`	`matrix` or `data.frame`; the data values.
`kstp`	`integer`; the time step.
`kper`	`integer`; the stress period.
`desc`	`character`; the variable name.
`ilay`	`integer`; the model-grid layer.
`delt`	`numeric`; the length of the current time step.
`pertim`	`numeric`; the time in the stress period.
`totim`	`numeric`; the total elapsed time.

Author(s)

J.C. Fisher

See Also

`SummariseBudget`

Examples

```
## Not run:
hds <- ReadModflowBinaryFile(file.path(getwd(), "Run", "wrv_mfusg.hds"), "array")
bud <- ReadModflowBinaryFile(file.path(getwd(), "Run", "wrv_mfusg.bud"), "flow")
## End(Not run)
```

ReadModflowListFile *Read Volumetric Budget from MODFLOW Listing File*

Description

Reads and parses the volumetric budget for the entire model at the end of time step and stress period.

Usage

```
ReadModflowListFile(f)
```

Arguments

f	character; the name of the MODFLOW listing file.

Value

Returns a list object of length equal to the number of times the volumetric budget was written to the listing file. Each component is a list and represents a single volumetric budget with components:

caption	character; a title for the volumetric budget information.
time.step	integer; the time step in the model run.
stress.period	integer; the stress period in the model run.
inputs	matrix; the volume and rate for input components.
outputs	matrix; the volume and rate for output components.
discrepancy	matrix; the volume and rate for the discrepancy between inputs and outputs.

Author(s)

J.C. Fisher

See Also

readLines

Examples

```
## Not run:
budgets <- ReadModflowListFile(file.path(getwd(), "tr.lst"))
## End(Not run)
```

`river.reaches` *Major River Reaches*

Description

The major reaches of the Wood River Valley, Idaho.

Usage

```
river.reaches
```

Format

An object of `SpatialLinesDataFrame-class` containing 22 `Lines` and a `data.frame` with the following variables:

Reach is the name of the subreaches measured in U.S. Geological Survey (USGS) seepage survey.

BigReach is the name of the reaches for which time series targets are available for part or all of the calibration period.

GainLoss is the flow type, specified as "Gaining", "Losing", or "Seasonal".

DrainRiver is the model boundary assignment, either "drain" or "river".

RchAvg is the estimated average reach gain in cubic meters per day for 1995-2010 based on a combination of gage data and the USGS seepage survey.

BigRAv is the estimated average reach gain in cubic meters per day for 1995-2010 based on gage data.

ReachNo is the reach number identifier.

Depth is the estimated average depth in meters of water in reach, measured from the air-water interface to the top of the riverbed sediments.

BedThk is the estimated thickness in meters of the saturated riverbed sediments.

cond is the river conductance in square meters per day.

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources

Examples

```
plot(river.reaches)
str(river.reaches@data)
```

rivers *Rivers and Streams*

Description

Rivers and streams of the Wood River Valley and surrounding areas.

Usage

```
rivers
```

Format

An object of `SpatialLinesDataFrame-class` containing 581 `Lines`. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources (IDWR)

Examples

```
spplot(rivers)
str(rivers)
```

rs.entities *Rasterized Monthly Irrigation Entities*

Description

Irrigation entities of the Wood River Valley and surrounding areas transferred to raster cells.

Usage

```
rs.entities
```

Format

An object of class `RasterStack`, a collection of `RasterLayer` objects. There are a total of 192 raster layers, one layer for each month in the 1995-2010 time period. For each raster layer, indexed cell values are linked to a raster attribute table (RAT). The RAT is a `data.frame` with the following components:

ID the integer cell index.

COUNT the frequency of the cell index in the raster grid.

EntityName the name of the irrigation entity served by a group of diversions.

Source

Calculated by transferring the `entity.components` dataset to grid cells in the `land.surface` dataset using the `rasterize` function; see the 'wrv-datasets' vignette for the R code used in this calculation.

Examples

```
names(rs.entities)
plot(rs.entities[["199507"]])
print(levels(rs.entities[["199507"]])[[1]])
```

`rs.rech.non.irr` *Rasterized Monthly Recharge on Non-Irrigated Lands*

Description

Aerial recharge on non-irrigated lands of the Wood River Valley and surrounding areas transferred to raster cells.

Usage

```
rs.rech.non.irr
```

Format

An object of class `RasterStack`, a collection of `RasterLayer` objects. There are a total of 192 raster layers, one layer for each month in the 1995-2010 time period. Each cell on a layers surface grid represents the monthly recharge in meters.

Source

Calculated from the `precipitation`, `precip.zones`, and `soils` datasets; see the 'wrv-datasets' vignette for the R code used in this calculation.

Examples

```
names(rs.rech.non.irr)
plot(rs.rech.non.irr[["199507"]])
```

SetPolygons *Analysis of Multi-Polygon Objects*

Description

Determines the intersection or difference between two multi-polygon objects.

Usage

```
SetPolygons(x, y, cmd = c("gIntersection", "gDifference"), buffer.width = NA)
```

Arguments

x	SpatialPolygons*; a multi-polygon object.
y	SpatialPolygons*; a multi-polygon object.
cmd	character; specifying "gIntersection", the default, cuts out portions of the x polygons that overlay the y polygons. If "gDifference" is specified, only those portions of the x polygons falling outside the y polygons are copied to the output polygons.
buffer.width	numeric; expands or contracts the geometry of y to include the area within the specified width, see gBuffer. Specifying NA, the default, indicates no buffer.

Details

This function tests if the resulting geometry is valid, see gIsValid.

Value

Returns an object of class SpatialPolygons*.

Author(s)

J.C. Fisher

See Also

gIntersection, gDifference

Examples

```
library(sp)

m1a <- matrix(c(17.5, 24.7, 22.6, 16.5, 55.1, 55.0, 61.1, 59.7), nrow = 4, ncol = 2)
m1b <- m1a
m1b[, 1] <- m1b[, 1] + 11
p1 <- SpatialPolygons(list(Polygons(list(Polygon(m1a, FALSE), Polygon(m1b, FALSE)), 1)))
plot(p1, col = "blue")

m2a <- matrix(c(19.6, 35.7, 28.2, 60.0, 58.8, 64.4), nrow = 3, ncol = 2)
m2b <- matrix(c(20.6, 30.9, 27.3, 56.2, 53.8, 51.4), nrow = 3, ncol = 2)
p2 <- SpatialPolygons(list(Polygons(list(Polygon(m2a, FALSE), Polygon(m2b, FALSE)), 2)))
plot(p2, col = "red", add = TRUE)
```

```
p <- SetPolygons(p1, p2, "gIntersection")
plot(p, col = "green", add = TRUE)

p <- SetPolygons(p2, p1, "gDifference")
plot(p, col = "purple", add = TRUE)
```

---

soils *Soil Units*

Description

Representation of mapped soil units created by the Idaho Office of the National Resource Conservation Service (NRCS). Soils have been assigned an infiltration rate based on the average, saturated hydraulic conductivity of the soils as classified using the Unified Soil Classification System (USCS).

Usage

```
soils
```

Format

An object of `SpatialPolygonsDataFrame-class` containing 718 `Polygons` and a `data.frame` with the following variables:

SoilLayer is an identifier used to differentiate the soil data source used to create the soils map. Data sources are either NRCS, USCS, or NRCS State Soil Geographic Data Base (STATSGO).

InfRate is the infiltration rate in meters per day.

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources

Examples

```
spplot(soils, "InfRate")
str(soils@data)
```

SummariseBudget — *Summarise Volumetric Water Budget*

Description

Something...

Usage

```
SummariseBudget(budget, desc = c("wells", "drains", "river leakage"))
```

Arguments

budget	list or character; something..., see ReadModflowBinaryFile.
desc	character; a vector of variable names.

Details

Something...

Value

Returns an object of class data.frame. Something...

Author(s)

J.C. Fisher

Examples

```
## Not run:
f <- "C:/Users/jfisher/Desktop/Test/wrv_20150126182214/Run/wrv_mfusg.bud"
d <- SummariseBudget(f)
str(d)
## End(Not run)
```

tributaries — *Location and Estimated Annual Flows in the Tributaries*

Description

Polygons used to define the location of specified flow boundaries in the major tributary canyons of the Wood River Valley aquifer system, south-central Idaho. An estimated groundwater flow is specified for each polygon.

Usage

```
tributaries
```

Format

An object of `SpatialPolygonsDataFrame-class` containing a set of 22 `Polygons` and a `data.frame` with the following variable:

Name is the tributary name.

Flow is the estimated volumetric flux in cubic meters per day.

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in a Idaho Transverse Mercator projection (IDTM).

Source

A Keyhole Markup Language (KML) file created in Google Earth with polygons drawn by hand in areas of known specified flow boundaries. Flow estimates were calculated using Darcian analysis of flux. Adjustments to these estimates were made for tributary canyons less than 2.6e+07 square meters (10 square miles) in area.

Examples

```
plot(tributaries)
str(tributaries@data)
```

`UpdateRecharge` *Update Recharge in the MODFLOW Well Package File*

Description

This function is used to update aquifer recharge in the MODFLOW Well Package file during parameter estimation.

Usage

```
UpdateRecharge(dir.run, id, write.summary = FALSE)
```

Arguments

`dir.run`	`character`; the path name of the directory to read/write model files.
`id`	`character`; a short identifier for the model run.
`write.summary`	`logical`; if `TRUE`, summary tables for calculated recharge values are written to the directory specified by `dir.run`.

Details

A '`.wel`' file is always written to disk; whereas, '`seep.csv`', '`eff.csv`', '`trib.csv`', and '`Update.bat`' files are only written if they do not already exist. Run this function in an interactive R session to initialize parameter estimation files.

Value

Returns an object of `difftime` class, the runtime for this function. Used for the side-effect of files written to disk.

Author(s)

J.C. Fisher

See Also

ProcessRecharge

Examples

```
## Not run:
UpdateRecharge("C:/Users/jfisher/Desktop/Test/wrv_20141207100728/Run", "wrv_mfusg", TRUE)
## End(Not run)
```

---

wetlands *Wetlands*

Description

Wetlands in the Wood River Valley and surrounding areas.

Usage

```
wetlands
```

Format

An object of SpatialPolygons-class containing 3,024 Polygons.

Source

U.S. Fish and Wildlife Service National Wetlands Inventory

Examples

```
plot(wetlands)
print(wetlands)
```

WriteModflowInputFiles *Write MODFLOW Input Files*

Description

Generate and write input files for a MODFLOW simulation of groundwater flow in the Wood River Valley (WRV) aquifer system.

Usage

```
WriteModflowInputFiles(rs.model, rech, well, trib, misc, river, drain, id,
                       dir.run, is.convertible = FALSE, ss.perlen = 0L,
                       tr.stress.periods = NULL, ntime.steps = 1L,
                       verbose = TRUE)
```

Arguments

`rs.model`	`RasterStack`; a collection of `RasterLayer` objects with the same extent and resolution, see 'Details' for required raster layers.
`rech`	`data.frame`; is the areal recharge on irrigated and non-irrigated lands, in cubic meters per day. Variables describe the model cell location (`lay`, `row`, `col`) and volumetric rate during each stress period (`ss`, `199501`, `199502`, ..., `201012`).
`well`	`data.frame`; is the well pumping at point locations in cubic meters per day. Variables describe the model cell location and volumetric rate during each stress period.
`trib`	`data.frame`; is the incoming flows from the major tributary canyons. Variables describe the model cell location and volumetric rate during each stress period.
`misc`	`data.frame`; is recharge from miscellaneous seepage sites in cubic meters per day. Variables describe the model cell location and volumetric rate during each stress period.
`river`	`data.frame`; is the river conditions. Variables describe the model cell location, river conductance (`cond`) in square meters per day, and river bottom elevation (`bottom`) in meters above the North American Vertical Datum of 1988 (NAVD 88).
`drain`	`data.frame`; is the drain conditions for groundwater outlet boundaries. Variables describe the model cell location, drain threshold elevation (`elev`) in meters above the NAVD 88, and drain conductance (`cond`) in square meters per day.
`id`	`character`; a short identifier for the model run.
`dir.run`	`character`; the path name of the directory to write model input files.
`is.convertible`	`logical`; if `TRUE`, indicates model layers are 'convertible', with transmissivity computed using upstream water-table depth. Otherwise, model layers are 'confined' and transmissivity is constant over time.
`ss.perlen`	`integer` or `difftime`; the length of the steady-state stress period in days.
`tr.stress.periods`	`Date`; a vector of start times for each stress period in the transient simulation. If missing, only steady-state conditions are simulated.
`ntime.steps`	`integer`; the number of time steps in a stress period.
`verbose`	`logical`; if `TRUE`, additional information is written to the listing file ('`.lst`').

Details

Groundwater flow in the WRV aquifer is simulated using the MODFLOW-USG groundwater flow model. This numerical model was chosen for its ability to solve complex unconfined groundwater flow simulations. The solver implemented in MODFLOW-USG incorporates the Newton-Raphson formulation for improving solution convergence and avoiding problems with the drying and rewetting of cells (Niswonger and others, 2011). A structured finite-difference grid is implemented in the model to (1) simplify discretization, (2) keep formats and structures for the MODFLOW-USG packages identical to those of MODFLOW-2005, and (3) allow any MODFLOW post-processor to be used to analyze the results of the MODFLOW-USG simulation (such as Model Viewer).

Model input files are written to `dir.run` and include the following MODFLOW Package files: Name ('`.nam`'), Basic ('`.ba6`'), Discretization ('`.dis`'), Layer-Property Flow ('`.lpf`'), Drain ('`.drn`'), River ('`.riv`'), Well ('`.wel`'), Sparse Matrix Solver ('`.sms`'), and Output Control ('`.oc`'). See the users guide (*Description of Model Input and Output*) included with the MODFLOW-USG software for details on input file formats and structures. The Layer-Property Flow file includes options for the calculation of vertical flow in partially dewatered cells. For the WRV model, where there is no indication that perched conditions exist, `CONSTANTCV` and `NOVFC` options are used to create the most stable solution (Panday and others, 2013, p. 15-16). Options for the Sparse Matrix Solver were set for unconfined simulations by implementing an upstream-weighting scheme with Newton-Raphson linearization, Delta-Bar-Delta under-relaxation, and the χMD solver of Ibaraki (2005).

The raster stack `rs.model` includes the following layers:

lay1.top is the elevation at the top of model layer 1 (land surface), in meters above the NAVD 88.

lay1.bot is the elevation at the bottom of model layer 1, in meters above the NAVD 88.

lay2.bot is the elevation at the bottom of model layer 2.

lay3.bot is the elevation at the bottom of model layer 3.

lay1.strt is the initial (starting) hydraulic head in model layer 1, in meters above the NAVD 88.

lay2.strt is the initial hydraulic head in model layer 2.

lay3.strt is the initial hydraulic head in model layer 3.

lay1.zones is the hydrogeologic zones in model layer 1 where values `= 1` is unconfined alluvium, `= 2` is basalt, `= 3` is clay, and `= 4` is confined alluvium.

lay2.zones is the hydrogeologic zones in model layer 2.

lay3.zones is the hydrogeologic zones in model layer 3.

lay1.hk is the horizontal hydraulic conductivity in model layer 1, in meters per day.

lay2.hk is the horizontal hydraulic conductivity in model layer 2.

lay3.hk is the horizontal hydraulic conductivity in model layer 3.

Reductions to specified pumping rates are written to the '`reduced-pumping.txt`' file if model layers are convertible and transient conditions are simulated.

Value

None. Used for the side-effect of files written to disk.

Author(s)

J.C. Fisher

References

Ibaraki, M., 2005, χMD User's guide-An efficient sparse matrix solver library, version 1.30: Columbus, Ohio State University School of Earth Sciences.

Niswonger, R.G., Panday, Sorab, and Ibaraki, Motomu, 2011, MODFLOW-NWT, A Newton formulation for MODFLOW-2005: U.S. Geological Survey Techniques and Methods 6-A37, 44 p., available at http://pubs.usgs.gov/tm/tm6a37/.

Panday, Sorab, Langevin, C.D., Niswonger, R.G., Ibaraki, Motomu, and Hughes, J.D., 2013, MODFLOW-USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation: U.S. Geological Survey Techniques and Methods, book 6, chap. A45, 66 p., available at http://pubs.usgs.gov/tm/06/a45/.

Examples

```
## Not run: # see wrv-model vignette
```

zone.properties *Hydraulic Properties of Hydrogeologic Zones*

Description

Hydraulic properties for each hydrogeologic zone.

Usage

```
zone.properties
```

Format

A `data.frame` object with 4 records and the following variables:

ID is a numeric identifier for the hydrogeologic zone.

name is the name of the hydrogeologic zone.

hk is the horizontal hydraulic conductivity in meters per day.

vani is the vertical anisotropy, unitless.

ss is the sotrage coefficient, unitless.

sy is the specific yield, unitless.

Source

Bartolino, J.R., and Adkins, C.B., 2012, Hydrogeologic framework of the Wood River Valley aquifer system, south-central Idaho: U.S. Geological Survey Scientific Investigations Report 2012-5053, 46 p., available at http://pubs.usgs.gov/sir/2012/5053/.

Examples

```
str(zone.properties)
```

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