

Package ‘LPDynR’

January 21, 2021

Title Land Productivity Dynamics Indicator

Version 1.0.1

Description

It uses 'phenological' and productivity-related variables derived from time series of vegetation indexes, such as the Normalized Difference Vegetation Index, to assess ecosystem dynamics and change, which eventually might drive to land degradation. The final result of the Land Productivity Dynamics indicator is a categorical map with 5 classes of land productivity dynamics, ranging from declining to increasing productivity. See <https://github.com/xavi-rp/LPD/blob/master/ATBD/LPD_ATBD.pdf> for a description of the methods used in the package to calculate the indicator.

Depends R (>= 3.6.0)

Imports raster, dplyr, stats, data.table, virtualspecies, magrittr, rgdal, parallel

Suggests knitr, rmarkdown

VignetteBuilder knitr

License GPL-3

Encoding UTF-8

LazyData true

RoxygenNote 6.1.1

URL <https://github.com/xavi-rp/LPDynR>

BugReports <https://github.com/xavi-rp/LPDynR/issues>

NeedsCompilation no

Author Xavier Rotllan-Puig [aut, cre],
Eva Ivits [aut],
Michael Cherlet [aut]

Maintainer Xavier Rotllan-Puig <xavier.rotllan.puig@aster-projects.cat>

Repository CRAN

Date/Publication 2021-01-21 09:10:05 UTC

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baseline_lev	<i>baseline_lev</i>
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Description

baseline_lev() derives land productivity at the beginning of the time series on study, resulting in a 3-class RasterLayer object with (1) low, (2) medium and (3) high productivity

Usage

```
baseline_lev(obj2process = NULL, yearsBaseline = 3,
  drylandProp = 0.4, highprodProp = 0.1, cores2use = 1,
  filename = "")
```

Arguments

obj2process	Raster* object (or its file name). If time series, each layer is one year
yearsBaseline	Numeric. Number of years to be averaged and used as baseline. Optional. Default is 3
drylandProp	Numeric. Proportion of drylands over total land, either expressed as a fraction of unity or percentage. Optional. Default is 0.4
highprodProp	Numeric. Proportion of land classified as 'highly productive' over total land, either expressed as a fraction of unity or percentage. Optional. Default is 0.1
cores2use	Numeric. Number of cores to use for parallelization. Optional. Default is 1 (no parallelization)
filename	Character. Output filename. Optional

Details

baseline_lev() uses the proportion of drylands over the total land ('drylandProp') to classify the level of productivity into low level. UNPD declares that 40 percent of the World's land resources are drylands (Middleton et al., 2011) and, therefore, 40 percent of pixels at the global level can be classified as low productivity land. This assumption is the default, but it should be adjusted for local and regional studies. In addition, baseline_lev() classifies by default 10 percent of pixels as high level of land productivity and the rest (100 - ('drylandProp' + 10)) as medium level. Proportion of pixels classified as 'high' can be also modified by passing the argument 'highprodProp'

Value

RasterLayer object

Author(s)

Xavier Rotllan-Puig

References

Middleton, N., L. Stringer, A. Goudie, and D. Thomas. 2011. "The Forgotten Billion. MDG Achievement in the Drylands." New York, NY, 10017, USA: United Nations Development Programme.

Examples

```
sb <- raster::brick(paste0(system.file(package='LPDynR'), "/extdata/sb_cat.tif"))
baseline_lev(obj2process = sb,
             yearsBaseline = 3,
             drylandProp = 0.4,
             cores2use = 2)
```

clust_optim

clust_optim

Description

clust_optim produces a scree plot with number of cluster at x-axis and total within-cluster sum of squares at y-axis

Usage

```
clust_optim(obj2clust = NULL, num_clstrs = seq(5, 50, 5), ...)
```

Arguments

obj2clust RasterStack or RasterBrick object (or its file name). Each layer is one variable
 num_clstrs Numeric. Optional. Vector with a sequence of number of clusters to check for optimal
 ... Optional. Arguments for [kmeans](#)

Details

The 'scree plot method' allows the user to assess how the quality of the K-means clustering improves when increasing the number of clusters. An elbow in the curve indicates the optimal number of clusters. K-means are run with [kmeans](#)

Value

A scree plot

Author(s)

Xavier Rotllan-Puig

See Also

[PCAs4clust](#); [EFT_clust](#); [kmeans](#)

Examples

```
dirctry <- paste0(system.file(package='LPDynR'), "/extdata")
variables_noCor <- rm_multicol(dir2process = dirctry,
                              multicol_cutoff = 0.7)
clust_optim(obj2clust = variables_noCor,
            num_clstrs = seq(5, 50, 5))
```

EFT_clust

EFT_clust

Description

EFT_clust derives the Ecosystem Functional Types using K-means to perform a clustering on the pixels of the Raster* object

Usage

```
EFT_clust(obj2clust = NULL, n_clust = 20, filename = "", ...)
```

Arguments

obj2clust	RasterStack or RasterBrick object (or its file name). Each layer is one variable
n_clust	Numeric. Number of total clusters. Optional. Default = 20
filename	Character. Output filename. Optional
...	Arguments for kmeans . Optional

Details

[kmeans](#) does not optimize the final number of clusters. It needs to be set by means of 'n_clust' (default = 20). There are several methods and statistics to determine the optimal number. [clust_optim](#) produces a scree plot to help the user to decide the optimal number of clusters.

EFT_clust passes as default to [kmeans](#) iter.max = 500 and algorithm = "MacQueen", but these can be modified passing these arguments through '...'

An evaluation of the clustering is provided together with the RasterLayer object. It is calculated as $\text{model\$betweenss} / \text{model\$totss} * 100$; where 'betweenss' and 'totss' are generated by [kmeans](#)

Value

A list with two components: (1) a RasterLayer object with the clusters and (2) a vector with the clustering evaluation in percentage

Author(s)

Xavier Rotllan-Puig

See Also

[PCAs4clust](#); [clust_optim](#); [kmeans](#)

Examples

```
dirctry <- paste0(system.file(package='LPDynR'), "/extdata")
variables_noCor <- rm_multicol(dir2process = dirctry,
                             multicol_cutoff = 0.7)
EFT_clust(obj2clust = variables_noCor,
          n_clust = 10)
```

LNScaling

*LNScaling***Description**

LNScaling (Local Net Productivity Scaling) uses a productivity variable (Raster*), e.g. season growth, to calculate the actual status of land productivity relative to its potential in homogeneous land areas or Ecosystem Functional Types (RasterLayer). If the productivity variable 'ProdVar' is a RasterStack or RasterBrick object with time series, it is calculated the average of the last 5 years

Usage

```
LNScaling(EFTs = NULL, ProdVar = NULL, cores2use = 1,
          filename = "")
```

Arguments

EFTs	RasterLayer object (or its file name). Ecosystem Functional Types. Its first variable has the number of EFT (cluster) each pixel belongs to
ProdVar	Raster* object (or its file name). Productivity variable (e.g. Cyclic fraction -season growth-)
cores2use	Numeric. Number of cores to use for parallelization. Optional. Default is 1 (no parallelization)
filename	Character. Output filename. Optional

Details

The Local Net Primary Production Scaling (LNS) method (Prince, 2009) calculates the difference between the potential and actual Net Primary Production for each pixel in homogeneous land areas. The current land production related to the local potential reflects the current level of productivity efficiency and, therefore, it is useful for the delineation of a land productivity status map

Value

RasterLayer object

Author(s)

Xavier Rotllan-Puig

References

Prince, S.D., Becker-Reshef, I. and Rishmawi, K. 2009. "Detection and Mapping of Long-Term Land Degradation Using Local Net Production Scaling: Application to Zimbabwe." REMOTE SENSING OF ENVIRONMENT 113 (5): 1046–57

See Also[EFT_clust](#)**Examples**

```

dirctry <- paste0(system.file(package='LPDynR'), "/extdata")
variables_noCor <- rm_multicol(dir2process = dirctry,
                             multicol_cutoff = 0.7)
EFTs_raster <- EFT_clust(obj2clust = variables_noCor,
                       n_clust = 10)
sb <- raster::brick(paste0(system.file(package='LPDynR'), "/extdata/sb_cat.tif"))

LNScaling(EFTs = EFTs_raster[[1]],
          ProdVar = sb)

```

*LongTermChange**LongTermChange*

Description

LongTermChange combines the Steadiness Index with the baseline levels of land productivity and with the change of state along the time series, resulting in a 22-class object (see details)

Usage

```

LongTermChange(SteadinessIndex = NULL, BaselineLevels = NULL,
              StateChange = NULL, filename = "")

```

Arguments

SteadinessIndex	RasterLayer object (or its file name). Steadiness Index (4-class)
BaselineLevels	RasterLayer object (or its file name). Baseline levels of land productivity (beginning of time series; 3-class)
StateChange	RasterLayer object (or its file name). Change of state of land productivity (beginning minus end of time series; 3-class)
filename	Character. Output filename. Optional

Details

St1-low-No Change <- 1

St1-low-Change 1 categ <- 2

St1-low-Change 2 or more categs <- 3

St1-medium-No Change <- 4
St1-medium-Change 1 categ <- 5
St1-medium-Change 2 or more categs <- 6
St1-high-No Change <- 7
St1-high-Change 1 categ <- 8
St1-high-Change 2 or more categs <- 9
St2-low-No Change <- 10
St2-low-Change 1 categ <- 10
St2-low-Change 2 or more categs <- 10
St2-medium-No Change <- 11
St2-medium-Change 1 categ <- 11
St2-medium-Change 2 or more categs <- 11
St2-high-No Change <- 12
St2-high-Change 1 categ <- 12
St2-high-Change 2 or more categs <- 12
St3-low-No Change <- 13
St3-low-Change 1 categ <- 13
St3-low-Change 2 or more categs <- 13
St3-medium-No Change <- 14
St3-medium-Change 1 categ <- 14
St3-medium-Change 2 or more categs <- 14
St3-high-No Change <- 15
St3-high-Change 1 categ <- 15
St3-high-Change 2 or more categs <- 15
St4-low-No Change <- 16
St4-low-Change 1 categ <- 17
St4-low-Change 2 or more categs <- 18
St4-medium-No Change <- 19
St4-medium-Change 1 categ <- 20
St4-medium-Change 2 or more categs <- 21
St4-high-No Change <- 22
St4-high-Change 1 categ <- 22
St4-high-Change 2 or more categs <- 22

Values = 0 in the final map indicates that there is a scarcity of data in the productivity variable (i.e. only 1 year with data), so that the indicator cannot be calculated

Value

RasterLayer object

Author(s)

Xavier Rotllan-Puig

See Also[steadiness](#), [baseline_lev](#), [state_change](#)**Examples**

```

sb <- raster::brick(paste0(system.file(package='LPDynR'), "/extdata/sb_cat.tif"))
SteadinessIndex_raster <- steadiness(obj2process = sb)
BaselineLevels_raster <- baseline_lev(obj2process = sb,
                                     yearsBaseline = 3,
                                     drylandProp = 0.4)
StateChange_raster <- state_change(obj2process = sb,
                                   yearsBaseline = 3)

LongTermChange(SteadinessIndex = SteadinessIndex_raster,
               BaselineLevels = BaselineLevels_raster,
               StateChange = StateChange_raster)

```

LPD_CombAssess

*LPD_CombAssess***Description**

LPD_CombAssess combines a 'LandProd_change' map (RasterLayer) with a 'LandProd_current' map (RasterLayer), giving a 5-classes map ranging from declining to increasing land productivity. 'LandProd_current' is reclassified into two classes: pixels with less than 50 highest local production (within the EFT) and pixels with more or equal to their 50. If 'LandProd_current' = NULL, 'LandProd_change' is directly reclassified into the same 5-classes map without using 'LandProd_current'. See the ATBD for the way pixels are reclassified.

Usage

```

LPD_CombAssess(LandProd_change = NULL, LandProd_current = NULL,
              filename = "")

```

Arguments

LandProd_change	RasterLayer object (or its file name). Land Productivity Long Term Change Map
LandProd_current	RasterLayer object (or its file name). Land Productivity Current Status Map
filename	Character. Output filename. Optional

Details

LandProd_change c(1:6, 8:9) & LandProd_current < 50 <- 1 Declining land productivity
 LandProd_change c(3, 6) & LandProd_current >= 50 <- 1 Declining land productivity
 LandProd_change c(7) & LandProd_current < 50 <- 2 Early signs of decline of land productivity
 LandProd_change c(1:2, 4:5, 8:9) & LandProd_current >= 50 <- 2 Early signs of decline of land productivity
 LandProd_change c(7) & LandProd_current >= 50 <- 3 Negative fluctuation (stable, but stressed land prod.)
 LandProd_change c(10:12) <- 3 Negative fluctuation (stable, but stressed land prod.) LandProd_change c(13:15) <- 4 Positive fluctuation (stable, not stressed land prod.)
 LandProd_change c(16:17, 19) & LandProd_current < 50 <- 4 Positive fluctuation (stable, not stressed land prod.)
 LandProd_change c(18, 20:22) & LandProd_current < 50 <- 5 Increasing land productivity
 LandProd_change c(16:22) & LandProd_current >= 50 <- 5 Increasing land productivity
 Values = 0 in the final map indicates that there is a scarcity of data in the productivity variable (i.e. only 1 year with data), so that the indicator cannot be calculated

Value

RasterLayer

Author(s)

Xavier Rotllan-Puig

See Also

[LongTermChange](#); [LNScaling](#)

Examples

```
sb <- raster::brick(paste0(system.file(package='LPDynR'), "/extdata/sb_cat.tif"))
SteadinessIndex_raster <- steadiness(obj2process = sb)
BaselineLevels_raster <- baseline_lev(obj2process = sb,
                                     yearsBaseline = 3,
                                     drylandProp = 0.4)
StateChange_raster <- state_change(obj2process = sb,
                                   yearsBaseline = 3)
LandProd_change_raster <- LongTermChange(SteadinessIndex = SteadinessIndex_raster,
                                         BaselineLevels = BaselineLevels_raster,
                                         StateChange = StateChange_raster)

dirctry <- paste0(system.file(package='LPDynR'), "/extdata")
variables_noCor <- rm_multicol(dir2process = dirctry,
                              multicol_cutoff = 0.7)
EFTs_raster <- EFT_clust(obj2clust = variables_noCor,
```

```

n_clust = 10)

LandProd_current_raster <- LNScaling(EFTs = EFTs_raster[[1]],
                                     ProdVar = sb)

LPD_CombAssess(LandProd_change = LandProd_change_raster,
               LandProd_current = LandProd_current_raster)

```

PCAs4clust

PCAs4clust

Description

PCAs4clust runs a two-steps process to prepare the data to be clustered

Usage

```

PCAs4clust(obj2process = NULL, cumul_var_threshold = 0.9,
           filename = "", ...)

```

Arguments

obj2process	Raster* object (or its file name). Each layer is one variable
cumul_var_threshold	Numeric. Optional (default = 0.9). Threshold of cumulative variance to select the number of useful PCs
filename	Character. Output filename. Optional
...	Optional. Arguments for prcomp

Details

Firstly, a Principal Component Analysis ('screening PCA') with all the variables in 'obj2process' is run in order to know the optimal number of variables to be used in a subsequent PCA, as well as the most associated variable to those Principal Components (PCs). A threshold of cumulative variance (cumul_var_threshold; default = 0.9) is needed. Secondly, a 'final PCA' is run with the results of the 'screening PCA' (i.e. number of PC axes and their most associated variables). PCAs4clust uses [prcomp](#) to run PCAs

Value

RasterBrick object

Author(s)

Xavier Rotllan-Puig

See Also[rm_multicol](#); [prcomp](#)**Examples**

```

dirctry <- paste0(system.file(package='LPDynR'), "/extdata")
variables_noCor <- rm_multicol(dir2process = dirctry,
                             multicol_cutoff = 0.7)
PCAs4clust(obj2process = variables_noCor,
           cumul_var_threshold = 0.9)

```

*rm_multicol**rm_multicol*

Description

`rm_multicol` calculates the average of each variable and removes those variables highly correlated

Usage

```

rm_multicol(dir2process = NULL, multicol_cutoff = 0.7, cores2use = 1,
            filename = "", ...)

```

Arguments

<code>dir2process</code>	Character. Directory where the Raster* objects are stored. All the .tif files in the directory will be read in to be used
<code>multicol_cutoff</code>	Numeric. Cutoff value of (Pearson's) correlation. Optional. Default is 0.70
<code>cores2use</code>	Numeric. Number of cores to use for parallelization. Optional. Default is 1 (no parallelization)
<code>filename</code>	Character. Output filename. Optional
<code>...</code>	Optional. Arguments for <code>removeCollinearity()</code>

Details

Firstly, after reading in all .tif files in 'dir2process', if they are multiband (time series), averages are calculated. Secondly, it creates a RasterBrick object with those (averaged) variables which have a Pearson's correlation coefficient below 'multicol_cutoff'. See [removeCollinearity](#) for further arguments and functionalities

Value

RasterBrick object

Author(s)

Xavier Rotllan-Puig

References

Leroy B, Meynard CN, Bellard C, Courchamp F (2015). “virtualspecies, an R package to generate virtual species distributions”. *Ecography*. doi: 10.1111/ecog.01388

See Also

[removeCollinearity](#)

Examples

```
dirctry <- paste0(system.file(package='LPDynR'), "/extdata") # directory with variables to process
rm_multicol(dir2process = dirctry,
             multicol_cutoff = 0.7,
             plot = TRUE)
```

sbd_cat

Season Beginning Day

Description

RasterBrick object containing time series of phenological data (400 cells; 10 layers). Years 2000-2009. The variable has been derived from MODIS using Timesat

Usage

sbd_cat

Format

GeoTIFF. RasterBrick object with dimensions: 20, 20, 400, 10 (nrow, ncol, ncell, nlayers)

sbd_cat Season beginning day

Details

Downloaded from www.eea.europa.eu (20/08/2020)

Coord. ref. : +proj=laea +lat_0=52 +lon_0=10 +x_0=4321000 +y_0=3210000 +ellps=GRS80 +units=m +no_defs

Resolution : 500, 500 (x, y)

Extent : 3640000, 3650000, 2140000, 2150000 (xmin, xmax, ymin, ymax)

Source

<https://www.eea.europa.eu/data-and-maps>

References

<https://www.eea.europa.eu/data-and-maps/data/annual-start-of-vegetation-growing>

Examples

```
raster::brick(paste0(system.file(package='LPDynR'), "/extdata/sbd_cat.tif"))
```

sb_cat

Standing Biomass

Description

RasterBrick object containing time series of land productivity data (400 cells; 10 layers). Years 2000-2009. The variable has been derived from MODIS using Timesat

Usage

sb_cat

Format

GeoTIFF. RasterBrick object with dimensions: 20, 20, 400, 10 (nrow, ncol, ncell, nlayers)

sb_cat Standing biomass

Details

Downloaded from www.eea.europa.eu (20/08/2020)

Coord. ref. : +proj=laea +lat_0=52 +lon_0=10 +x_0=4321000 +y_0=3210000 +ellps=GRS80
+units=m +no_defs

Resolution : 500, 500 (x, y)

Extent : 3640000, 3650000, 2140000, 2150000 (xmin, xmax, ymin, ymax)

Source

<https://www.eea.europa.eu/data-and-maps>

References

<https://www.eea.europa.eu/data-and-maps/data/annual-above-ground-vegetation-productivity>

Examples

```
raster::brick(paste0(system.file(package='LPDynR'), "/extdata/sb_cat.tif"))
```

sl_cat	<i>Season Length</i>
--------	----------------------

Description

RasterBrick object containing time series of phenological data (400 cells; 10 layers). Years 2000-2009. The variable has been derived from MODIS using Timesat

Usage

```
sl_cat
```

Format

GeoTIFF. RasterBrick object with dimensions: 20, 20, 400, 10 (nrow, ncol, ncell, nlayers)

sl_cat Season Length

Details

Downloaded from www.eea.europa.eu (20/08/2020)

Coord. ref. : +proj=laea +lat_0=52 +lon_0=10 +x_0=4321000 +y_0=3210000 +ellps=GRS80
+units=m +no_defs

Resolution : 500, 500 (x, y)

Extent : 3640000, 3650000, 2140000, 2150000 (xmin, xmax, ymin, ymax)

Source

<https://www.eea.europa.eu/data-and-maps>

References

<https://www.eea.europa.eu/data-and-maps/data/annual-above-ground-vegetation-season>

Examples

```
raster::brick(paste0(system.file(package='LPDynR'), "/extdata/sl_cat.tif"))
```

state_change	<i>state_change</i>
--------------	---------------------

Description

state_change derives land productivity state change between the beginning and the end of the time series on study, resulting in a 3-class RasterLayer object with (1) not change, (2) changed 1 class and (3) changed 2 or more classes

Usage

```
state_change(obj2process = NULL, yearsBaseline = 3, cores2use = 1,  
            filename = "")
```

Arguments

obj2process	Raster* object (or its file name). If time series, each layer is one year
yearsBaseline	Numeric. Number of years to be averaged at the beginning and end of the time series. Optional. Default is 3
cores2use	Numeric. Number of cores to use for parallelization. Optional. Default is 1 (no parallelization)
filename	Character. Output filename. Optional

Details

state_change uses the average of 'yearsBaseline' number of years at the beginning and the end of the time series

Value

RasterLayer object

Author(s)

Xavier Rotllan-Puig

Examples

```
sb <- raster::brick(paste0(system.file(package='LPDynR'), "/extdata/sb_cat.tif"))  
state_change(obj2process = sb,  
            yearsBaseline = 3,  
            cores2use = 2)
```

steadiness	<i>steadiness</i>
------------	-------------------

Description

steadiness derives the Steadiness Index from a land productivity variable

Usage

```
steadiness(obj2process = NULL, cores2use = 1, filename = "")
```

Arguments

obj2process	Raster* object (or its file name). If time series, each layer is one year
cores2use	Numeric. Number of cores to use for parallelization. Optional. Default is 1 (no parallelization)
filename	Character. Output filename. Optional

Details

The Steadiness Index is based on the combination of two metrics calculated per pixel: (1) the slope derived from a linear regression of the different years of the time series and (2) the net change on the same period. It results in a 4-class RasterLayer object ranging from (1) strong negative to (4) strong positive ecosystem dynamics. See Ivits et al. (2013) for further explanations.

Values = 0 in the final map indicates that there is a scarcity of data in the productivity variable (i.e. only 1 year with data), so that the indicator cannot be calculated

Value

RasterLayer object

Author(s)

Xavier Rotllan-Puig

References

Ivits, E., M. Cherlet, W. Mehl, and S. Sommer. 2013. "Ecosystem Functional Units Characterized by Satellite Observed Phenology and Productivity Gradients: A Case Study for Europe." *Ecological Indicators* 27: 17–28. doi: [10.1016/j.ecolind.2012.11.010](https://doi.org/10.1016/j.ecolind.2012.11.010)

Examples

```
sb <- raster::brick(paste0(system.file(package='LPDynR'), "/extdata/sb_cat.tif"))
steadiness(obj2process = sb)
```

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