Package 'pointRes'

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Title Analyzing Pointer Years and Components of Resilience

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Description Functions to calculate and plot event and pointer years as well as components of resilience. Designed for dendroecological applications, but also suitable to analyze patterns in other ecological time series.

License GPL (>= 2)

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`event.plot` *Plot event years for individual trees*

Description

The function creates a dot plot showing positive and (or) negative event years from a `list` of the type as produced by `pointer.norm` or `pointer.rgc`.

Usage

```
event.plot(list.name, sign = c("both", "pos", "neg"),
           start.yr = NULL, end.yr = NULL,
           x.tick.major = 10, x.tick.minor = 5)
```

Arguments

`list.name`	a `list` as produced by `pointer.norm` or `pointer.rgc`
`sign`	a `character` string specifying whether both positive and negative (`"both"`), or only positive (`"pos"`) or negative (`"neg"`) event years should be displayed. Defaults to `"both"`.
`start.yr`	an `integer` specifying the first year to be plotted. Defaults to the first year with data if *start.yr* is `NULL`.
`end.yr`	an `integer` specifying the last year to be plotted. Defaults to the last year with data if *end.yr* is `NULL`.
`x.tick.major`	an `integer` controlling the major x-axis tick labels. Defaults to 10 years.
`x.tick.minor`	an `integer` controlling the minor x-axis ticks. Defaults to 5 years.

Details

The function makes a dot plot showing event years for individual trees. Positive and negative event years are indicated with different symbols. If event years were defined using `method.thresh "Neuwirth"` (`pointer.norm`), different tones of gray indicate weak, strong and extreme event years.

Value

Dot plot.

Author(s)

Marieke van der Maaten-Theunissen and Ernst van der Maaten.

Examples

```
## Plot event years from pointer.rgc output
data(s033)
py <- pointer.rgc(s033)
event.plot(py, start.yr = 1950, end.yr = NULL)

## Plot negative event years from pointer.norm output (method "Neuwirth")
data(s033)
py_n <- pointer.norm(s033, window = 5, method.thresh = "Neuwirth")
event.plot(py_n, sign = "neg", start.yr = 1950, end.yr = NULL)
```

`lowpass13` *Apply 13-year low-pass filter*

Description

The function applies a 13-year weighted low-pass filter, as described by Fritts (1976), on a `data.frame` with tree-ring series.

Usage

```
lowpass13(data)
```

Arguments

`data`	a `data.frame` with raw tree-ring series as columns and years as rows (e.g., output of `read.rwl` of package dplR).

Details

A 13-year weighted low-pass filter, as described by Fritts (1976, p. 270), can be applied to tree-ring series prior to the calculation of event and pointer years using `pointer.norm`. According to Cropper (1979), such a filter improves the detection of event and pointer years for complacent series, whereas for sensitive series filtering has little effect.

Note that the resulting time series are truncated by 6 years at both ends inherent to the calculation method.

Value

The function returns a `data.frame` with 13-year low-pass filtered index series.

Author(s)

Marieke van der Maaten-Theunissen and Ernst van der Maaten.

References

Cropper, J.P. (1979) Tree-ring skeleton plotting by computer. *Tree-Ring Bulletin* 39: 47-59.

Fritts, H.C. (1976) Tree rings and climate. Academic Press Inc. (London) Ltd.

Examples

```
data(s033)
lp13_s033 <- lowpass13(s033)
```

`norm.plot` *Plot mean Cropper values and pointer years*

Description

The function creates a bar plot of mean Cropper values from a `list` of the type as produced by `pointer.norm` and highlights years identified as pointer years.

Usage

```
norm.plot(list.name, start.yr = NULL, end.yr = NULL,
          sd.disp = FALSE, x.tick.major = 10, x.tick.minor = 5)
```

Arguments

`list.name`	a `list` as produced by `pointer.norm`
`start.yr`	an `integer` specifying the first year to be plotted. Defaults to the first year included in the `out` component of the `list` if *start.yr* is `NULL`.
`end.yr`	an `integer` specifying the last year to be plotted. Defaults to the last year included in the `out` component of the `list` if *end.yr* is `NULL`.
`sd.disp`	a `logical` specifying whether error bars (stdev) should be displayed. Defaults to FALSE.
`x.tick.major`	an `integer` controlling the major x-axis tick labels. Defaults to 10 years.
`x.tick.minor`	an `integer` controlling the minor x-axis ticks. Defaults to 5 years.

Details

The function makes a plot showing mean Cropper values; pointer years are indicated with dark-gray bars. If event years were defined using `method.thresh "Neuwirth"` (`pointer.norm`), different tones of gray indicate weak, strong and extreme pointer years, based on the most common event year class. Error bars can be set.

Value

Bar plot.

Author(s)

Marieke van der Maaten-Theunissen and Ernst van der Maaten.

Examples

```
## Plot mean Cropper values and pointer years (method "Cropper")
data(s033)
py_c <- pointer.norm(s033, window = 5, method.thresh = "Cropper",
                     series.thresh = 75)
norm.plot(py_c, start.yr = 1950, end.yr = NULL,
          sd.disp = FALSE, x.tick.major = 10, x.tick.minor = 5)

## Plot mean Cropper values and pointer years (method "Neuwirth")
data(s033)
py_n <- pointer.norm(s033, window = 5, method.thresh = "Neuwirth",
                     series.thresh = 75)
norm.plot(py_n, start.yr = 1950, end.yr = NULL,
          sd.disp = FALSE, x.tick.major = 10, x.tick.minor = 5)
```

`pointer.norm` *Calculate pointer years using the normalization in a moving window method*

Description

The function calculates event and pointer years on a `data.frame` with tree-ring series using the normalization in a moving window method introduced by Cropper (1979; cf. Schweingruber et al. 1990). This method z-transforms tree growth in year *i* within a symmetric moving window of *n* years, thereby providing the number of standard deviations that tree growth deviates in individual years (Cropper values, C) from the window average. To identify event years, one absolute threshold on the number of standard deviations can be set (cf. Cropper 1979), or, alternatively, three intensity classes (cf. Neuwirth et al. 2007). Threshold values for defining event and pointer years can be adjusted.

Prior to the calculation of event and pointer years with `pointer.norm`, a 13-year weighted low-pass filter, as described by Fritts (1976), may be applied on the tree-ring series using `lowpass13`. According to Cropper (1979), such a filter improves the detection of event and pointer years for complacent series, whereas for sensitive series filtering has little effect.

Usage

```
pointer.norm(data, window = 5, method.thresh = c("Cropper", "Neuwirth"),
             C.thresh = 0.75, N.thresh1 = 1, N.thresh2 = 1.28,
             N.thresh3 = 1.645, series.thresh = 75)
```

Arguments

data	a data.frame with raw tree-ring series as columns and years as rows (e.g., output of read.rwl of package dplR), or a data.frame with filtered series (output of lowpass13).
window	an integer specifying the window size (i.e. number of years) to be used to calculate normalized growth deviations. Must be an odd number (>=3). Defaults to 5.
method.thresh	a character string of "Cropper" or "Neuwirth", specifying whether one absolute threshold or three intensity classes should be used for defining event years. Argument matching is performed.
C.thresh	a numeric specifying the threshold for identification of event years using method "Cropper". Defaults to 0.75.
N.thresh1	a numeric specifying the threshold for identification of weak event years using method "Neuwirth". Defaults to 1.
N.thresh2	a numeric specifying the threshold for identification of strong event years using method "Neuwirth". Defaults to 1.28.
N.thresh3	a numeric specifying the threshold for identification of extreme event years using method "Neuwirth". Defaults to 1.645.
series.thresh	a numeric specifying the minimum percentage of trees that should display a positive (or negative) event year for that year to be considered as positive (or negative) pointer year. Defaults to 75.

Details

The function z-transforms tree growth in year *i* within a symmetric moving window of *n* years. For method.thresh "Cropper", event years are defined as those years having absolute Cropper values above a specified threshold (defaults to |C| > 0.75). For method.thresh "Neuwirth", three classes of distinct growth deviations can be defined, being 'weak', 'strong' and 'extreme' (defaults to |C| > 1, |C| > 1.28, and |C| > 1.645). The window size can be adjusted, as well as the minimum percentage of trees that should display a positive (or negative) event year for that year to be considered as positive (or negative) pointer year.

Note that the resulting time series are truncated by *(window-1)/2* at both ends inherent to the calculation methods.

Value

The function returns a list containing the following components:

- for method.thresh "Cropper":

Cvalues	a matrix with Cropper values for individual tree-ring series
EYvalues	a matrix indicating positive (1), negative (-1) and non-event years (0) for individual tree-ring series
out	a data.frame containing the following columns:
	year - time stamp

nb.series - number of series considered

perc.pos - percentage of trees showing a positive event year

perc.neg - percentage of trees showing a negative event year

nature - number indicating whether the year is a positive (1), negative (-1) or no pointer year (0)

Cvalues_mean - mean Cropper value over the available series

Cvalues_sd - standard deviation of Cropper values

spec.param — a data.frame specifying the arguments used in the calculation

- for method.thresh "Neuwirth":

Cvalues — a matrix with Cropper values for individual tree-ring series

EYvalues — a matrix indicating weak (1/-1), strong (2/-2) and extreme (3/-3) positive/negative event years, as well as non-event years (0) for individual tree-ring series

out — a data.frame containing the following columns:

year - time stamp

nb.series - number of series considered

perc.pos.extreme - percentage of trees showing a positive extreme event year

perc.pos.strong - percentage of trees showing a positive strong event year

perc.pos.weak - percentage of trees showing a positive weak event year

perc.neg.weak - percentage of trees showing a negative weak event year

perc.neg.strong - percentage of trees showing a negative strong event year

perc.neg.extreme - percentage of trees showing a negative extreme event year

nature - number indicating whether the year is a positive (1), negative (-1) or no pointer year (0)

Cvalues_mean - mean Cropper value over the available series

Cvalues_sd - standard deviation of Cropper values

spec.param — a data.frame specifying the arguments used in the calculation

Author(s)

Marieke van der Maaten-Theunissen and Ernst van der Maaten.

References

Cropper, J.P. (1979) Tree-ring skeleton plotting by computer. *Tree-Ring Bulletin* 39: 47-59.

Fritts, H.C. (1976) Tree rings and climate. Academic Press Inc. (London) Ltd.

Neuwirth, B., Schweingruber, F.H. and Winiger, M. (2007) Spatial patterns of central European pointer years from 1901 to 1971. *Dendrochronologia* 24: 79-89.

Schweingruber, F.H., Eckstein, D., Serre-Bachet, F. and Bräker, O.U. (1990) Identification, presentation and interpretation of event years and pointer years in dendrochronology. *Dendrochronologia* 8: 9-38.

Examples

```
## Calculate pointer years on tree-ring series using method.thresh "Cropper"
## and a user-defined threshold for event-year definition of 1
data(s033)
py_c <- pointer.norm(s033, window = 5, method.thresh = "Cropper",
                     C.thresh = 1, series.thresh = 75)
py_c$out

## Calculate pointer years on tree-ring series using method.thresh "Neuwirth"
data(s033)
py_n <- pointer.norm(s033, window = 5, method.thresh = "Neuwirth",
                     series.thresh = 75)
py_n$out
```

`pointer.plot` *Plot pointer years for multiple sites*

Description

The function creates a dot plot showing positive and (or) negative pointer years from `lists` of the type as produced by either `pointer.norm` or `pointer.rgc`.

Usage

```
pointer.plot(list.sites, sign = c("both", "pos", "neg"),
             start.yr = NULL, end.yr = NULL, labels = NULL,
             x.tick.major = 10, x.tick.minor = 5)
```

Arguments

`list.sites`	a `list` with `lists` as produced by either `pointer.norm` or `pointer.rgc` for individual sites (created using list(site1, site2,..)).
`sign`	a `character` string specifying whether both positive and negative (`"both"`), or only positive (`"pos"`) or negative (`"neg"`) pointer years should be displayed. Defaults to `"both"`.
`start.yr`	an `integer` specifying the first year to be plotted. Defaults to the first year with data if *start.yr* is `NULL`.
`end.yr`	an `integer` specifying the last year to be plotted. Defaults to the last year with data if *end.yr* is `NULL`.
`labels`	a `character` vector with labels for the sites. Defaults to 'site 1, 2, .., *i*'.
`x.tick.major`	an `integer` controlling the major x-axis tick labels. Defaults to 10 years.
`x.tick.minor`	an `integer` controlling the minor x-axis ticks. Defaults to 5 years.

Details

The function makes a dot plot showing pointer years for multiple sites. Positive and negative pointer years are indicated with different symbols. If event years were defined using `method.thresh "Neuwirth"` (`pointer.norm`), different tones of gray indicate weak, strong and extreme pointer years, based on the most common event year class.

Value

Dot plot.

Author(s)

Marieke van der Maaten-Theunissen and Ernst van der Maaten.

Examples

```
## Plot negative pointer years for multiple sites from pointer.rgc output
data(s033)
site1 <- pointer.rgc(s033, nb.yrs = 4)
site2 <- pointer.rgc(s033, nb.yrs = 6)
sites <- list(site1, site2)
pointer.plot(sites, sign = "neg", start.yr = 1950, end.yr = NULL)

## Plot pointer years for multiple sites from pointer.norm output (method "Neuwirth")
data(s033)
site1 <- pointer.norm(s033, window = 5, method.thresh = "Neuwirth")
site2 <- pointer.norm(s033, window = 11, method.thresh = "Neuwirth")
sites <- list(site1, site2)
site.names <- c("schneetal5", "schneetal11")
pointer.plot(sites, start.yr = 1950, end.yr = NULL, labels = site.names)
```

---

pointer.rgc *Calculate pointer years using the relative growth change method*

Description

The function calculates event and pointer years on a `data.frame` with tree-ring series using the relative growth change method, described as abrupt growth change method in Schweingruber et al. (1990). This method relates tree growth in year i to the average growth of n preceding years. Thresholds for event- and pointer-year calculations can be adjusted.

Usage

```
pointer.rgc(data, nb.yrs = 4, rgc.thresh.pos = 60, rgc.thresh.neg = 40,
            series.thresh = 75)
```

Arguments

data	a data.frame with raw tree-ring series as columns and years as rows (e.g., output of read.rwl of package dplR).
nb.yrs	an integer specifying the number of preceding years to be used in calculating relative growth changes. Defaults to 4.
rgc.thresh.pos	a numeric specifying the threshold above which a relative growth change (in percentage) for a specific tree and year is considered a positive event year. Defaults to 60.
rgc.thresh.neg	a numeric specifying the threshold below which a relative growth change (in percentage) for a specific tree and year is considered a negative event year. Defaults to 40.
series.thresh	a numeric specifying the minimum percentage of trees that should display a positive (or negative) event year for that year to be considered as positive (or negative) pointer year. Defaults to 75.

Details

The function calculates the ratio of tree growth in year *i* and the average growth of *n* preceding years for individual trees. Resulting relative growth changes are used to identify event years for trees, and these event years to define pointer years for the site.

Following Schweingruber et al. (1990), *nb.yrs*, *rgc.thresh.pos*, *rgc.thresh.neg* and *series.thresh* are set to 4, 60, 40 and 75 respectively, meaning that a positive or negative pointer year will be defined when at least 75% of the tree-ring series display an event year with a growth increase or decrease of at least 60% or 40%, respectively, relative to the average growth in the 4 preceding years.

Note that the resulting time series are truncated by *nb.yrs* at the beginning inherent to the calculation methods.

Value

The function returns a list containing the following components:

rgc	a matrix with relative growth changes for individual tree-ring series
EYvalues	a matrix indicating positive (1), negative (-1) and non-event years (0) for individual tree-ring series
out	a data.frame containing the following columns:
	year - time stamp
	nb.series - number of series considered
	perc.pos - percentage of trees showing a positive event year
	perc.neg - percentage of trees showing a negative event year
	nature - number indicating whether the year is a positive (1), negative (-1) or no pointer year (0)
	dev_mean - mean growth deviation in percentage over the available series
	dev_sd - standard deviation of the growth deviation
spec.param	a data.frame specifying the arguments used in the calculation

Author(s)

Marieke van der Maaten-Theunissen and Ernst van der Maaten.

References

Schweingruber, F.H., Eckstein, D., Serre-Bachet, F. and Bräker, O.U. (1990) Identification, presentation and interpretation of event years and pointer years in dendrochronology. *Dendrochronologia* 8: 9-38.

In writing the function, the code of the dplR function `pointer` (Pierre Mérian) was used as a reference.

Examples

```
## Calculate pointer years on tree-ring series
data(s033)
py <- pointer.rgc(s033, nb.yrs = 4, rgc.thresh.pos = 60, rgc.thresh.neg = 40,
                  series.thresh = 75)
py$out
```

`res.comp` *Calculate resilience components: resistance, recovery, resilience and relative resilience*

Description

The function calculates resilience components on a `data.frame` of tree-ring series after Lloret et al. (2011), useful to analyze growth of individual trees prior, during and after extreme events / disturbances. The component 'resistance' is conceptually identical to 'abrupt growth changes' as described in Schweingruber et al. (1990). To identify negative event and pointer years, thresholds can be set as for the function `pointer.rgc`. 'Recovery' is the ability of tree growth to recover after disturbance, whereas 'resilience' reflects the ability of trees to reach pre-disturbance growth levels. Weighting of the resilience by the experienced growth reduction results in 'relative resilience'.

Usage

```
res.comp(data, nb.yrs = 4, post = NULL, res.thresh.neg = 40, series.thresh = 75)
```

Arguments

`data`	a `data.frame` with tree-ring series as columns and years as rows (e.g., output of `read.rwl`, `bai.in` or `bai.out` of package dplR)
`nb.yrs`	an `integer` specifying the number of years for pre- and (or) post-disturbance periods to be considered in calculating resilience components. Defaults to 4.
`post`	an `integer` specifying the number of years for post-disturbance periods. Defaults to *nb.yrs*. Optional argument in case pre- and post-period lengths should differ.

`res.thresh.neg` a `numeric` specifying the threshold below which the resistance, expressed as a percentual change (i.e. relative growth reduction), is considered a negative event year for individual trees and years. Defaults to 40.

`series.thresh` a `numeric` specifying the minimum percentage of trees that should display a negative event year for that year to be considered as negative pointer year. Defaults to 75.

Details

The function calculates the resilience components resistance, recovery, resilience and relative resilience as described in Lloret et al. (2011). A threshold on resistance can be set to identify negative event years for trees (cf. *rgc.thresh.neg* in function `pointer.rgc`), which are used to define negative pointer years for the site.

If *nb.yrs*, *res.thresh.neg* and *series.thresh* are set to 4, 40 and 75 respectively, a negative pointer year will be defined when at least 75% of the tree-ring series display an event year with resistance values indicating a growth decrease of at least 40%, relative to the average growth in the 4 preceding years. The output provides the resilience components for all possible years, as well as for the selected pointer years separately.

Note that the resulting time series are truncated at both ends by the number of years specified in *nb.yrs* (and *post*), inherent to the calculation methods.

Value

#' The function returns a `list` containing the following components:

`resist` a `matrix` with resistance values (i.e. relative growth changes) for individual tree-ring series

`EYvalues` a `matrix` indicating negative (-1) and non-event years (0) for individual tree-ring series

`recov` a `matrix` with recovery values for individual tree-ring series

`resil` a `matrix` with resilience values for individual tree-ring series

`rel.resil` a `matrix` with relative resilience values for individual tree-ring series

`out` a `data.frame` containing the following columns:

`year` - time stamp

`nb.series` - number of series considered

`perc.neg` - percentage of trees showing a negative event year

`nature` - number indicating whether the year is a negative (-1) or no pointer year (0)

`resist_mean` - mean resistance as percentual change over the available series

`resist_sd` - standard deviation of the resistance

`recov_mean` - mean recovery as percentual change over the available series

`recov_sd` - standard deviation of the recovery

`resil_mean` - mean resilience as percentual change over the available series

`resil_sd` - standard deviation of the resilience

	rel.resil_mean - mean relative resilience calculated over the available series
	rel.resil_sd - standard deviation of the relative resilience
out.select	a data.frame containing a subset of rows from out that provide all statistics for years that were identified as negative pointer years
spec.param	a data.frame specifying the arguments used in the calculation

Author(s)

Marieke van der Maaten-Theunissen and Ernst van der Maaten.

References

Lloret, F., Keeling, E.G. and Sala, A. (2011) Components of tree resilience: effects of successive low-growth episodes in old ponderosa pine forests. *Oikos* 120: 1909-1920.

Schweingruber, F.H., Eckstein, D., Serre-Bachet, F. and Bräker, O.U. (1990) Identification, presentation and interpretation of event years and pointer years in dendrochronology. *Dendrochronologia* 8: 9-38.

Examples

```
## Calculate resilience components on tree-ring series
data(s033)
res <- res.comp(s033, nb.yrs = 4, post = NULL, res.thresh.neg = 40, series.thresh = 75)
res$out
res$out.select
```

---

res.plot *Plot resilience components*

Description

The function creates box plots of the resilience components resistance, recovery, resilience and relative resilience as produced by res.comp for years identified as negative pointer years, as well as for selected years.

Usage

```
res.plot(list.name, select.yr = NULL, multi.panel = TRUE)
```

Arguments

list.name	a list as produced by res.comp.
select.yr	an integer specifying the (pointer) years to be plotted (e.g., c(1948, 1992)). Defaults to all years defined as negative pointer year with *nb.series* >= 5 in the list component out.select.
multi.panel	a logical specifying whether box plots should be plotted in a 2x2 grid. Defaults to TRUE.

Details

The function makes a box plot for each resilience component showing the full range of variation for individual trees in negative pointer years (or selected years). Box plots are only created for years with *nb.series* >= 5, as this value represents the number of statistics that a box plot represents in its' simplest form.

Value

Four box plots.

Author(s)

Marieke van der Maaten-Theunissen and Ernst van der Maaten.

Examples

```
## Plot resilience components for all defined pointer years
# note: pointer years with < 5 series (here 1882) are not displayed (warning)
data(s033)
res <- res.comp(s033, nb.yrs = 4, res.thresh.neg = 40, series.thresh = 75)
res.plot(res, select.yr = NULL, multi.panel = TRUE)

## Plot resilience components for selected years
# note: inclusion of non-pointer years (here 2002) results in a warning
data(s033)
res <- res.comp(s033, nb.yrs = 4, res.thresh.neg = 40, series.thresh = 75)
res.plot(res, select.yr = c(1948, 1992, 2002), multi.panel = TRUE)
```

---

rgc.plot *Plot mean relative growth changes and pointer years*

Description

The function creates a bar plot of mean relative growth changes from a `list` of the type as produced by `pointer.rgc` and highlights years identified as pointer years.

Usage

```
rgc.plot(list.name, start.yr = NULL, end.yr = NULL,
         sd.disp = FALSE, x.tick.major = 10, x.tick.minor = 5)
```

Arguments

`list.name`	a `list` as produced by `pointer.rgc`
`start.yr`	an `integer` specifying the first year to be plotted. Defaults to the first year with data if *start.yr* is `NULL`.

end.yr	an integer specifying the last year to be plotted. Defaults to the last year with data if *end.yr* is NULL.
sd.disp	a logical specifying whether error bars (stdev) should be displayed. Defaults to FALSE.
x.tick.major	an integer controlling the major x-axis tick labels. Defaults to 10 years.
x.tick.minor	an integer controlling the minor x-axis ticks. Defaults to 5 years.

Details

The function makes a plot showing mean relative growth changes; pointer years are indicated with dark-gray bars. Error bars can be set.

Value

Bar plot.

Author(s)

Marieke van der Maaten-Theunissen and Ernst van der Maaten.

Examples

```
## Plot mean relative growth changes and pointer years
data(s033)
py <- pointer.rgc(s033, nb.yrs = 4, rgc.thresh.pos = 60, rgc.thresh.neg = 40,
                  series.thresh = 75)
rgc.plot(py, start.yr = 1950, end.yr = NULL,
         sd.disp = FALSE, x.tick.major = 10, x.tick.minor = 5)
```

---

s033 *Tree-ring series Schneetal*

Description

This dataset presents tree-ring series for 20 European beech (*Fagus sylvatica* L.) trees from the forest reserve Schneetal, Bavaria, Germany. Series are averages of two cores.

Usage

```
data(s033)
```

Format

A data.frame containing 20 tree-ring series in columns and 136 years in rows.

References

Principe, A.S., van der Maaten, E., van der Maaten-Theunissen, M., Struwe, T., Wilmking, M. & Kreyling, J. (2017) Low resistance but high resilience in growth of a major deciduous forest tree (*Fagus sylvatica* L.) in response to late spring frost in southern Germany. *Trees*. doi: 10.1007/s00468-016-1505-3.

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