

# Package ‘r3PG’

December 20, 2022

**Type** Package

**Title** Simulating Forest Growth using the 3-PG Model

**Description** Provides a flexible and easy-to-use interface for the Physiological Processes Predicting Growth (3-PG) model written in Fortran. The r3PG serves as a flexible and easy-to-use interface for the 3-PGpjs (monospecific, evenaged and evergreen forests) described in Landsberg & Waring (1997) <doi:10.1016/S0378-1127(97)00026-1> and the 3-PGmix (deciduous, un-even-aged or mixed-species forests) described in Forrester & Tang (2016) <doi:10.1016/j.ecolmodel.2015.07.010>.

**Date** 2021-06-24

**Version** 0.1.4

**License** GPL-3

**Depends** R (>= 3.5.0)

## Imports

**Suggests** knitr (>= 1.15.1),  
rmarkdown (>= 1.3),  
R.rsp (>= 0.40.0),  
testthat (>= 1.0.2),  
roxygen2,  
BayesianTools,  
sensitivity,  
dplyr,  
ggplot2

**VignetteBuilder** R.rsp

**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 7.2.2

**URL** <https://github.com/trotsiuk/r3PG>

**BugReports** <https://github.com/trotsiuk/r3PG/issues>

**Roxygen** list(old\_usage = TRUE)

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C_init	<i>Initializing the steady states of the decomposing pools</i>
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## Description

This function utilizes the steady states solutions for the Q decomposition model to initialize the decomposing pools assuming that the simulation starts at their steady states, which are determined once the Q model parameters are known and we can assume steady inputs. It assumes, with some approximation, as steady inputs of C the average inputs from a whole management cycle.

## Usage

```
C_init(lat, site, species, climate, thinning, parameters, parsQlitter,
       size_dist, settings = list(light_model = 2, transp_model = 2, phys_model =
       2, height_model = 1, correct_bias = 0, calculate_d13c = 0))
```

## Arguments

site	refer to <a href="#">run_3PG</a>
species	refer to <a href="#">run_3PG</a>
climate	refer to <a href="#">run_3PG</a>
thinning	refer to <a href="#">run_3PG</a>

parameters	refer to <a href="#">run_3PG</a>
parsqlitter	refer to <a href="#">run_3PG</a>
size_dist	refer to <a href="#">run_3PG</a>
settings	refer to <a href="#">run_3PG</a>
latitude	self explanatory, it is used to initialize the Q model through the function refer to <a href="#">u0_calc</a>
soil	refer to <a href="#">run_3PG</a>

## Details

the function assumes the management plan from the function [management\\_plan](#), which contains the references for standard Swedish clear-cut forestry practices. The function considers as simulation length the whole cycle indicated by [management\\_plan](#) plus one year, and utilizes the function [extend\\_time](#) to repeat the provided climatic time series over the needed time.

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d_climate	<i>Climate input</i>
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## Description

Table containing the information about monthly values for climatic data.

## Usage

```
d_climate
```

## Format

A data frame with 156 rows and 7 variables:

**year** calendar year

**month** month

**tmp\_min** monthly mean daily minimum temperature (C)

**tmp\_max** monthly mean daily maximum temperature (C)

**tmp\_ave** monthly mean daily average temperature (C). (optional)

**prcp** monthly rainfall (mm month-1)

**srad** monthly mean daily solar radiation (MJ m-2 d-1)

**frost\_days** frost days per month (d month-1)

**co2** monthly mean atmospheric co2 (ppm), required if calculate\_d13c=1 (optional)

**d13catm** Monthly mean isotopic composition of air (‰), required if calculate\_d13c=1 (optional)

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d_parameters	<i>Parameters input</i>
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### Description

Table containing the information about parameters.

### Usage

d\_parameters

### Format

A data frame with 65 rows and x variables:

**parameter** name of the parameter, must be consistent in naming with [i\\_parameters](#)

**Fagus sylvatica** parameter values for species 1

**Pinus sylvestris** parameter values for species 2

---

d_parsQlitter	<i>Q litter Parameters input</i>
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### Description

Table containing the information about parameters.

Table containing the information about the default parameters for the decomposition module (Q)

### Usage

d\_parsQlitter

d\_parsQlitter

### Format

A data frame with 28 rows and x variables:

**parameter** name of the parameter, must be consistent in naming with [i\\_parameters](#)

**Fagus sylvatica** parameter values for species 1

**Pinus sylvestris** parameter values for species 2

A data frame with 28 rows and x variables, each variable being a particular species:

**parameter** name of the parameter, must be consistent in naming with [i\\_parameters](#)

**Fagus sylvatica** parameter values for species 1

**Pinus sylvestris** parameter values for species 2

The parameters the Q model works with are:

$$\beta$$

$$\eta_{11}$$

$$e_0$$

$$f_c$$

$$q_0$$

$$delay$$

$$z$$

and are considered for 4 different cohorts: foliage, roots, branches and stems. A more detailed description is available in the description of the Q model function. Please note that the table columns are representing tree species, and there must be contained at least the same species you are simulating with the 3PG module!

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d_parsQsoc	<i>Parameters input</i>
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## Description

Table containing the information about Q SOC parameters.

## Usage

d\_parsQsoc

## Format

A data frame with 65 rows and x variables:

**parameter** name of the parameter, must be consistent in naming with [i\\_parameters](#)

**value** parameter values

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d_site	<i>Site input</i>
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### Description

Table containing the information about site conditions.

### Usage

d\_site

### Format

A data frame with 1 rows and 8 variables:

**latitude** site latitude in the WGS84 coordinate system

**altitude** site altitude, m a.s.l.

**soil\_class** soil class, according to table 2 user manual of 3PGpjs. 1 - Sandy; 2 - Sandy loam; 3 - Clay loam; 4 - Clay; 0 - No effect of available soil water on production

**asw\_i** initial available soil water (mm)

**asw\_max** minimum available soil water (mm)

**asw\_min** maximum available soil water (mm)

**from** year and month indicating the start of simulation. Provided in form of year-month. E.g. "2000-01"

**to** year and month indicating the end of simulation. Provided in form of year-month. E.g. "2009-12", will include December 2009 as last simulation month

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d_sizeDist	<i>sizeDist input</i>
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### Description

Table containing the information about size distribution.

### Usage

d\_sizeDist

### Format

A data frame with 47 rows and x variables:

**parameter** name of the parameter, must be consistent in naming with [i\\_sizeDist](#)

**Fagus sylvatica** parameter values for species 1

**Pinus sylvestris** parameter values for species 2

---

d_species	<i>Species input</i>
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### Description

Table containing the information about species level data. Each row corresponds to one species/cohort.

### Usage

d\_species

### Format

A data frame with number of rows corresponding to each species/cohort and 8 variables:

**species** species or cohort id/name. It must be consistent with species names in [d\\_thinning](#), [d\\_parameters](#) and [d\\_sizeDist](#) tables.

**planted** year and month indicating when the species was planted. Provided in form of year-month.  
E.g. "2000-01"

**fertility** soil fertility for a given species. Range from 0 to 1

**stems\_n** number of trees per ha

**biom\_stem** stem biomass for a given species (Mg/ha)

**biom\_root** root biomass for a given species (Mg/ha)

**biom\_foliage** initial foliage biomass (Mg/ha). If this is a leafless period, provide the spring foliage biomass.

---

d_thinning	<i>Thinning input</i>
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### Description

Table containing the information about thinnings

### Usage

d\_thinning

### Format

A data frame with 3 rows and 6 variables:

**species** species or cohort id/name. It must be consistent with species names in [d\\_species](#), [d\\_parameters](#) and [d\\_sizeDist](#) tables.

**age** age when thinning is performed

**stems\_n** number of trees remaining after thinning

**stem** type of thinning (above/below). Default is 1

**root** type of thinning (above/below). Default is 1

**foliage** type of thinning (above/below). Default is 1

---

extend_time	<i>This function repeats the climate time series for a specified length of time. It is used for initialization.</i>
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---

### Usage

```
extend_time(climate, from, length)
```

### Arguments

climate	the original climatic time series.
from	the start date of the desired new time series
length	length in years of the desired new time series.

---

i_output	<i>Information about model outputs</i>
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### Description

A dataset containing the list of output variables and their description.

### Usage

```
i_output
```

### Format

A data frame with 150 rows and 7 variables:

**group\_id** serial number of the group

**variable\_id** serial number of the variable

**variable\_group** group name to which variable belongs

**variable\_name** variable name as named in output

**description** description of the variable

**unit** unit of the variable

**variable\_vba** corresponding name of the variable as output from Excel version of 3-PGmix



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i_parameters	<i>Information about parameters</i>
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**Description**

A dataset containing the parameters order and description.

**Usage**

i\_parameters

**Format**

A data frame with 82 rows and 3 variables:

**parameter** parameter name

**description** description of the parameter

**unit** unit

**default** default value for E.globulus from original 3-PG

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i_parsQlitter	<i>Information about Q litter parameters</i>
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---

**Description**

A dataset containing the parameters order and description for Q litter.

**Usage**

i\_parsQlitter

**Format**

A data frame with 28 rows and 3 variables:

**parameter** parameter name

**description** description of the parameter

**unit** unit

**default** default value for E.globulus from original 3-PG

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i\_parsQsoc

*Information about Q SOC parameters*


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### Description

A dataset containing the parameters order and description for Q SOC.

### Usage

i\_parsQsoc

### Format

A data frame with 6 rows and 3 variables:

**parameter** parameter name

**description** description of the parameter

**unit** unit

**default** default value for E.globulus from original 3-PG

---

i\_sizeDist

*Information about size distribution parameters*


---

### Description

A dataset containing the parameters order and description.

### Usage

i\_sizeDist

### Format

A data frame with 30 rows and 3 variables:

**parameter** parameter name

**description** description of the parameter

**unit** unit

**default** default value equal to 0

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management_plan	<i>The function for determining the appropriate management plan.</i>
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### Description

The management.plan functions contains a series of vectors with management data from Sweden. It selects the most appropriate values based on site index and latitude, and determines the values for the management plan.

### Usage

```
management_plan(SI, Lat)
```

### Arguments

SI	The site index.
Lat	The latitude of the simulated site.

### Value

a data frame with :

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prepare_climate	<i>Subsets or replicate a climate data</i>
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---

### Description

Prepares the climate table, by either replicating the average climate for the required number of years, or by subsetting from a longer time-series of climate data.

### Usage

```
prepare_climate(climate, from = "2000-04", to = "2010-11")
```

### Arguments

climate	<p>table containing the information about monthly values for climatic data. If the climate table have exactly 12 rows it will be replicated for the number of years and months specified by from - to. Otherwise, it will be subsetting to the selected time period. If this is required, year and month columns must be included in the climate table. The minimum required columns are listed below, but additionally you can include: tmp_ave, c02, d13catm. Please refer to <a href="#">d_climate</a> for example.</p> <ul style="list-style-type: none"> <li>• year: year of observation (only required for subsetting) (numeric).</li> <li>• month: months of observation (only required for subsetting) (numeric).</li> <li>• tmp_min: monthly mean daily minimum temperature (C).</li> <li>• tmp_max: monthly mean daily maximum temperature (C).</li> <li>• tmp_ave: monthly mean daily average temperature (C) (optional).</li> </ul>
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- prcp: monthly rainfall (mm month-1).
  - srad: monthly mean daily solar radiation (MJ m-2 d-1).
  - frost\_days: frost days per month (d month-1).
  - co2: monthly mean atmospheric co2 (ppm), required if calculate\_d13c=1 (optional).
  - d13catm: monthly mean isotopic composition of air (‰), required if calculate\_d13c=1 (optional).
- from year and month indicating the start of simulation. Provided in form of year-month. E.g. "2000-01".
- to year and month indicating the end of simulation. Provided in form of year-month. E.g. "2009-12", will include December 2009 as last simulation month.

### Details

This function prepares the climate table for [run\\_3PG](#).

In case a user provides only average climate, this is replicated for the desired simulation period.

In case a larger climate file is provided, the simulation period is selected from this.

### Value

a data.frame with number of rows corresponding to number of simulated month and 10 columns

### See Also

[run\\_3PG](#), [prepare\\_input](#), [prepare\\_parameters](#), [prepare\\_sizeDist](#), [prepare\\_thinning](#)

### Examples

```
# subsetting climate data
prepare_climate( climate = d_climate, from = '2003-04', to = '2010-11')

# replicating climate data
climate = matrix(rnorm(60), ncol = 5)
colnames(climate) = c("tmp_min", "tmp_max", "prcp", "srad", "frost_days")

prepare_climate( climate = climate, from = '2000-04', to = '2010-11')
```

---

```
prepare_input
```

---

*Check and prepare input for running 3-PG model*

---

### Description

Checks and prepares all input tables to be used in [run\\_3PG](#). For detailed descriptions see Forrester (2020).

### Usage

```
prepare_input(site, species, climate, thinning = NULL, parameters = NULL,
  size_dist = NULL, settings = NULL, parsQlitter = NULL,
  parsQsoc = NULL)
```

**Arguments**

site	<p>table containing the information about site conditions.</p> <ul style="list-style-type: none"> <li>• latitude: site latitude in the WGS84 coordinate system.</li> <li>• altitude: site altitude, m a.s.l.</li> <li>• soil_class: 1 - Sandy; 2 - Sandy loam; 3 - Clay loam; 4 - Clay; 0 - No effect of asw on production.</li> <li>• asw_i: initial available soil water (mm).</li> <li>• asw_min: minimum available soil water (mm).</li> <li>• asw_max: maximum available soil water (mm).</li> <li>• from: year and month indicating the start of simulation. Provided in form of year-month. E.g. "2000-01".</li> <li>• to: year and month indicating the end of simulation. Provided in form of year-month. E.g. "2009-12", will include December 2009 as last simulation month</li> </ul>
species	<p>table containing the information about species level data. Each row corresponds to one species/cohort.</p> <ul style="list-style-type: none"> <li>• species: species or cohort id/name. It must be consistent with species names in thinning, parameters and sizeDist tables.</li> <li>• planted: year and month indicating when species was planted. Provided in form of year-month. E.g. "2000-01".</li> <li>• fertility: soil fertility for a given species. Range from 0 to 1.</li> <li>• stems_n: number of trees per ha.</li> <li>• biom_stem: stem biomass for a given species (Mg/ha).</li> <li>• biom_root: root biomass for a given species (Mg/ha).</li> <li>• biom_foliage: initial foliage biomass (Mg/ha). If this is a leafless period, provide the spring foliage biomass.</li> </ul>
climate	<p>table containing the information about monthly values for climatic data. If the climate table has exactly 12 rows it will be replicated for the number of years and months specified by from - to. Otherwise, it will be subsetted to the selected time period. More details about preparing climate data are at <a href="#">prepare_climate</a>.</p> <ul style="list-style-type: none"> <li>• year: year of observation (only required for subsetting) (optional).</li> <li>• month: months of observation (only required for subsetting) (optional).</li> <li>• tmp_min: monthly mean daily minimum temperature (C).</li> <li>• tmp_max: monthly mean daily maximum temperature (C).</li> <li>• tmp_ave: monthly mean daily average temperature (C) (optional).</li> <li>• prcp: monthly rainfall (mm month<sup>-1</sup>).</li> <li>• srad: monthly mean daily solar radiation (MJ m<sup>-2</sup> d<sup>-1</sup>).</li> <li>• frost_days: frost days per month (d month<sup>-1</sup>).</li> <li>• vpd_day: frost days per month (mbar) (optional).</li> <li>• co2: monthly mean atmospheric co2 (ppm), required if calculate_d13c=1 (optional)</li> <li>• d13catm: monthly mean isotopic composition of air (‰), required if calculate_d13c=1 (optional)</li> </ul>
thinning	<p>table containing the information about thinnings. If there is no thinning, it must be NULL.</p> <ul style="list-style-type: none"> <li>• species: species or cohort id/name. It must be consistent with species names in species, parameters and sizeDist tables.</li> </ul>

	<ul style="list-style-type: none"> <li>• age: age when thinning is performed.</li> <li>• stems_n: number of trees remaining after thinning</li> <li>• foliage: type of thinning (above/below). Default is 1.</li> <li>• root: type of thinning (above/below). Default is 1.</li> <li>• stem: type of thinning (above/below). Default is 1.</li> </ul>
parameters	<p>table containing the information about parameters to be modified. Values that are not provided are replaced by defaults.</p> <ul style="list-style-type: none"> <li>• parameter: name of the parameter, must be consistent in naming with <code>i_parameters</code></li> <li>• species: each column must correspond to species/cohort id/name, as defined in species table</li> </ul>
size_dist	<p>table containing the information about size distribution to be modified. Values that are not provided are replaced by defaults.</p> <ul style="list-style-type: none"> <li>• parameter: name of the parameter, must be consistent in naming with <code>i_sizeDist</code></li> <li>• species: each column must correspond to species/cohort id/name, as defined in species table</li> </ul>
settings	<p>a list with settings for the model. Values that are not provided are replaced by defaults.</p> <ul style="list-style-type: none"> <li>• light_model: '1' - 3-PGpjs (default); '2' - 3-PGmix</li> <li>• transp_model: '1' - 3-PGpjs (default); '2' - 3-PGmix</li> <li>• phys_model: '1' - 3-PGpjs (default); '2' - 3-PGmix</li> <li>• height_model: '1' - linear (default); '2' - non-linear</li> <li>• correct_bias: '0' - no (default); '1' - yes</li> <li>• calculate_d13c: '0' - no (default); '1' - yes</li> </ul>
parsQlitter	<p>table containing the information about Q litter parameters to be modified. Values that are not provided are replaced by defaults.</p> <ul style="list-style-type: none"> <li>• parameter: name of the parameter, must be consistent in naming with <code>i_parsQlitter</code></li> <li>• species: each column must correspond to species/cohort id/name, as defined in species table</li> </ul>
parsQsoc	<p>table containing the information about Q soc parameters to be modified. Values that are not provided are replaced by defaults.</p> <ul style="list-style-type: none"> <li>• parameter: name of the parameter, must be consistent in naming with <code>i_parsQsoc</code></li> </ul>

## Details

This function checks and prepares the input data for the `run_3PG`. The output is a list with 7 tables. Each of them corresponds to the one from input.

## Value

a list with seven tables. Each table corresponds to one of the input tables.

## References

Forrester, D. I., 2020. 3-PG User Manual. Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, Switzerland. 70 p. Available at the following web site: <http://sites.google.com/site/davidforresterssite/home/projects/3PGmix/3pgmixdownload>

Sands, P. J., 2010. 3PGpjs user manual. Available at the following web site: [http://3pg.sites.olt.ubc.ca/files/2014/04/3PGpjs\\_UserManual.pdf](http://3pg.sites.olt.ubc.ca/files/2014/04/3PGpjs_UserManual.pdf)

**See Also**

[run\\_3PG](#), [prepare\\_parameters](#), [prepare\\_sizeDist](#), [prepare\\_thinning](#), [prepare\\_climate](#)

**Examples**

```
prepare_input( site = d_site, species = d_species, climate = d_climate, d_thinning)
```

---

prepare_parameters	<i>Prepare parameters table</i>
--------------------	---------------------------------

---

**Description**

Prepares the parameters table, by either replicating the defaults or replicating defaults for each of the species.

**Usage**

```
prepare_parameters(parameters = NULL, sp_names = c("Fagus sylvatica",
"Pinus sylvestris"))
```

**Arguments**

parameters	table containing the information about parameters to be modified. Values that are not provided are replaced by defaults. <ul style="list-style-type: none"> <li>parameter: name of the parameter, must be consistent in naming with <a href="#">i_parameters</a></li> <li>species: each column must correspond to species/cohort id/name, as defined in species table</li> </ul>
sp_names	names of the species / cohorts used for the simulations. The 'sp_names' must be identical to those from species table.

**Details**

This function prepares the parameter table for [run\\_3PG](#)

**Value**

a data.frame with 47 rows and columns corresponding to each species.

**See Also**

[run\\_3PG](#), [prepare\\_input](#), [prepare\\_sizeDist](#), [prepare\\_thinning](#), [prepare\\_climate](#)

**Examples**

```
# replace some
prepare_parameters( parameters = d_parameters[1:4,],
  sp_names = c('Fagus sylvatica', 'Pinus sylvestris' ))

# Make default
prepare_parameters( parameters = NULL, sp_names = c('Quercus', 'Abies'))
```

---

```
prepare_parsQlitter
```

*Prepare Q parameters Litter table*

---

## Description

Prepares the litter parameters table used in Q, by either replicating the defaults or replicating defaults for each of the species.

## Usage

```
prepare_parsQlitter(parameters = NULL, sp_names = c("Fagus sylvatica",
  "Pinus sylvestris"))
```

## Arguments

parameters	table containing the information about parameters to be modified. Values that are not provided are replaced by defaults. <ul style="list-style-type: none"> <li>parameter: name of the parameter, must be consistent in naming with <a href="#">i_parsQlitter</a></li> <li>species: each column must correspond to species/cohort id/name, as defined in species table</li> </ul>
sp_names	names of the species / cohorts used for the simulations. The 'sp_names' must be identical to those from species table.

## Details

This function prepares the parameter table for [run\\_3PG](#)

## Value

a data.frame with 47 rows and columns corresponding to each species.

## See Also

[run\\_3PG](#), [prepare\\_input](#), [prepare\\_sizeDist](#), [prepare\\_thinning](#), [prepare\\_climate](#)

## Examples

```
# replace some
prepare_parameters( parameters = d_parameters[1:4,],
  sp_names = c('Fagus sylvatica', 'Pinus sylvestris' ))

# Make default
prepare_parameters( parameters = NULL, sp_names = c('Quercus', 'Abies'))
```



---

prepare_parsQsoc	<i>Prepare Q parameters Litter table</i>
------------------	--

---

## Description

Prepares the soc parameters table used in Q, by either replicating the defaults or replicating defaults.

## Usage

```
prepare_parsQsoc(parameters = NULL)
```

## Arguments

parameters	table containing the information about parameters to be modified. Values that are not provided are replaced by defaults. <ul style="list-style-type: none"> <li>parameter: name of the parameter, must be consistent in naming with <a href="#">i_parsQsoc</a></li> <li>species: each column must correspond to species/cohort id/name, as defined in species table</li> </ul>
sp_names	names of the species / cohorts used for the simulations. The 'sp_names' must be identical to those from species table.

## Details

This function prepares the parameter table for [run\\_3PG](#)

## Value

a data.frame with 47 rows and columns corresponding to each species.

## See Also

[run\\_3PG](#), [prepare\\_input](#), [prepare\\_sizeDist](#), [prepare\\_thinning](#), [prepare\\_climate](#)

## Examples

```
# replace some
prepare_parameters( parameters = d_parameters[1:4,],
  sp_names = c('Fagus sylvatica', 'Pinus sylvestris' ))

# Make default
prepare_parameters( parameters = NULL, sp_names = c('Quercus', 'Abies'))
```

---

prepare_sizeDist	<i>Prepare parameters table</i>
------------------	---------------------------------

---

## Description

Prepares the parameters table, by either replicating the defaults or replicating defaults for each of the species.

## Usage

```
prepare_sizeDist(size_dist = NULL, sp_names = c("Fagus sylvatica",
  "Pinus sylvestris"))
```

## Arguments

size_dist	table containing the information about size distribution to be modified. Values that are not provided are replaced by defaults. <ul style="list-style-type: none"> <li>parameter: name of the parameter, must be consistent in naming with <a href="#">i_sizeDist</a>.</li> <li>species: each column must correspond to species/cohort id/name, as defined in species table.</li> </ul>
sp_names	names of the species / cohorts used for the simulations. The 'sp_names' must be identical to those from species table.

## Details

This function prepares the parameter table for [run\\_3PG](#).

## Value

a data.frame with 47 rows and columns corresponding to each species.

## See Also

[run\\_3PG](#), [prepare\\_input](#), [prepare\\_parameters](#), [prepare\\_thinning](#), [prepare\\_climate](#)

## Examples

```
# replace some
prepare_sizeDist( size_dist = d_sizeDist[1:4,],
  sp_names = c('Fagus sylvatica', 'Pinus sylvestris' ))

# Make default
prepare_sizeDist( size_dist = NULL, sp_names = c('Quercus', 'Abies'))
```

---

prepare_thinning	<i>Check and prepare management information.</i>
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---

## Description

Prepares the management table and checks for consistency.

## Usage

```
prepare_thinning(thinning = NULL, sp_names = c("Fagus sylvatica",
"Pinus sylvestris"))
```

## Arguments

thinning	table containing the information about thinnings. If there is no thinning, it must be NULL. The following columns are required: <ul style="list-style-type: none"> <li>• species: species or cohort id/name.</li> <li>• age: age at which thinning is done.</li> <li>• stems_n: number of trees remaining after thinning</li> <li>• stem: type of thinning (above/below). Default is 1.</li> <li>• foliage: type of thinning (above/below). Default is 1.</li> <li>• root: type of thinning (above/below). Default is 1.</li> </ul>
sp_names	names of the species / cohorts used for the simulations. This is required whether ‘thinning=NULL’ or if not all species are indicated in the ‘thinning’ table. The ‘sp_names’ must be identical to those from species table.

## Details

This function prepares the thinning table for [run\\_3PG](#).

In case there is no thinning it will return empty 3-d array.

In case there will be thinning it will return 3-d array, where one dimension correspond to each species.

## Value

a 3-dimentional array, where third dimention correspond to each species.

## See Also

[run\\_3PG](#), [prepare\\_input](#), [prepare\\_parameters](#), [prepare\\_sizeDist](#), [prepare\\_climate](#)

## Examples

```
prepare_thinning( thinning = NULL, sp_names = c('Quercus', 'Abies'))

prepare_thinning( thinning = d_thinning, sp_names = c('Fagus sylvatica', 'Pinus sylvestris'))
```

---

Q <sub>dec</sub>	<i>Q decomposition function</i>
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---

### Description

A new implementation of the Q model included in this package. This implementation is derived from Menichetti et al. (2021)

### Usage

```
Q_dec(inputs = inputs, fc, beta, e0, eta_11, u0, q0, delay, tmax, nSim)
```

### Arguments

inputs	the C inputs for the simulated cohorts
fc	the C ratio of the input material
e0	the efficiency of the microbial biomass
u0	the growth rate of the microbial biomass
q0	the initial quality of the C inputs coming to the cohort
delay	the C inputs for the simulated cohorts
tmax	the maximum diameter of the material particles or residuals
nSim	time steps of the simulation

### Details

this function is just a demo version of what was then implemented in the FORTRAN code run by the wrapper [run\\_3PG](#), and its purpose is to simulate the decomposition of the outputs from the growth module 3PG.

### References

Menichetti, L., Mäkinen, H., Stendahl, J., Ågren, G.I., Hyvönen, R., 2021. Modeling persistence of coarse woody debris residuals in boreal forests as an ecological property. *Ecosphere* 12. <https://doi.org/10.1002/ecs2.3792>

---

Q <sub>ss</sub>	<i>Steady state solution to the Q decomposition function</i>
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---

### Usage

```
Q_ss(fc, inputs, e0, eta11, b, u0, q0, Tmax)
```

## Arguments

fc	the C ratio of the input material
inputs	the C inputs for the simulated cohorts
e0	the efficiency of the microbial biomass
u0	the growth rate of the microbial biomass
q0	the initial quality of the C inputs coming to the cohort
tmax	the maximum diameter of the material particles or residuals

## Details

The function is used to initialize the decomposing pools in the C stocks simulation

## References

Menichetti, L., Mäkinen, H., Stendahl, J., Ågren, G.I., Hyvönen, R., 2021. Modeling persistence of coarse woody debris residuals in boreal forests as an ecological property. *Ecosphere* 12. <https://doi.org/10.1002/ecs2.3792>

---

r3PG	<i>Simulating Forest Growth using the 3-PG Process-Based Vegetation Model</i>
------	---

---

## Description

The r3PG package provides a flexible and easy-to-use interface for Fortran implementations of the 3-PGpjs (monospecific, evenaged and evergreen forests) or 3-PGmix (deciduous, uneven-aged or mixed-species forests) forest growth models. The user can flexibly switch between various options and submodules, to use the original 3-PGpjs model version for monospecific, even-aged and evergreen forests and the 3-PGmix model, which can also simulate multi-cohort stands (e.g. mixtures, uneven-aged) that contain deciduous species. The core function to run the model is [run\\_3PG](#). For more background, please consult the vignette via `vignette(package = "r3PG")`

## Value

None

## References

Forrester, D. I., 2020. 3-PG User Manual. Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, Switzerland. 70 p. Available at the following web site: <http://sites.google.com/site/davidforrester/site/home/projects/3PGmix/3pgmixdownload>

Forrester, D. I., & Tang, X. (2016). Analysing the spatial and temporal dynamics of species interactions in mixed-species forests and the effects of stand density using the 3-PG model. *Ecological Modelling*, 319, 233–254. doi: [10.1016/j.ecolmodel.2015.07.010](https://doi.org/10.1016/j.ecolmodel.2015.07.010)

Landsberg, J. J., & Waring, R. H., 1997. A generalised model of forest productivity using simplified concepts of radiation-use efficiency, carbon balance and partitioning. *Forest Ecology and Management*, 95(3), 209–228. doi: [10.1016/S03781127\(97\)000261](https://doi.org/10.1016/S03781127(97)000261)

Sands, P. J., 2010. 3PGpjs user manual. Available at the following web site: [http://3pg.sites.olt.ubc.ca/files/2014/04/3PGpjs\\_UserManual.pdf](http://3pg.sites.olt.ubc.ca/files/2014/04/3PGpjs_UserManual.pdf)

See Also

[run\\_3PG](#)

Examples

```
out <- run_3PG(
  site = d_site,
  species = d_species,
  climate = d_climate,
  thinning = d_thinning,
  parameters = d_parameters,
  size_dist = d_sizeDist,
  parsQlitter = NULL,
  settings = list(light_model = 2, transp_model = 2, phys_model = 2,
    correct_bias = 1, calculate_d13c = 0),
  check_input = TRUE, df_out = TRUE) # note that default is TRUE

str(out) # List output format
```

---

run_3PG	<i>Runs a 3-PG model simulation</i>
---------	-------------------------------------

---

Description

Runs the 3-PGpjs (monospecific, evenaged and evergreen forests) or 3-PGmix (deciduous, uneven-aged or mixed-species forests) model. For more details on parameters and structure of input visit [prepare\\_input](#).

Usage

```
run_3PG(site, species, climate, soil = NULL, thinning = NULL,
  parameters = NULL, size_dist = NULL, parsQlitter = NULL,
  parsQsoc = NULL, settings = NULL, check_input = TRUE, df_out = TRUE)
```

Arguments

site	table as described in <a href="#">prepare_input</a> containing the information about site conditions.
species	table as described in <a href="#">prepare_input</a> containing the information about species level data. Each row corresponds to one species/cohort.
climate	table as described in <a href="#">prepare_input</a> containing the information about monthly values for climatic data. See also <a href="#">prepare_climate</a>
soil	table containing the information about the decomposing C pools initialization
thinning	table as described in <a href="#">prepare_input</a> containing the information about thinning. See also <a href="#">prepare_thinning</a>
parameters	table as described in <a href="#">prepare_input</a> containing the information about parameters to be modified. See also <a href="#">prepare_parameters</a>
size_dist	table as described in <a href="#">prepare_input</a> containing the information about size distributions. See also <a href="#">prepare_sizeDist</a>

parsQlitter	table as described in <a href="#">prepare_input</a> containing the information about parameters to be modified. See also <a href="#">prepare_parsQlitter</a>
parsQsoc	table as described in <a href="#">prepare_input</a> containing the information about parameters to be modified. See also <a href="#">prepare_parsQsoc</a>
settings	a list as described in <a href="#">prepare_input</a> with settings for the model.
check_input	logical if the input shall be checked for consistency. It will call <a href="#">prepare_input</a> function.
df_out	logical if the output shall be long data.frame (TRUE) the 4-dimensional array (FALSE).

## Details

‘r3PG’ provides an implementation of the Physiological Processes Predicting Growth **3-PG** model, which simulates forest growth and productivity. The ‘r3PG’ serves as a flexible and easy-to-use interface for the ‘3-PGpjs’ (monospecific, evenaged and evergreen forests) and the ‘3-PGmix’ (deciduous, uneven-aged or mixed-species forests) model written in ‘Fortran’. The package, allows for fast and easy interaction with the model, and ‘Fortran’ re-implementation facilitates computationally intensive sensitivity analysis and calibration. The user can flexibly switch between various options and submodules, to use the original ‘3-PGpjs’ model version for monospecific, even-aged and evergreen forests and the ‘3-PGmix’ model, which can also simulate multi-cohort stands (e.g. mixtures, uneven-aged) that contain deciduous species.

This implementation of 3-PG includes several major variants / modifications of the model in particular the ability to switch between 3-PGpjs (the more classic model version for monospecific stands) vs. 3-PGmix (a version for mixed stands), as well as options for bias corrections and  $\delta^{13}C$  calculations (see parameters).

Another addition is the implementation of the decomposition function from the Q model, as defined in Menichetti et al. (2021). Briefly, the Q model is a first-order decomposition kinetic based on a generalization of the compartmental model theory, where the decomposing organic material is represented, instead of as a set of different "pools" each with a distinct decomposition kinetic from the fastest to the slowest, with a continuous distribution of a quality term (which is the reciprocal of recalcitrance). The decomposition model is here implemented in a module receiving material from the 3PG simulated tree growth, and in particular to represent the four different cohorts simulated by 3PG: leaves, branches, stems and roots. The decomposition module kinetics are modified (in the term  $u_o$ ) by climate, which in this version is calculated based on latitude with a simple empirical relationship.

$$u0 = (0.0855 + 0.0157 \cdot (50.6 - 0.768 \cdot latitude))$$

For a more detailed description of the module look into the documentation of its demo version [Q\\_dec](#).

## Value

either a 4-dimensional array or a data.frame, depending on the parameter df\_out. More details on the output is [i\\_output](#)

## Note

The run\_3PG also checks the quality of input data. When names, or structures are not consistent with requirements it will return an error. Turn this off to optimize for speed. The parameter table must have the same order than the example in this package.

## References

- Forrester, D. I., 2020. 3-PG User Manual. Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, Switzerland. 70 p. Available at the following web site: <http://sites.google.com/site/davidforrester/site/home/projects/3PGmix/3pgmixdownload>
- Forrester, D. I., & Tang, X. (2016). Analysing the spatial and temporal dynamics of species interactions in mixed-species forests and the effects of stand density using the 3-PG model. *Ecological Modelling*, 319, 233–254. doi: [10.1016/j.ecolmodel.2015.07.010](https://doi.org/10.1016/j.ecolmodel.2015.07.010)
- Landsberg, J. J., & Waring, R. H., 1997. A generalised model of forest productivity using simplified concepts of radiation-use efficiency, carbon balance and partitioning. *Forest Ecology and Management*, 95(3), 209–228. doi: [10.1016/S03781127\(97\)000261](https://doi.org/10.1016/S03781127(97)000261)
- Sands, P. J., 2010. 3PGjs user manual. Available at the following web site: [http://3pg.sites.olt.ubc.ca/files/2014/04/3PGjs\\_UserManual.pdf](http://3pg.sites.olt.ubc.ca/files/2014/04/3PGjs_UserManual.pdf)
- Menichetti, L., Mäkinen, H., Stendahl, J., Ågren, G.I., Hyvönen, R., 2021. Modeling persistence of coarse woody debris residuals in boreal forests as an ecological property. *Ecosphere* 12. <https://doi.org/10.1002/ecs2.3792>

## See Also

[prepare\\_input](#), [prepare\\_parameters](#), [prepare\\_sizeDist](#), [prepare\\_thinning](#), [prepare\\_climate](#)

## Examples

```
out <- run_3PG(
  site = d_site,
  species = d_species,
  climate = d_climate,
  thinning = d_thinning,
  parameters = d_parameters,
  size_dist = d_sizeDist,
  parsQlitter = NULL,
  settings = list(light_model = 2, transp_model = 2, phys_model = 2,
    correct_bias = 1, calculate_d13c = 0),
  check_input = TRUE, df_out = TRUE) # note that default is TRUE

str(out) # List output format
```

---

u0\_calc

*Scaling of the microbial activity term*

---

## Usage

```
u0_calc(latitude)
```

## Arguments

lat                      latitude, self explanatory

## Details

The function is used to rescale the microbial activity (and therefore the kinetic of decomposition) based on latitude



**References**

Menichetti, L., Mäkinen, H., Stendahl, J., Ågren, G.I., Hyvönen, R., 2021. Modeling persistence of coarse woody debris residuals in boreal forests as an ecological property. *Ecosphere* 12. <https://doi.org/10.1002/ecs2.3792>

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