

Package ‘Rquefts’

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Title Quantitative Evaluation of the Native Fertility of Tropical Soils

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SystemRequirements C++11

Imports meteor, methods, Rcpp (>= 0.12.4)

Suggests terra, limSolve

Description An implementation of the QUEFTS (Quantitative Evaluation of the Native Fertility of Tropical Soils) model. The model (1) estimates native nutrient (N, P, K) supply of soils from a few soil chemical properties; and (2) computes crop yield given that supply, crop parameters, fertilizer application, and crop attainable yield. See Janssen et al. (1990) <[doi:10.1016/0016-7061\(90\)90021-Z](https://doi.org/10.1016/0016-7061(90)90021-Z)> for the technical details and Sattari et al. (2014) <[doi:10.1016/j.fcr.2013.12.005](https://doi.org/10.1016/j.fcr.2013.12.005)> for a recent evaluation and improvements.

License GPL (>= 3)

BugReports <https://github.com/cropmodels/Rquefts/issues>

URL <https://CRAN.R-project.org/package=Rquefts>

NeedsCompilation yes

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Rquefts-package	<i>Quantitative Evaluation of the Native Fertility of Tropical Soils</i>
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Description

This package provides implements the QUEFTS model.

QUEFTS (Quantitative Evaluation of the Native Fertility of Tropical Soils) model (1) estimates native nutrient (N, P, K) supply of soils from a few soil chemical properties; and (2) computes crop yield given that supply, fertilizer application and crop parameters. See Janssen et al. (1990) <doi:10.1016/0016-7061(90)90021-Z> for the technical details and Sattari et al. (2014) <doi:10.1016/j.fcr.2013.12.005> for a recent evaluation and improvements.

The package is particularly useful if you want to make spatial predictions with QUEFTS.

There are also a few functions that can help with computing the amount of nutrients supplied with fertilizer (blends) and compute the optimal use of fertilizer given a goal in nutrients, available products, and their prices.

fertApp	<i>Optimal fertilizer application</i>
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Description

Compute the optimal fertilizer application rates given a target nutrient application and the available products (fertilizer blends) and their prices.

Usage

```
fertApp(nutrients, fertilizers, price, exact=TRUE, retCost=FALSE)
```

Arguments

nutrients	data.frame with columns "N", "P", "K" in kg (per unit area)
fertilizers	data.frame with fertilizer products (see examples)
price	numeric. Vector with fertilizer product prices. Should have length of nrow(fertilizers)
exact	logical. If FALSE the cheapest solution is returned that includes at least as much of each nutrient as desired, but possibly more, if that is cheaper than the exact solution; or when there is no exact solution
retCost	logical. If FALSE the optimal solution is returned (the amounts of fertilizers). If TRUE, the price of the optimal solution is returned

Examples

```
# fertilizer product list
fert <- fertilizers()
# shortening some of the names for display
fert[,2] = substr(fert[,2], 1, 20)
# contents are expressed as a percentage.
ferts <- fert[c(8,15:17), 2:5]
ferts

x <- fertApp(data.frame(N=100, P=50, K=50), ferts, c(1, 1.5, 1.25, 1))
# show that it is correct
nutrientRates(ferts, x[,2])

fertApp(data.frame(N=seq(0,200,50), P=50, K=50), ferts, c(1, 1.5, 1.25, 0.75))
fertApp(data.frame(N=seq(0,200,50), P=50), ferts[,-3], c(1, 1.5, 1.25, 0.75))
fertApp(data.frame(N=seq(0,200,50), P=50), ferts[,-3], c(1, 1.5, 1.25, 5.75))
```

Fertilizers

Helper functions to go from fertilizers to nutrients

Description

Computes the amount of nutrients given a rate of fertilizer.

Usage

```
fertilizers()
nutrientRates(supply, treatment)
```

Arguments

supply	data.frame with columns "N", "P", "K" expressed as percentage of the product (row)
treatment	amounts applied

Examples

```
# fertilizer product list
fert <- fertilizers()
# shortening some of the names for display
fert[,2] = substr(fert[,2], 1, 20)
# contents are expressed as a percentage.
fert

myferts <- fert[c(8,15), ]
nutrientRates(myferts, c(100,50))
```

nutSupply

Soil nutrients supply for QUEFTS model

Description

nutSupply1 computes the base (unfertilized) soil supply of N, P and K according to Janssen et al. (1990), Table 2. For use with the QUEFTS model.

nutSupply2 is a modified version following Sattari et al. (2014). It has an additional variable "temperature", and P-total is required. Sattari et al suggest that, for soils that have not been fertilized with P, you can estimate P-total as $95 * P\text{-Olsen}$. Using AfSIS data I found $55 * P\text{-Olsen}$.

Usage

```
nutSupply1(pH, SOC, Kex, Polsen, Ptotal=NA)
nutSupply2(temp, pH, SOC, Kex, Polsen, Ptotal)
```

Arguments

temp	average growing season temperature (C)
pH	soil pH (H2O)
SOC	soil organic carbon (g/kg)
Kex	exchangeable K in the soil (mmol/kg)
Polisen	soil P measured with the P-Olsen method (mg/kg)
Ptotal	total soil P (mg/kg)

Value

Matrix with three columns: Nsup, Psup and Ksup. These are the potential supply of N, P and K of the unfertilized soil (kg/ha).

References

Janssen B.H., F.C.T. Guiking, D. van der Eijk, E.M.A. Smaling, J. Wolf and H. van Reuler, 1990. A system for the quantitative evaluation of the fertility of tropical soils (QUEFTS). *Geoderma* 46: 299-318

Sattari, S.Z., M.K. van Ittersum, A.F. Bouwman, A.L. Smit, and B.H. Janssen, 2014. Crop yield response to soil fertility and N, P, K inputs in different environments: Testing and improving the QUEFTS model. *Field Crops Research* 157: 35-46

Examples

```
s1 <- nutSupply1(6, c(23, 11, 35), 15, c(1.6, 2.6, 2.4))
s1
s2 <- nutSupply2(20, 6, c(23, 11, 35), 15, c(1.6, 2.6, 2.4), 225)
s2
```

predict

Spatial QUEFTS model predictions

Description

Make spatial predictions with a QUEFTS model. First create a model, then use the model with a `SpatRaster` of soil properties to make spatial predictions.

Usage

```
## S4 method for signature 'Rcpp_QueftsModel'
predict(object, supply, yatt, var="yield", filename="", overwrite=FALSE, ...)
```

Arguments

<code>object</code>	<code>QUEFTSModel</code>
<code>supply</code>	<code>SpatRaster</code> with nutrient supply data (Ns, Ps, Ks)
<code>yatt</code>	<code>SpatRaster</code> with attainable yield
<code>var</code>	character. Output variable name. Either "yield" or "gap"
<code>filename</code>	character. Output filename. Optional
<code>overwrite</code>	logical. If TRUE, filename is overwritten
<code>...</code>	list. Options for writing files as in <code>writeRaster</code>

Value

`SpatRaster`

Examples

```

library(Rquefts)
library(terra)

ff <- list.files(system.file("sp", package="Rquefts"), full.names=TRUE)
r <- rast(ff)

soil <- r[[c("Tavg", "pH", "SOC", "Kex", "Pex", "Ptot")]]
supply <- lapp(soil, nutSupply2)
plot(supply)

yatt <- rast(system.file("sp/Ya.tif", package="Rquefts"))

maize <- quefts_crop("Maize")
fertilizer <- list(N=0, P=0, K=0)
q <- quefts(crop=maize, fert=fertilizer)

p <- predict(q, supply, yatt)
plot(p)

g <- predict(q, supply, yatt, "gap")
plot(g)

```

quefts

QUEFTS model

Description

Create a QUEFTS model, set parameters, and run it to compute nutrient requirements and nutrient limited yield.

A number of default crop parameter sets are provided, as well as one example soil. You need to provide attainable crop production (in this context that is the maximum production in the absence of nutrient limitation), or target dry-matter biomass for leaves, stems and the storage organ (e.g. grain, root or tuber). Some crops are grown for the stems/leaves, in which case there is no relevant storage organ (e.g. sugarcane, jute). production yield estimates can be obtained with a crop growth model.

For a cereal crop you can assume that 50

Usage

```

quefts(soil, crop, fert, biom)
quefts_soil()
quefts_fert()
quefts_crop(name="")
quefts_biom()
crop(x) <- value
soil(x) <- value

```

```
fert(x) <- value
biom(x) <- value
run(x, ...)
```

Arguments

soil	list with named soil parameters. See Details. An example is returned by quefts_soil()
crop	list with named crop parameters. See Details. An example is returned by quefts_crop()
fert	list with named fertilizer parameters (N, P and K). An example is returned by quefts_fert()
biom	list with named biomass and growing season length parameters. An example is returned by quefts_biom()
name	character. crop name
x	QueftsModel object
value	list with soil, crop, fertilizer, or biomass parameters as above
...	additional arguments. None implemented

Details

Input Parameters

Soil

N_base_supply, P_base_supply, K_base_supply
 N_recovery, P_recovery, K_recovery
 UptakeAdjust

Crop

_minVeg, _maxVeg, _minStore, _maxStore
 Yzero
 Nfix

Management

N, P, K

Crop yield

leaf_att, stem_att, store_att
 SeasonLength

.

.

Output Variables

N_actual_supply, P_actual_supply, K_actual_supply
 leaf_lim, stem_lim, store_lim
 N_gap, P_gap, K_gap

Explanation

.

Potential supply (kg/ha) of N, P and K of the (unfertilized) soil.
 Fertilizer recovery, that is, the fraction of applied fertilizer that is taken up by the crop.
 Two-column matrix to compute the fraction uptake from soil.

.

minimum and maximum concentration of "_" (N, P, or K) in soil.
 the maximum biomass of vegetative organs at zero yield of storage organs.
 the fraction of a crop's nitrogen uptake supplied by biological fixation.

.

N, P, and K fertilizer applied.

.

Attainable (in the absence of nutrient limitation), or target crop yield.
 Length of the growing season (days)

.

.

Explanation

nutrient uptake from soil (not fertilizer) (kg/ha)
 nutrient limited biomass of leaves, stems, and storage organs (kg/ha)
 fertilizer required to reach the specified biomass (kg/ha)

Value

vector with output variables as described in the Details

References

Janssen B.H., F.C.T. Guiking, D. van der Eijk, E.M.A. Smaling, J. Wolf and H. van Reuler, 1990. A system for the quantitative evaluation of the fertility of tropical soils (QUEFTS). *Geoderma* 46: 299-318

Sattari, S.Z., M.K. van Ittersum, A.F. Bouwman, A.L. Smit, and B.H. Janssen, 2014. Crop yield response to soil fertility and N, P, K inputs in different environments: Testing and improving the QUEFTS model. *Field Crops Research* 157: 35-46

Examples

```
# create a QUEFTS model
# 1. get parameters
soiltype <- quefts_soil()
barley <- quefts_crop("Barley")
fertilizer <- list(N=0, P=0, K=0)
att_yield <- list(leaf_att=2200, stem_att=2700, store_att=4800, SeasonLength=110)

# 2. create a model
q <- quefts(soiltype, barley, fertilizer, att_yield)

# 3. run the model
run(q)

# change some parameters
q$SeasonLength <- 162
q$leaf_att <- 2651
q$stem_att <- 5053
q$store_att <- 8208

q$N <- 100
q$P <- 50
q$K <- 50

run(q)

## note that Rquefts uses C++ reference classes.
## This means that if you copy a quefts model, you do not create a
## new instance of the model, but you point to the same one!
q <- quefts()
q["N"]
k <- q
k["N"] <- 150
k["N"]
# the value of q has also changed!
q["N"]
```



```
## different ways of subsetting / replacement
q <- quefts()
q$N
q$N <- 30
q["N"]
q["N"] <- 90
q["model", "N"]
q["model", "N"] <- 60
q$N

q$soil$N_recovery
q["soil$N_recovery"]
q["soil$N_recovery"] <- .6
q["soil", "N_recovery"]
q["soil", "N_recovery"] <- .4
q$soil$N_recovery
```

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