

# Package ‘Rquefts’

October 23, 2024

**Type** Package

**Title** Quantitative Evaluation of the Native Fertility of Tropical Soils

**Version** 1.2-4

**Date** 2024-10-23

**LinkingTo** Rcpp

**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> for the technical details and Sattari et al. (2014) <doi: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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**Repository** CRAN

**Date/Publication** 2024-10-23 08:50:06 UTC

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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.

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batch	<i>Batch QUEFTS model predictions</i>
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---

## Description

Make many predictions with a QUEFTS model.

## Usage

```
## S4 method for signature 'Rcpp_QueftsModel'
batch(x, supply, fert, yatt, leaf_ratio, stem_ratio, var="yield")
```

**Arguments**

x	QUEFTSModel
supply	matrix or data.frame with soil nutrient supply data for N, P, and K
fert	matrix or data.frame with fertilizer nutrient supply data for N, P, and K
yatt	numeric. Attainable yield
leaf_ratio	positive numeric (typically between 0 and 1) indicating the leaf weight relative to the storage organ weight. For example: 0.46 for maize, 0.17 for potato, and 0.18 for rice
stem_ratio	positive numeric (typically between 0 and 1) indicating the stem weight relative to the storage organ weight, For example: 0.56 for maize, 0.14 for potato, and 0.67 for rice
var	character. Output variable name. Either "yield" or "gap"

**Value**

numeric or matrix (if var="gap")

**Examples**

```
potato <- quefts_crop("potato")
q <- quefts(crop=potato)
fert=cbind(c(0,100), c(0,200), c(0,30))
supply=cbind(50,50,25)
yatt <- 10000
batch(q, supply, fert, yatt, 0.45, 0.4)

batch(q, supply, fert, yatt, 0.45, 0.4, var="gap")
```

---

fertApp

*Optimal fertilizer application*

---

**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)
Polsen	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, leaf_ratio, stem_ratio,
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>leaf_ratio</code>	positive numeric (typically between 0 and 1) indicating the leaf weight relative to the storage organ weight. For example: 0.46 for maize, 0.17 for potato, and 0.18 for rice
<code>stem_ratio</code>	positive numeric (typically between 0 and 1) indicating the stem weight relative to the storage organ weight, For example: 0.56 for maize, 0.14 for potato, and 0.67 for rice
<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(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, 0.46, 0.56)
plot(p)

g <- predict(q, supply, yatt, 0.46, 0.56, "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 available from [quefts\\_crop](#), and an example soil from [quefts\\_soil](#). You need to provide attainable or target crop production (in this context that is the maximum production in the absence of nutrient limitation), expressed as dry-matter biomass for leaves, stems and the storage organ (e.g. grain, root or tuber). See [quefts\\_biom](#). 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.

**Usage**

```
quefts(soil, crop, fert, 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 <a href="#">quefts_soil</a>
crop	list with named crop parameters. See Details. An example is returned by <a href="#">quefts_crop</a>
fert	list with named fertilizer parameters (N, P and K). An example is returned by <a href="#">quefts_fert</a>
biom	list with named biomass and growing season length parameters. An example is returned by <a href="#">quefts_biom</a>
x	QueftsModel object
value	list with soil, crop, fertilizer, or biomass parameters as above
...	Additional arguments. None implemented

**Details**

For input parameters see [quefts\\_crop](#), [quefts\\_soil](#), [quefts\\_fert](#) and [quefts\\_biom](#)

**Crop yield (biom)**

leaf\_att, stem\_att, store\_att  
SeasonLength

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

**Output Variables**

N\_actual\_supply, P\_actual\_supply, K\_actual\_supply  
leaf\_lim, stem\_lim, store\_lim  
N\_gap, P\_gap, K\_gap

**Explanation**

nutrient uptake from soil (not fertilizer) (kg/ha)  
nutrient limited biomass of leaves, stems, and storage organ  
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
```

---

---

quefts\_biom                      *biomass parameters*

---

### Description

Crop biomass parameters

For a cereal crop you can generally assume that about 50% of the total biomass is grain, and about 30% is stem and 20% is leaf biomass.

### Usage

```
quefts_biom()
```

### Details

#### Crop yield (biom)

leaf_att, stem_att, store_att	Attainable (in the absence of nutrient limitation), or target crop biomass (dry-matter, %)
SeasonLength	Length of the growing season (days)

### Value

list

### Examples

```
b <- quefts_biom()
str(b)
```

---

quefts\_crop                      *Crop parameters*

---

### Description

A number of default crop parameter sets are provided

### Usage

```
quefts_crop(name="")
```

### Arguments

name	character. crop name
------	----------------------

**Details****Input Parameters**

\_minVeg, \_maxVeg, \_minStore, \_maxStore  
 Yzero  
 Nfix

**Explanation**

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

**Value**

list with crop parameters. See Details

**Examples**

```
barley <- quefts_crop("Barley")
str(barley)
```

---

quefts\_fert                      *fertilizer parameters*

---

**Description**

Get a list with the default fertilization parameters

**Usage**

```
quefts_fert()
```

**Details****Input Parameters  
Management (fert)**

N, P, K

**Explanation**

.  
 N, P, and K fertilizer applied.

**Value**

list

**Examples**

```
f <- quefts_fert()
str(f)
```

---

quefts\_soil                      *soil parameters*

---

### Description

Example soil parameters.

### Usage

```
quefts_soil()
```

### Details

#### Input Parameters

N\_base\_supply, P\_base\_supply, K\_base\_supply  
 N\_recovery, P\_recovery, K\_recovery  
 UptakeAdjust

#### Explanation

Potential supply (kg/ha) of N, P and K of the (unfertilized) soil in a  
 Fertilizer recovery, that is, the fraction of applied fertilizer that can be  
 Two-column matrix to compute the fraction uptake from soil supply

### Value

list with soil parameters

### Examples

```
soiltype <- quefts_soil()
str(soiltype)
```

---

revSupply                      *Estimate soil nutrients supply*

---

### Description

Estimate the apparent base (unfertilized) soil supply of N, P and K based on nutrient omission trial data and a "reverse" QUEFTS approach. The apparent supply is found with optimization.

### Usage

```
revSupply(obs, crop, soil, Ya, leaf_ratio, stem_ratio, SeasonLength = 120, ...)
```

**Arguments**

obs	data.frame with observed data from a nutrient omission trial. It must have these four columns: "N", "P", "K" and "Y"; that give the N, P, and K fertilizer application and the crop yield in kg/ha
Ya	numeric. Attainable yield
soil	list with named soil parameters. See <a href="#">quefts_soil</a>
crop	list with named crop parameters. See <a href="#">quefts_crop</a>
leaf_ratio	positive numeric (typically between 0 and 1) indicating the leaf weight relative to the storage organ weight. For example: 0.46 for maize, 0.17 for potato, and 0.18 for rice
stem_ratio	positive numeric (typically between 0 and 1) indicating the stem weight relative to the storage organ weight, For example: 0.56 for maize, 0.14 for potato, and 0.67 for rice
SeasonLength	positive integer
...	additional arguments supplied to <a href="#">optim</a>

**Value**

numeric vector with the N, P, and K supply in kg/ha

**References**

?

**Examples**

```
set.seed(777)
trial_data <- data.frame(treat = c("CON", "NPK", "NPK", "PK", "NK", "NP"),
  N = c(0, 120, 120, 0, 120, 120),
  P = c(0, 30, 30, 30, 0, 30),
  K = c(0, 60, 60, 60, 60, 0),
  Y = c(2000, 6000, 6000, 2500, 4500, 5500) + rnorm(6, 0, 500))
Ya <- max(trial_data$Y) + 1000
crop <- quefts_crop("Potato")
soil <- quefts_soil()

revSupply(trial_data, crop, soil, Ya, leaf_ratio=.17, stem_ratio=.14)
```

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