

Package ‘quickNmix’

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Title Asymptotic N-Mixture Model Fitting

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Description For fitting N-mixture models using either FFT or asymptotic approaches. FFT N-mixture models extend the work of Cowen et al. (2017) <[doi:10.1111/biom.12701](https://doi.org/10.1111/biom.12701)>. Asymptotic N-mixture models extend the work of Dail and Madsen (2011) <[doi:10.1111/j.1541-0420.2010.01465.x](https://doi.org/10.1111/j.1541-0420.2010.01465.x)>, to consider asymptotic solutions to the open population N-mixture models. The FFT models are derived and described in ``Parker, M.R.P., Elliott, L., Cowen, L.L.E. (2022). Computational efficiency and precision for replicated-count and batch-marked hidden population models [Manuscript in preparation]. Department of Statistics and Actuarial Sciences, Simon Fraser University.". The asymptotic models are derived and described in: ``Parker, M.R.P., Elliott, L., Cowen, L.L.E., Cao, J. (2022). Fast asymptotic solutions for N-mixtures on large populations [Manuscript in preparation]. Department of Statistics and Actuarial Sciences, Simon Fraser University.".

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Suggests testthat, knitr, rmarkdown

Depends R (>= 2.10)

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NeedsCompilation no

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anmu	<i>Ancient Murrelet Chick Counts</i>
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Description

Parker et al. (2020) include a data set collected by the Laskeek Bay Conservation Society on yearly Ancient Murrelet chick counts from the year 1990 to 2006. The data is collected for six sampling sites on East Limestone Island.

Usage

anmu

Format

A matrix with 6 rows and 17 columns. Each row represents a sampling location, and each column represents a sampling occasion:

Source

Parker et al. (2020) doi: [10.1007/s10651020004553](https://doi.org/10.1007/s10651020004553)

References

Parker, M.R.P., Pattison, V. & Cowen, L.L.E. Estimating population abundance using counts from an auxiliary population. Environ Ecol Stat 27, 509–526 (2020). doi: [10.1007/s10651020004553](https://doi.org/10.1007/s10651020004553)

Ax_log

FUNCTION_TITLE

Description

FUNCTION_DESCRIPTION

Usage

Ax_log(logA, logx)

Arguments

logA PARAM_DESCRIPTION

logx PARAM_DESCRIPTION

Details

DETAILS

Value

OUTPUT_DESCRIPTION

Examples

```
## Not run:
if(interactive()){
  #EXAMPLE1
}

## End(Not run)
```

eagles

Golden Eagle Counts Data

Description

Golden Eagle counts for the years 1993 to 2020, collected by the Rocky Mountain Eagle Research Foundation (RMERF). Counts are made during the spring from April 1st until March 22nd each year. Data is available from Eaglewatch.ca.

Usage

eagles

Format

A data frame with 28 rows and 11 columns. Each row represents a spring observation period, and each column represents a variable:

Year observation year

Hours hours spent collecting observations

Eagles number of Golden Eagles observed

TotPrec total precipitation measured in mm

UniqueObservers number of principle observers who performed observations

PeterSherrington_Year indicator variable which is 1 for years in which Peter Sherrington was the most prevalent principle observer

observerPC1 top 5 principal component scores calculated from the top twelve most prevalent principal observers

observerPC2 top 5 principal component scores calculated from the top twelve most prevalent principal observers

observerPC3 top 5 principal component scores calculated from the top twelve most prevalent principal observers

observerPC4 top 5 principal component scores calculated from the top twelve most prevalent principal observers

observerPC5 top 5 principal component scores calculated from the top twelve most prevalent principal observers

Source

RMERF (2020) EagleWatch.ca

References

Rocky Mountain Eagle Research Foundation (RMERF). EagleWatch.ca. (2020).

fitNmix

Fit Asymptotic N-mixture Model

Description

Fit an open population N-mixture model using the asymptotic approximation. The four parameters are mean initial site abundance λ , mean recruitments γ , survival probability ω , and probability of detection p_{det} . Parameters can be made to vary over sites and over times by including parameter covariates. Note that this function is essentially a wrapper for `optim` acting on the `nll` function.

Usage

```

fitNmix(
  nit,
  K = NULL,
  starts = NULL,
  l_s_c = NULL,
  g_s_c = NULL,
  g_t_c = NULL,
  o_s_c = NULL,
  o_t_c = NULL,
  p_s_c = NULL,
  p_t_c = NULL,
  SMALL_a_CORRECTION = FALSE,
  VERBOSE = FALSE,
  outfile = NULL,
  method = "BFGS",
  ...
)

```

Arguments

<code>nit</code>	Matrix of counts data. Rows represent sites, columns represent sampling occasions. Note that if the data is a vector, then it will be converted to a matrix with a single row.
<code>K</code>	Upper bound on summations in the likelihood function. <code>K</code> should be chosen large enough that the negative log likelihood function is stable (unchanging as <code>K</code> increases). If <code>K=NULL</code> , <code>K=5*max(nit)</code> will be used as default. Default: <code>NULL</code>
<code>starts</code>	Either <code>NULL</code> for default starting values, or a vector of parameter values: <code>c(log(lambda), log(gamma), logit(omega), logit(pdet))</code> . Note that the parameter vector will need to be longer by one for each parameter coefficient if covariate values are supplied. The order of coefficients is: <code>c(lambda, l_s_c, gamma, g_s_c, g_t_c, omega, o_s_c, o_t_c, pdet, p_s_c, p_t_c)</code>
<code>l_s_c</code>	List of lambda site covariates, Default: <code>NULL</code>
<code>g_s_c</code>	List of gamma site covariates, Default: <code>NULL</code>
<code>g_t_c</code>	List of gamma time covariates, Default: <code>NULL</code>
<code>o_s_c</code>	List of omega site covariates, Default: <code>NULL</code>
<code>o_t_c</code>	List of omega time covariates, Default: <code>NULL</code>
<code>p_s_c</code>	List of pdet site covariates, Default: <code>NULL</code>
<code>p_t_c</code>	List of pdet time covariates, Default: <code>NULL</code>
<code>SMALL_a_CORRECTION</code>	If <code>TRUE</code> will apply the small a correction when calculating the transition probability matrix, Default: <code>FALSE</code>
<code>VERBOSE</code>	If <code>TRUE</code> , will print additional information during model fitting, Default: <code>FALSE</code>
<code>outfile</code>	Location of csv file to write/append parameter values, can be used to checkpoint long running model fits. Default: <code>NULL</code>

method	Optimization method, passed to optim function, options include: "BFGS", "Nelder-Mead", "CG". Default: "BFGS"
...	Additional arguments passed to the optimization function optim. For example: control = list(trace=1, REPORT=1, reltol=1e-10)

Value

Returns the fitted model object.

Examples

```
if (interactive()) {
  nit = matrix(c(1,1,0,1,1), nrow=1) # observations for 1 site, 5 sampling occasions
  model1 = fitNmix(nit, K=2)           # fit the model with population upper bound K=2
}
```

fitNmixPara

Fit Asymptotic N-mixture Model Using optimParallel

Description

Fit an open population N-mixture model using the asymptotic approximation. The four parameters are mean initial site abundance λ , mean recruitments γ , survival probability ω , and probability of detection p_{det} . Parameters can be made to vary over sites and over times by including parameter covariates. Note that this function is essentially a wrapper for optim acting on the nll function.

Usage

```
fitNmixPara(
  cluster,
  nit,
  K = NULL,
  starts = NULL,
  l_s_c = NULL,
  g_s_c = NULL,
  g_t_c = NULL,
  o_s_c = NULL,
  o_t_c = NULL,
  p_s_c = NULL,
  p_t_c = NULL,
  SMALL_a_CORRECTION = FALSE,
  VERBOSE = FALSE,
  outfile = NULL,
  LowerBounds = NULL,
  ...
)
```

Arguments

<code>cluster</code>	cluster object created using <code>makeCluster</code> , for example: <code>cl <- makeCluster(parallel::detectCores())</code>
<code>nit</code>	Matrix of counts data. Rows represent sites, columns represent sampling occasions. Note that if the data is a vector, then it will be converted to a matrix with a single row.
<code>K</code>	Upper bound on summations in the likelihood function. <code>K</code> should be chosen large enough that the negative log likelihood function is stable (unchanging as <code>K</code> increases). If <code>K=NULL</code> , <code>K=5*max(nit)</code> will be used as default. Default: <code>NULL</code>
<code>starts</code>	Either <code>NULL</code> for default starting values, or a vector of parameter values: <code>c(log(lambda), log(gamma), logit(omega), logit(pdet))</code> . Note that the parameter vector will need to be longer by one for each parameter coefficient if covariate values are supplied. The order of coefficients is: <code>c(lambda, l_s_c, gamma, g_s_c, g_t_c, omega, o_s_c, o_t_c, pdet, p_s_c, p_t_c)</code>
<code>l_s_c</code>	List of lambda site covariates, Default: <code>NULL</code>
<code>g_s_c</code>	List of gamma site covariates, Default: <code>NULL</code>
<code>g_t_c</code>	List of gamma time covariates, Default: <code>NULL</code>
<code>o_s_c</code>	List of omega site covariates, Default: <code>NULL</code>
<code>o_t_c</code>	List of omega time covariates, Default: <code>NULL</code>
<code>p_s_c</code>	List of pdet site covariates, Default: <code>NULL</code>
<code>p_t_c</code>	List of pdet time covariates, Default: <code>NULL</code>
<code>SMALL_a_CORRECTION</code>	If <code>TRUE</code> will apply the small a correction when calculating the transition probability matrix, Default: <code>FALSE</code>
<code>VERBOSE</code>	If <code>TRUE</code> , will print additional information during model fitting, Default: <code>FALSE</code>
<code>outfile</code>	Location of csv file to write/append parameter values, can be used to checkpoint long running model fits. Default: <code>NULL</code>
<code>LowerBounds</code>	Lower bounds to be passed to <code>optimParallel</code> (if <code>NULL</code> , default values will be used), you may need to set this manually if you receive errors such as: "LBFGS-B needs finite values of 'fn'".
<code>...</code>	Additional arguments passed to the optimization function <code>optimParallel</code> .

Value

Returns the fitted model object.

Examples

```
if (interactive()) {
  cl <- makeCluster(parallel::detectCores()-1) # number of clusters should be 2*p+1 for optimal gains
  nit = matrix(c(1,1,0,1,1,2,2), nrow=1) # observations for 1 site, 7 sampling occasions
  model1 = fitNmixPara(cl, nit, K=100) # fit the model with population upper bound K=100
  parallel::stopCluster(cl)
}
```

logSubtractExp	FUNCTION_TITLE
Description	
FUNCTION_DESCRIPTION	
Usage	
logSubtractExp(x)	
Arguments	
x	PARAM_DESCRIPTION
Details	
DETAILS	
Value	
OUTPUT_DESCRIPTION	
Examples	
<pre>## Not run: if(interactive()){ #EXAMPLE1 } ## End(Not run)</pre>	
logSumExp	FUNCTION_TITLE

Description	
FUNCTION_DESCRIPTION	
Usage	
logSumExp(x)	
Arguments	
x	PARAM_DESCRIPTION

Details

DETAILS

Value

OUTPUT_DESCRIPTION

Examples

```
## Not run:
if(interactive()){
  #EXAMPLE1
}

## End(Not run)
```

log_tp_MAT_lse	<i>FUNCTION_TITLE</i>
----------------	-----------------------

Description

FUNCTION_DESCRIPTION

Usage

```
log_tp_MAT_lse(M, omeg, gamm, corrections)
```

Arguments

M	PARAM_DESCRIPTION
omeg	PARAM_DESCRIPTION
gamm	PARAM_DESCRIPTION
corrections	PARAM_DESCRIPTION

Details

DETAILS

Value

OUTPUT_DESCRIPTION

See Also

[foreach](#)

Examples

```
## Not run:
if(interactive()){
  #EXAMPLE1
}

## End(Not run)
```

nll

Negative Log Likelihood

Description

Computes the negative log likelihood function for the open population asymptotic N-mixtures model.

Usage

```
nll(
  par,
  nit,
  K,
  l_s_c = NULL,
  g_s_c = NULL,
  g_t_c = NULL,
  o_s_c = NULL,
  o_t_c = NULL,
  p_s_c = NULL,
  p_t_c = NULL,
  SMALL_a_CORRECTION = FALSE,
  VERBOSE = FALSE,
  outfile = NULL
)
```

Arguments

par	Vector of parameter values: c(log(lambda), log(gamma), logit(omega), logit(pdet)). Note that the parameter vector will need to be longer if covariate values are supplied.
nit	Matrix of counts data. Rows represent sites, columns represent sampling occasions. Note that if the data is a vector, then it will be converted to a matrix with a single row.
K	Upper bound on summations in the likelihood function. K should be chosen large enough that the negative log likelihood function is stable (unchanging as K increases).
l_s_c	List of lambda site covariates, Default: NULL

g_s_c	List of gamma site covariates, Default: NULL
g_t_c	List of gamma time covariates, Default: NULL
o_s_c	List of omega site covariates, Default: NULL
o_t_c	List of omega time covariates, Default: NULL
p_s_c	List of pdet site covariates, Default: NULL
p_t_c	List of pdet time covariates, Default: NULL
SMALL_a_CORRECTION	If TRUE will apply the small a correction when calculating the transition probability matrix, Default: FALSE
VERBOSE	If TRUE, will print additional information, Default: FALSE
outfile	Location of csv file to write/append parameter values, Default: NULL

Details

DETAILS

Value

Returns the negative log likelihood function evaluated at par.

Examples

```
if (interactive()) {
  nit = matrix(c(1,1,0,1,1), nrow=1) # observations for 1 site, 5 sampling occasions
  par = c(1,1,1,0) # parameter values at which to calculate the negative log likelihood (nll)
  nll(par, nit, K=10) # nll with K=10
  nll(par, nit, K=10, SMALL_a_CORRECTION=TRUE) # nll with small a correction
}
```

Pab

FUNCTION_TITLE

Description

FUNCTION_DESCRIPTION

Usage

Pab(a, b, omega, gamma)

Arguments

a	PARAM_DESCRIPTION
b	PARAM_DESCRIPTION
omega	PARAM_DESCRIPTION
gamma	PARAM_DESCRIPTION

Details

DETAILS

Value

OUTPUT_DESCRIPTION

Examples

```
## Not run:
if(interactive()){
  #EXAMPLE1
}

## End(Not run)
```

Pab_asymptotic	<i>FUNCTION_TITLE</i>
----------------	-----------------------

Description

FUNCTION_DESCRIPTION

Usage

```
Pab_asymptotic(a, b, omega, gamma, corrections = FALSE)
```

Arguments

a	PARAM_DESCRIPTION
b	PARAM_DESCRIPTION
omega	PARAM_DESCRIPTION
gamma	PARAM_DESCRIPTION
corrections	PARAM_DESCRIPTION, Default: FALSE

Details

DETAILS

Value

OUTPUT_DESCRIPTION

Examples

```
## Not run:
if(interactive()){
  #EXAMPLE1
}

## End(Not run)
```

Pab_gamma	FUNCTION_TITLE
-----------	----------------

Description

FUNCTION_DESCRIPTION

Usage

Pab_gamma(a, b, gamma)

Arguments

a	PARAM_DESCRIPTION
b	PARAM_DESCRIPTION
gamma	PARAM_DESCRIPTION

Details

DETAILS

Value

OUTPUT_DESCRIPTION

Examples

```
## Not run:
if(interactive()){
  #EXAMPLE1
}

## End(Not run)
```

Pab_omega	FUNCTION_TITLE
Description	
FUNCTION_DESCRIPTION	
Usage	
Pab_omega(a, b, omega)	
Arguments	
a	PARAM_DESCRIPTION
b	PARAM_DESCRIPTION
omega	PARAM_DESCRIPTION
Details	
DETAILS	
Value	
OUTPUT_DESCRIPTION	
Examples	
<pre>## Not run: if(interactive()){ #EXAMPLE1 } ## End(Not run)</pre>	
pCountOpenFFT	Fit FFT N-mixture Model

Description

Fit an open population N-mixture model using the FFT method of computing the Transition Probability matrix. The four parameters are mean initial site abundance lambda, mean recruitments gamma, survival probability omega, and probability of detection pdet. Parameters can be made to vary over sites and over times by including parameter covariates. Note that this function is essentially a wrapper for optim acting on the nll_FFT function.

Usage

```
pCountOpenFFT(
  nit,
  K = NULL,
  starts = NULL,
  l_s_c = NULL,
  g_s_c = NULL,
  g_t_c = NULL,
  o_s_c = NULL,
  o_t_c = NULL,
  p_s_c = NULL,
  p_t_c = NULL,
  VERBOSE = FALSE,
  outfile = NULL,
  method = "BFGS",
  ...
)
```

Arguments

<code>nit</code>	Matrix of counts data. Rows represent sites, columns represent sampling occasions. Note that if the data is a vector, then it will be converted to a matrix with a single row.
<code>K</code>	Upper bound on summations in the likelihood function. <code>K</code> should be chosen large enough that the negative log likelihood function is stable (unchanging as <code>K</code> increases). If <code>K=NULL</code> , <code>K=5*max(nit)</code> will be used as default. Default: <code>NULL</code>
<code>starts</code>	Either <code>NULL</code> for default starting values, or a vector of parameter values: <code>c(log(lambda), log(gamma), logit(omega), logit(pdet))</code> . Note that the parameter vector will need to be longer by one for each parameter coefficient if covariate values are supplied. The order of coefficients is: <code>c(lambda, l_s_c, gamma, g_s_c, g_t_c, omega, o_s_c, o_t_c, pdet, p_s_c, p_t_c)</code>
<code>l_s_c</code>	List of lambda site covariates, Default: <code>NULL</code>
<code>g_s_c</code>	List of gamma site covariates, Default: <code>NULL</code>
<code>g_t_c</code>	List of gamma time covariates, Default: <code>NULL</code>
<code>o_s_c</code>	List of omega site covariates, Default: <code>NULL</code>
<code>o_t_c</code>	List of omega time covariates, Default: <code>NULL</code>
<code>p_s_c</code>	List of pdet site covariates, Default: <code>NULL</code>
<code>p_t_c</code>	List of pdet time covariates, Default: <code>NULL</code>
<code>VERBOSE</code>	If <code>TRUE</code> , will print additional information during model fitting, Default: <code>FALSE</code>
<code>outfile</code>	Location of csv file to write/append parameter values, can be used to checkpoint long running model fits. Default: <code>NULL</code> (no csv file created).
<code>method</code>	Optimization method, passed to optim function, options include: "BFGS", "Nelder-Mead", "CG". Default: "BFGS"
<code>...</code>	Additional arguments passed to the optimization function optim. For example: <code>control = list(trace=1, REPORT=1, reltol=1e-10)</code>

Value

Returns the fitted model object.

Examples

```
if (interactive()) {
  # No Covariates
  nit = matrix(c(1,1,0,2,3), nrow=1) # observations for 1 site, 5 sampling occasions
  model1 = pCountOpenFFT(nit, K=10) # fit the model with population upper bound K=10

  # Site Covariates
  o_s_c = list(cov1=c(0,0,1)) # omega site covariates, cov1 is categorical
  nit = matrix(c(1,1,0,2,3,
                 1,0,1,3,2,
                 4,1,3,2,0), nrow=3, byrow=T) # 3 sites, 5 sampling occasions
  model2 = pCountOpenFFT(nit, K=20, o_s_c=o_s_c) # fit the model with population upper bound K=20

  # Time Covariates
  g_t_c = list(temp=c(0.5,0.3,0.6,0.7,NA)) # transition covariates: only first T-1=4 values used
  model3 = pCountOpenFFT(nit, K=10, g_t_c=g_t_c) # fit the model with population upper bound K=10
}
```

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