

Package: bboutools (via r-universe)

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Title Boreal Caribou Survival, Recruitment and Population Growth

Version 0.1.0

Description Estimates annual survival, recruitment and population growth for boreal caribou populations using Bayesian and Maximum Likelihood models with fixed and random effects.

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<https://poissonconsulting.github.io/bboutools/>

BugReports <https://github.com/poissonconsulting/bboutools/issues>

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<code>augment.bboufit</code>	<i>Get Augmented Data from bboufit Object</i>
------------------------------	---

Description

Get a tibble of the original data with augmentation.

Usage

```
## S3 method for class 'bboufit'
augment(x, ...)
```

Arguments

<code>x</code>	The object.
<code>...</code>	Unused parameters.

Value

A tibble of the augmented data.

See Also

Other generics: [augment.bboufit_ml\(\)](#), [glance.bboufit\(\)](#), [glance.bboufit_ml\(\)](#), [tidy.bboufit\(\)](#), [tidy.bboufit_ml\(\)](#)

Examples

```
if (interactive()) {
  fit <- bb_fit_survival(bboudata::bbousurv_a)
  augment(fit)
}
```

augment.bboufit_ml *Get Augmented Data from bboufit_ml Object*

Description

Get a tibble of the original data with augmentation.

Usage

```
## S3 method for class 'bboufit_ml'  
augment(x, ...)
```

Arguments

x	The object.
...	Unused parameters.

Value

A tibble of the augmented data.

See Also

Other generics: [augment.bboufit\(\)](#), [glance.bboufit\(\)](#), [glance.bboufit_ml\(\)](#), [tidy.bboufit\(\)](#), [tidy.bboufit_ml\(\)](#)

Examples

```
if (interactive()) {  
  fit <- bb_fit_survival_ml(bboudata::bbousurv_a)  
  augment(fit)  
}
```

bb_fit_recruitment *Fit Recruitment Model*

Description

Fit heirarchical Bayesian recruitment model using Nimble.

Usage

```
bb_fit_recruitment(
  data,
  adult_female_proportion = 0.65,
  sex_ratio = 0.5,
  min_random_year = 5,
  year_trend = FALSE,
  year_start = 4L,
  nthin = 10,
  niters = 1000,
  priors = NULL,
  quiet = FALSE
)
```

Arguments

<code>data</code>	The data.frame.
<code>adult_female_proportion</code>	A number between 0 and 1 of the expected proportion of adults that are female. If NULL, the proportion is estimated from the data (i.e., $Cows \sim \text{Binomial}(\text{adult_female_proportion}, Cows + Bulls)$) and a prior of $\text{dbeta}(65, 35)$ is used. This prior can be changed via the <code>priors</code> argument.
<code>sex_ratio</code>	A number between 0 and 1 of the proportion of females at birth. This proportion is applied to yearlings.
<code>min_random_year</code>	A whole number of the minimum number of years required to fit year as a random effect (as opposed to a fixed effect).
<code>year_trend</code>	A flag indicating whether to fit a year trend effect. Year trend cannot be fit if there is also a fixed year effect (as opposed to random effect).
<code>year_start</code>	A whole number between 1 and 12 indicating the start of the caribou (i.e., biological) year. By default, April is set as the start of the caribou year.
<code>nthin</code>	A whole number of the thinning rate.
<code>niters</code>	A whole number of the number of iterations per chain after thinning and burn-in.
<code>priors</code>	A named vector of the parameter prior distribution values. Any missing values are assigned their default values in <code>priors_survival()</code> and <code>priors_recruitment()</code> . If NULL, all parameters are assigned their default priors.
<code>quiet</code>	A flag indicating whether to suppress messages and progress bars.

Details

If the number of years is $> \text{min_random_year}$, a fixed-effects model is fit. Otherwise, a mixed-effects model is fit with random intercept for each year. If `year_trend` is TRUE and the number of years is $> \text{min_random_year}$, the model will be fit with year as a continuous effect (i.e. trend) and no fixed effect of year. If `year_trend` is TRUE and the number of years is $\leq \text{min_random_year}$, the model will be fit with year as a continuous effect and a random intercept for each year.

The start month of the Caribou year can be adjusted with `year_start`.

Value

A list of the Nimble model object, data and mcmc samples.

See Also

Other model: `bb_fit_recruitment_ml()`, `bb_fit_survival()`, `bb_fit_survival_ml()`

Examples

```
if (interactive()) {
  fit <- bb_fit_recruitment(bboudata::bbourecruit_a)
}
```

`bb_fit_recruitment_ml` *Fit Recruitment Model with Maximum Likelihood*

Description

Fit recruitment model with Maximum Likelihood using Nimble Laplace Approximation.

Usage

```
bb_fit_recruitment_ml(
  data,
  adult_female_proportion = 0.65,
  sex_ratio = 0.5,
  min_random_year = 5,
  year_trend = FALSE,
  year_start = 4L,
  inits = NULL,
  quiet = FALSE
)
```

Arguments

<code>data</code>	The data.frame.
<code>adult_female_proportion</code>	A number between 0 and 1 of the expected proportion of adults that are female. If NULL, the proportion is estimated from the data (i.e., $Cows \sim \text{Binomial}(adult_female_proportion, Cows + Bulls)$) and a prior of $\text{dbeta}(65, 35)$ is used. This prior can be changed via the <code>priors</code> argument.
<code>sex_ratio</code>	A number between 0 and 1 of the proportion of females at birth. This proportion is applied to yearlings.
<code>min_random_year</code>	A whole number of the minimum number of years required to fit year as a random effect (as opposed to a fixed effect).

year_trend	A flag indicating whether to fit a year trend effect. Year trend cannot be fit if there is also a fixed year effect (as opposed to random effect).
year_start	A whole number between 1 and 12 indicating the start of the caribou (i.e., biological) year. By default, April is set as the start of the caribou year.
inits	A named vector of the parameter initial values. Any missing values are assigned a default value of 0. If NULL, all parameters are assigned a default value of 0.
quiet	A flag indicating whether to suppress messages and progress bars.

Details

If the number of years is $> \text{min_random_year}$, a fixed-effects model is fit. Otherwise, a mixed-effects model is fit with random intercept for each year. If `year_trend` is TRUE and the number of years is $> \text{min_random_year}$, the model will be fit with year as a continuous effect (i.e. trend) and no fixed effect of year. If `year_trend` is TRUE and the number of years is $\leq \text{min_random_year}$, the model will be fit with year as a continuous effect and a random intercept for each year.

The start month of the Caribou year can be adjusted with `year_start`.

Value

A list of the Nimble model object and Maximum Likelihood output with estimates and standard errors on the transformed scale.

See Also

Other model: [bb_fit_recruitment\(\)](#), [bb_fit_survival\(\)](#), [bb_fit_survival_ml\(\)](#)

Examples

```
if (interactive()) {
  fit <- bb_fit_recruitment_ml(bboudata::bbourecruit_a)
}
```

bb_fit_survival	<i>Fit Survival Model</i>
-----------------	---------------------------

Description

Fits hierarchical Bayesian survival model using Nimble.

Usage

```
bb_fit_survival(
  data,
  min_random_year = 5,
  year_trend = FALSE,
  include_uncertain_morts = TRUE,
  year_start = 4L,
```

```

  nthin = 10,
  niters = 1000,
  priors = NULL,
  quiet = FALSE
)

```

Arguments

<code>data</code>	The data.frame.
<code>min_random_year</code>	A whole number of the minimum number of years required to fit year as a random effect (as opposed to a fixed effect).
<code>year_trend</code>	A flag indicating whether to fit a year trend effect. Year trend cannot be fit if there is also a fixed year effect (as opposed to random effect).
<code>include_uncertain_morts</code>	A flag indicating whether to include uncertain mortalities in total mortalities.
<code>year_start</code>	A whole number between 1 and 12 indicating the start of the caribou (i.e., biological) year. By default, April is set as the start of the caribou year.
<code>nthin</code>	A whole number of the thinning rate.
<code>niters</code>	A whole number of the number of iterations per chain after thinning and burn-in.
<code>priors</code>	A named vector of the parameter prior distribution values. Any missing values are assigned their default values in <code>priors_survival()</code> and <code>priors_recruitment()</code> . If NULL, all parameters are assigned their default priors.
<code>quiet</code>	A flag indicating whether to suppress messages and progress bars.

Details

If the number of years is $> \text{min_random_year}$, a fixed-effects model is fit. Otherwise, a mixed-effects model is fit with random intercept for each year. If `year_trend` is TRUE and the number of years is $> \text{min_random_year}$, the model will be fit with year as a continuous effect (i.e. trend) and no fixed effect of year. If `year_trend` is TRUE and the number of years is $\leq \text{min_random_year}$, the model will be fit with year as a continuous effect and a random intercept for each year.

The model is always fit with random intercept for each month.

The start month of the Caribou year can be adjusted with `year_start`.

Value

A list of the Nimble model object, data and mcmc samples.

See Also

Other model: [bb_fit_recruitment\(\)](#), [bb_fit_recruitment_ml\(\)](#), [bb_fit_survival_ml\(\)](#)

Examples

```

if (interactive()) {
  fit <- bb_fit_survival(bboudata::bbousurv_a)
}

```

bb_fit_survival_ml *Fit Survival Model with Maximum Likelihood*

Description

Fits hierarchical survival model with Maximum Likelihood using Nimble Laplace approximation.

Usage

```
bb_fit_survival_ml(
  data,
  min_random_year = 5,
  year_trend = FALSE,
  include_uncertain_morts = FALSE,
  year_start = 4L,
  inits = NULL,
  quiet = FALSE
)
```

Arguments

data	The data.frame.
min_random_year	A whole number of the minimum number of years required to fit year as a random effect (as opposed to a fixed effect).
year_trend	A flag indicating whether to fit a year trend effect. Year trend cannot be fit if there is also a fixed year effect (as opposed to random effect).
include_uncertain_morts	A flag indicating whether to include uncertain mortalities in total mortalities.
year_start	A whole number between 1 and 12 indicating the start of the caribou (i.e., biological) year. By default, April is set as the start of the caribou year.
inits	A named vector of the parameter initial values. Any missing values are assigned a default value of 0. If NULL, all parameters are assigned a default value of 0.
quiet	A flag indicating whether to suppress messages and progress bars.

Details

If the number of years is $> \text{min_random_year}$, a fixed-effects model is fit. Otherwise, a mixed-effects model is fit with random intercept for each year. If `year_trend` is TRUE and the number of years is $> \text{min_random_year}$, the model will be fit with year as a continuous effect (i.e. trend) and no fixed effect of year. If `year_trend` is TRUE and the number of years is $\leq \text{min_random_year}$, the model will be fit with year as a continuous effect and a random intercept for each year.

The model is always fit with random intercept for each month.

The start month of the Caribou year can be adjusted with `year_start`.

Value

A list of the Nimble model object and Maximum Likelihood output with estimates and standard errors on the transformed scale.

See Also

Other model: `bb_fit_recruitment()`, `bb_fit_recruitment_ml()`, `bb_fit_survival()`

Examples

```
if (interactive()) {
  fit <- bb_fit_survival_ml(bboudata::bbousurv_a)
}
```

bb_plot_month
Plot Month

Description

Plots month estimates with credible limits.

Usage

```
bb_plot_month(x, ...)

## S3 method for class 'data.frame'
bb_plot_month(x, ...)

## S3 method for class 'bboufit_survival'
bb_plot_month(x, conf_level = 0.95, estimate = median, ...)
```

Arguments

<code>x</code>	The object.
<code>...</code>	Unused parameters.
<code>conf_level</code>	A number between 0 and 1 of the confidence level.
<code>estimate</code>	A function to calculate the estimate.

Methods (by class)

- `bb_plot_month(data.frame)`: Plot monthly estimate for a data frame.
- `bb_plot_month(bboufit_survival)`: Plot monthly estimates for a `bboufit_survival` object.

`bb_plot_month_survival`*Plot Monthly Survival*

Description

Plots monthly survival estimates with credible limits. Estimates represent annual survival if a given month lasted the entire year.

Usage

```
bb_plot_month_survival(x, ...)
```

```
## S3 method for class 'data.frame'
```

```
bb_plot_month_survival(x, ...)
```

```
## S3 method for class 'bboufit_survival'
```

```
bb_plot_month_survival(x, conf_level = 0.95, estimate = median, ...)
```

Arguments

<code>x</code>	The object.
<code>...</code>	Unused parameters.
<code>conf_level</code>	A number between 0 and 1 of the confidence level.
<code>estimate</code>	A function to calculate the estimate.

Methods (by class)

- `bb_plot_month_survival(data.frame)`: Plot monthly survival estimate for a data frame.
- `bb_plot_month_survival(bboufit_survival)`: Plot monthly survival estimates for a `bboufit_survival` object.

`bb_plot_year`*Plot Year*

Description

Plots annual estimates with credible limits.

Usage

```
bb_plot_year(x, ...)

## S3 method for class 'data.frame'
bb_plot_year(x, ...)

## S3 method for class 'bboufit'
bb_plot_year(x, conf_level = 0.95, estimate = median, ...)

## S3 method for class 'bboufit_ml'
bb_plot_year(x, conf_level = 0.95, estimate = median, ...)
```

Arguments

x	The object.
...	Unused parameters.
conf_level	A number between 0 and 1 of the confidence level.
estimate	A function to calculate the estimate.

Methods (by class)

- `bb_plot_year(data.frame)`: Plot annual estimate for a data frame.
- `bb_plot_year(bboufit)`: Plot annual estimates for a `bboufit` object.
- `bb_plot_year(bboufit_ml)`: Plot annual estimates for a `bboufit_ml` object.

`bb_plot_year_growth` *Plot Year Population Growth*

Description

Plots annual population growth with credible limits.

Usage

```
bb_plot_year_growth(x)
```

Arguments

x	A data frame of the lambda estimates (output of <code>bb_predict_growth()</code>).
---	---

```
bb_plot_year_population_change
      Plot Year Population Change
```

Description

Plots annual population change (%) with credible limits.

Usage

```
bb_plot_year_population_change(x)
```

Arguments

x A data frame of the population change estimates (output of `bb_predict_population_change()`).

```
bb_plot_year_recruitment
      Plot Year Recruitment
```

Description

Plot annual recruitment estimates with credible limits. Recruitment is adjusted following DeCesare et al. (2012) methods.

Usage

```
bb_plot_year_recruitment(x, ...)

## S3 method for class 'data.frame'
bb_plot_year_recruitment(x, ...)

## S3 method for class 'bboufit_recruitment'
bb_plot_year_recruitment(x, conf_level = 0.95, estimate = median, ...)
```

Arguments

x The object.
 ... Unused parameters.
 conf_level A number between 0 and 1 of the confidence level.
 estimate A function to calculate the estimate.

Methods (by class)

- `bb_plot_year_recruitment(data.frame)`: Plot annual recruitment estimate for a data frame.
- `bb_plot_year_recruitment(bboufit_recruitment)`: Plot annual recruitment estimates for a `bboufit_recruitment` object.

References

DeCesare, Nicholas J., Mark Hebblewhite, Mark Bradley, Kirby G. Smith, David Hervieux, and Lalenia Neufeld. 2012 “Estimating Ungulate Recruitment and Growth Rates Using Age Ratios.” *The Journal of Wildlife Management* 76 (1): 144–53 <https://doi.org/10.1002/jwmg.244>.

`bb_plot_year_survival` *Plot Year Survival*

Description

Plots annual survival estimates with credible limits.

Usage

```
bb_plot_year_survival(x, ...)

## S3 method for class 'data.frame'
bb_plot_year_survival(x, ...)

## S3 method for class 'bboufit_survival'
bb_plot_year_survival(x, conf_level = 0.95, estimate = median, ...)
```

Arguments

<code>x</code>	The object.
<code>...</code>	Unused parameters.
<code>conf_level</code>	A number between 0 and 1 of the confidence level.
<code>estimate</code>	A function to calculate the estimate.

Methods (by class)

- `bb_plot_year_survival(data.frame)`: Plot annual survival estimate for a data frame.
- `bb_plot_year_survival(bboufit_survival)`: Plot annual survival estimates for a `bboufit_survival` object.

bb_plot_year_trend_recruitment
Plot Annual Recruitment Trend

Description

Plots annual recruitment estimates as trend line with credible limits.

Usage

```
bb_plot_year_trend_recruitment(x, ...)  
  
## S3 method for class 'data.frame'  
bb_plot_year_trend_recruitment(x, ...)  
  
## S3 method for class 'bboufit_recruitment'  
bb_plot_year_trend_recruitment(x, conf_level = 0.95, estimate = median, ...)
```

Arguments

x	The object.
...	Unused parameters.
conf_level	A number between 0 and 1 of the confidence level.
estimate	A function to calculate the estimate.

Methods (by class)

- `bb_plot_year_trend_recruitment(data.frame)`: Plot annual recruitment estimate as trend line for a data frame.
- `bb_plot_year_trend_recruitment(bboufit_recruitment)`: Plot annual estimates as trend line for a `bboufit_recruitment` object.

bb_plot_year_trend_survival
Plot Annual Survival Trend

Description

Plots annual survival estimates as trend line with credible limits.

Usage

```
bb_plot_year_trend_survival(x, ...)

## S3 method for class 'data.frame'
bb_plot_year_trend_survival(x, ...)

## S3 method for class 'bboufit_survival'
bb_plot_year_trend_survival(x, conf_level = 0.95, estimate = median, ...)
```

Arguments

x	The object.
...	Unused parameters.
conf_level	A number between 0 and 1 of the confidence level.
estimate	A function to calculate the estimate.

Methods (by class)

- `bb_plot_year_trend_survival(data.frame)`: Plot annual survival estimate as trend line for a data frame.
- `bb_plot_year_trend_survival(bboufit_survival)`: Plot annual estimates as trend line for a `bboufit_survival` object.

bb_predict_calf_cow_ratio

Predict Calf-Cow Ratio

Description

Predict calves per adult female by year. If year is FALSE, predictions are made for a 'typical' year.

Usage

```
bb_predict_calf_cow_ratio(
  recruitment,
  year = TRUE,
  conf_level = 0.95,
  estimate = median,
  sig_fig = 3
)
```


Arguments

recruitment	An object of class 'bboufit_recruitment' (output of bb_fit_recruitment())
year	A flag indicating whether to predict by year.
conf_level	A number between 0 and 1 of the confidence level.
estimate	A function to calculate the estimate.
sig_fig	A whole number of the significant figures to round estimates by.

Value

A tibble of the predicted estimates.

See Also

Other analysis: [bb_predict_growth\(\)](#), [bb_predict_population_change\(\)](#), [bb_predict_recruitment\(\)](#), [bb_predict_recruitment_trend\(\)](#), [bb_predict_survival\(\)](#), [bb_predict_survival_trend\(\)](#)

bb_predict_growth *Predict Population Growth Lambda*

Description

Predicts population growth (lambda) from survival and recruitment fit objects using the Hatter-Bergerud equation (Hatter and Bergerud, 1991).

Usage

```
bb_predict_growth(  
  survival,  
  recruitment,  
  sex_ratio = 0.5,  
  conf_level = 0.95,  
  estimate = median,  
  sig_fig = 3  
)  
  
bb_predict_lambda(  
  survival,  
  recruitment,  
  conf_level = 0.95,  
  estimate = median,  
  sig_fig = 3  
)
```

Arguments

survival	An object of class 'bboufit_survival' (output of bb_fit_survival()).
recruitment	An object of class 'bboufit_recruitment' (output of bb_fit_recruitment()).
sex_ratio	A number between 0 and 1 of the proportion of females at birth.
conf_level	A number between 0 and 1 of the confidence level.
estimate	A function to calculate the estimate.
sig_fig	A whole number of the significant figures to round estimates by.

Value

A tibble of the lambda estimates with upper and lower credible intervals.

Functions

- [bb_predict_lambda\(\)](#): Deprecated for [bb_predict_growth\(\)](#) [**Deprecated**]

References

Hatter, Ian, and Wendy Bergerud. 1991. "Moose Recruitment, Adult Mortality and Rate of Change" 27: 65–73.

See Also

Other analysis: [bb_predict_calf_cow_ratio\(\)](#), [bb_predict_population_change\(\)](#), [bb_predict_recruitment\(\)](#), [bb_predict_recruitment_trend\(\)](#), [bb_predict_survival\(\)](#), [bb_predict_survival_trend\(\)](#)

Examples

```
if (interactive()) {
  survival <- bb_fit_survival(bboudata::bbousurv_a)
  recruitment <- bb_fit_recruitment(bboudata::bbourecruit_a)
  growth <- bb_predict_growth(survival, recruitment)
}
```

bb_predict_population_change

Predict Population Change

Description

Predicts population change (%) from survival and recruitment fit objects. Population change is the cumulative product of population growth rate (i.e., output of [bb_predict_growth\(\)](#))

Usage

```
bb_predict_population_change(
  survival,
  recruitment,
  sex_ratio = 0.5,
  conf_level = 0.95,
  estimate = median,
  sig_fig = 3
)
```

Arguments

survival	An object of class 'bboufit_survival' (output of bb_fit_survival()).
recruitment	An object of class 'bboufit_recruitment' (output of bb_fit_recruitment())
sex_ratio	A number between 0 and 1 of the proportion of females at birth.
conf_level	A number between 0 and 1 of the confidence level.
estimate	A function to calculate the estimate.
sig_fig	A whole number of the significant figures to round estimates by.

Value

A tibble of the population change estimates with upper and lower credible intervals.

See Also

Other analysis: [bb_predict_calf_cow_ratio\(\)](#), [bb_predict_growth\(\)](#), [bb_predict_recruitment\(\)](#), [bb_predict_recruitment_trend\(\)](#), [bb_predict_survival\(\)](#), [bb_predict_survival_trend\(\)](#)

Examples

```
if (interactive()) {
  survival <- bb_fit_survival(bboudata::bbousurv_a)
  recruitment <- bb_fit_recruitment(bboudata::bbourecruit_a)
  change <- bb_predict_population_change(survival, recruitment)
}
```

 bb_predict_recruitment

Predict Recruitment

Description

Predict adjusted recruitment by year using DeCesare et al. (2012) methods. If year is FALSE, predictions are made for a 'typical' year. See [bb_predict_calf_cow_ratio\(\)](#) for unadjusted recruitment.

Usage

```
bb_predict_recruitment(
  recruitment,
  year = TRUE,
  sex_ratio = 0.5,
  conf_level = 0.95,
  estimate = median,
  sig_fig = 3
)
```

Arguments

recruitment	An object of class 'bboufit_recruitment' (output of bb_fit_recruitment())
year	A flag indicating whether to predict by year.
sex_ratio	A number between 0 and 1 of the proportion of females at birth.
conf_level	A number between 0 and 1 of the confidence level.
estimate	A function to calculate the estimate.
sig_fig	A whole number of the significant figures to round estimates by.

Value

A tibble of the predicted estimates.

References

DeCesare, Nicholas J., Mark Hebblewhite, Mark Bradley, Kirby G. Smith, David Hervieux, and Lalenia Neufeld. 2012 "Estimating Ungulate Recruitment and Growth Rates Using Age Ratios." *The Journal of Wildlife Management* 76 (1): 144–53 <https://doi.org/10.1002/jwmg.244>.

See Also

Other analysis: [bb_predict_calf_cow_ratio\(\)](#), [bb_predict_growth\(\)](#), [bb_predict_population_change\(\)](#), [bb_predict_recruitment_trend\(\)](#), [bb_predict_survival\(\)](#), [bb_predict_survival_trend\(\)](#)

bb_predict_recruitment_trend

Predict Recruitment Trend

Description

Predict recruitment by year as trend line. Recruitment fit object provided must be created with `year_trend = TRUE`.

Usage

```
bb_predict_recruitment_trend(  
  recruitment,  
  sex_ratio = 0.5,  
  conf_level = 0.95,  
  estimate = median,  
  sig_fig = 5  
)
```

Arguments

recruitment	An object of class 'bboufit_recruitment' (output of bb_fit_recruitment())
sex_ratio	A number between 0 and 1 of the proportion of females at birth.
conf_level	A number between 0 and 1 of the confidence level.
estimate	A function to calculate the estimate.
sig_fig	A whole number of the significant figures to round estimates by.

Value

A tibble of the predicted estimates.

See Also

Other analysis: [bb_predict_calf_cow_ratio\(\)](#), [bb_predict_growth\(\)](#), [bb_predict_population_change\(\)](#), [bb_predict_recruitment\(\)](#), [bb_predict_survival\(\)](#), [bb_predict_survival_trend\(\)](#)

bb_predict_survival *Predict Survival*

Description

Predict survival by year and/or month. If year and month are FALSE, predictions are made for a 'typical' year and month.

Usage

```
bb_predict_survival(  
  survival,  
  year = TRUE,  
  month = FALSE,  
  conf_level = 0.95,  
  estimate = median,  
  sig_fig = 3  
)
```

Arguments

survival	An object of class 'bboufit_survival' (output of bb_fit_survival()).
year	A flag indicating whether to predict by year.
month	A flag indicating whether to predict by month.
conf_level	A number between 0 and 1 of the confidence level.
estimate	A function to calculate the estimate.
sig_fig	A whole number of the significant figures to round estimates by.

Value

A tibble of the predicted estimates.

See Also

Other analysis: [bb_predict_calf_cow_ratio\(\)](#), [bb_predict_growth\(\)](#), [bb_predict_population_change\(\)](#), [bb_predict_recruitment\(\)](#), [bb_predict_recruitment_trend\(\)](#), [bb_predict_survival_trend\(\)](#)

bb_predict_survival_trend

Predict Survival Trend

Description

Predict survival by year as trend line. Survival fit object provided must be created with year_trend = TRUE.

Usage

```
bb_predict_survival_trend(  
  survival,  
  conf_level = 0.95,  
  estimate = median,  
  sig_fig = 5  
)
```

Arguments

survival	An object of class 'bboufit_survival' (output of bb_fit_survival()).
conf_level	A number between 0 and 1 of the confidence level.
estimate	A function to calculate the estimate.
sig_fig	A whole number of the significant figures to round estimates by.

Value

A tibble of the predicted estimates.

See Also

Other analysis: [bb_predict_calf_cow_ratio\(\)](#), [bb_predict_growth\(\)](#), [bb_predict_population_change\(\)](#), [bb_predict_recruitment\(\)](#), [bb_predict_recruitment_trend\(\)](#), [bb_predict_survival\(\)](#)

bb_priors_recruitment *Recruitment model default priors*

Description

Prior distribution parameters and default values for recruitment model parameters.

Usage

```
bb_priors_recruitment()
```

Details

Intercept

$b0 \sim \text{Normal}(\mu = b0_mu, \text{sd} = b0_sd)$

Year Trend

$bYear \sim \text{Normal}(\mu = bYear_mu, \text{sd} = bYear_sd)$

Year fixed effect

$bAnnual \sim \text{Normal}(\mu = 0, \text{sd} = bAnnual_sd)$

Standard deviation of annual random effect

$sAnnual \sim \text{Exponential}(\text{rate} = sAnnual_rate)$

Adult female proportion

$adult_female_proportion \sim \text{Beta}(\alpha = adult_female_proportion_alpha, \text{beta} = adult_female_proportion_beta)$

Value

A named vector.

Examples

```
bb_priors_survival()
```

bb_priors_survival *Survival model default priors*

Description

Prior distribution parameters and default values for survival model parameters.

Usage

```
bb_priors_survival()
```

Details

Intercept

$b_0 \sim \text{Normal}(\mu = b_0_mu, \text{sd} = b_0_sd)$

Year Trend

$b_{\text{Year}} \sim \text{Normal}(\mu = b_{\text{Year}}_mu, \text{sd} = b_{\text{Year}}_sd)$

Year fixed effect

$b_{\text{Annual}} \sim \text{Normal}(\mu = 0, \text{sd} = b_{\text{Annual}}_sd)$

Standard deviation of annual random effect

$s_{\text{Annual}} \sim \text{Exponential}(\text{rate} = s_{\text{Annual}}_rate)$

Standard deviation of month random effect

$s_{\text{Month}} \sim \text{Exponential}(\text{rate} = s_{\text{Month}}_rate)$

Value

A named vector.

Examples

```
bb_priors_survival()
```

coef.bboufit *Get Tidy Tibble from bboufit Object.*

Description

A wrapper on `tidy.bboufit()`.

Usage

```
## S3 method for class 'bboufit'  
coef(object, ...)
```


Arguments

object The object.
... Unused parameters.

See Also

[tidy.bboufit\(\)](#)

Examples

```
if (interactive()) {  
  fit <- bb_fit_recruitment(bboadata::bbourecruit_a)  
  coef(fit)  
}
```

coef.bboufit_ml *Get Tidy Tibble from bboufit_ml Object.*

Description

A wrapper on [tidy.bboufit_ml\(\)](#).

Usage

```
## S3 method for class 'bboufit_ml'  
coef(object, ...)
```

Arguments

object The object.
... Unused parameters.

See Also

[tidy.bboufit_ml\(\)](#)

Examples

```
if (interactive()) {  
  fit <- bb_fit_recruitment_ml(bboadata::bbourecruit_a)  
  coef(fit)  
}
```

converged.bboufit *Get Convergence of bboufit Object*

Description

Get Convergence of bboufit Object

Usage

```
## S3 method for class 'bboufit'
converged(x, rhat = 1.05, ...)
```

Arguments

x	The object.
rhat	A number greater than 1 of the maximum rhat value required for model convergence.
...	Unused parameters.

Value

A flag indicating convergence.

converged.bboufit_ml *Get Convergence of bboufit_ml Object*

Description

Successful convergence indicates that no convergence warnings were produced by optim and all standard errors could be estimated.

Usage

```
## S3 method for class 'bboufit_ml'
converged(x, ...)
```

Arguments

x	The object.
...	Unused parameters.

Value

A flag indicating convergence.

esr.bboufit	<i>Get Effective Sample Rate of bboufit Object</i>
-------------	--

Description

Get Effective Sample Rate of bboufit Object

Usage

```
## S3 method for class 'bboufit'  
esr(x, ...)
```

Arguments

x	The object.
...	Unused parameters.

Value

A number of the number of chains.

estimates.bboufit	<i>Estimates for bboufit Object</i>
-------------------	-------------------------------------

Description

Gets a named list of the estimated values by term.

Usage

```
## S3 method for class 'bboufit'  
estimates(x, term = NULL, ...)
```

Arguments

x	The object.
term	A string of the term name.
...	Unused parameters.

Value

A named list of the estimates.

See Also

[tidy.bboufit\(\)](#)

Examples

```
if (interactive()) {  
  fit <- bb_fit_survival(bboudata::bbousurv_a)  
  estimates(fit)  
}
```

estimates.bboufit_ml *Estimates for bboufit_ml Object*

Description

Gets a named list of the estimated values by term.

Usage

```
## S3 method for class 'bboufit_ml'  
estimates(x, term = NULL, original_scale = FALSE, ...)
```

Arguments

x	The object.
term	A string of the term name.
original_scale	A flag indicating whether to return the estimates in the original scale.
...	Unused parameters.

Value

A named list of the estimates.

See Also

[tidy.bboufit\(\)](#)

Examples

```
if (interactive()) {  
  fit <- bb_fit_survival_ml(bboudata::bbousurv_a)  
  estimates(fit)  
}
```

glance.bboufit	<i>Get a Glance Summary of bboufit Object</i>
----------------	---

Description

Get a tibble of a one-row summary of the model fit.

Usage

```
## S3 method for class 'bboufit'
glance(x, rhat = 1.05, ...)
```

Arguments

x	The object.
rhat	A number greater than 1 of the maximum rhat value required for model convergence.
...	Unused parameters.

Value

A tibble of the glance summary.

See Also

Other generics: [augment.bboufit\(\)](#), [augment.bboufit_ml\(\)](#), [glance.bboufit_ml\(\)](#), [tidy.bboufit\(\)](#), [tidy.bboufit_ml\(\)](#)

Examples

```
if (interactive()) {
  fit <- bb_fit_survival(bboudata::bbousurv_a)
  glance(fit)
}
```

glance.bboufit_ml	<i>Get a Glance Summary of bboufit_ml Object</i>
-------------------	--

Description

Get a tibble of a one-row summary of the model fit.

Usage

```
## S3 method for class 'bboufit_ml'
glance(x, ...)
```

Arguments

x The object.
... Unused parameters.

Value

A tibble of the glance summary.

See Also

Other generics: [augment.bboufit\(\)](#), [augment.bboufit_ml\(\)](#), [glance.bboufit\(\)](#), [tidy.bboufit\(\)](#), [tidy.bboufit_ml\(\)](#)

Examples

```
if (interactive()) {  
  fit <- bb_fit_survival_ml(bboudata::bbousurv_a)  
  glance(fit)  
}
```

model_code

Get Model Code

Description

Get code from Nimble model.

Usage

```
model_code(x, ...)  
  
## S3 method for class 'bboufit'  
model_code(x, ...)  
  
## S3 method for class 'bboufit_ml'  
model_code(x, ...)
```

Arguments

x The object.
... Unused parameters.

Methods (by class)

- `model_code(bboufit)`: Get model code from `bboufit` object.
- `model_code(bboufit_ml)`: Get model code from `bboufit_ml` object.

model_recruitment	<i>Build Nimble recruitment model.</i>
-------------------	--

Description

This is for use by developers.

Usage

```
model_recruitment(
  data,
  year_random = TRUE,
  year_trend = TRUE,
  adult_female_proportion = 0.65,
  sex_ratio = 0.5,
  demographic_stochasticity = TRUE,
  priors = NULL
)
```

Arguments

<code>data</code>	The data.frame.
<code>year_random</code>	A flag indicating whether to include year random effect. If FALSE, year is fitted as a fixed effect.
<code>year_trend</code>	A flag indicating whether to fit a year trend effect. Year trend cannot be fit if there is also a fixed year effect (as opposed to random effect).
<code>adult_female_proportion</code>	A number between 0 and 1 of the expected proportion of adults that are female. If NULL, the proportion is estimated from the data (i.e., $Cows \sim \text{Binomial}(\text{adult_female_proportion}, Cows + Bulls)$) and a prior of $\text{dbeta}(65, 35)$ is used. This prior can be changed via the <code>priors</code> argument.
<code>sex_ratio</code>	A number between 0 and 1 of the proportion of females at birth.
<code>demographic_stochasticity</code>	A flag indicating whether to include <code>demographic_stochasticity</code> in the recruitment model.
<code>priors</code>	A named vector of the parameter prior distribution values. Any missing values are assigned their default values in <code>priors_survival()</code> and <code>priors_recruitment()</code> . If NULL, all parameters are assigned their default priors.

model_survival	<i>Build Nimble survival model.</i>
----------------	-------------------------------------

Description

This is for use by developers.

Usage

```
model_survival(
  data,
  year_random = TRUE,
  year_trend = FALSE,
  priors = NULL,
  build_derivs = TRUE
)
```

Arguments

data	The data.frame.
year_random	A flag indicating whether to include year random effect. If FALSE, year is fitted as a fixed effect.
year_trend	A flag indicating whether to fit a year trend effect. Year trend cannot be fit if there is also a fixed year effect (as opposed to random effect).
priors	A named vector of the parameter prior distribution values. Any missing values are assigned their default values in priors_survival() and priors_recruitment(). If NULL, all parameters are assigned their default priors.
build_derivs	A flag indicating whether to build derivatives Laplace approximation.

nchains.bboufit	<i>Get Number of Chains from bboufit Object</i>
-----------------	---

Description

Get Number of Chains from bboufit Object

Usage

```
## S3 method for class 'bboufit'
nchains(x, ...)
```

Arguments

x	The object.
...	Unused parameters.

Value

A number of the number of chains.

niters.bboufit	<i>Get Number of Iterations from bboufit Object</i>
----------------	---

Description

Get Number of Iterations from bboufit Object

Usage

```
## S3 method for class 'bboufit'
niters(x, ...)
```

Arguments

x	The object.
...	Unused parameters.

Value

A number of the number of iterations.

npars.bboufit	<i>Get Number of Parameters from bboufit Object</i>
---------------	---

Description

Get Number of Parameters from bboufit Object

Usage

```
## S3 method for class 'bboufit'
npars(x, ...)
```

Arguments

x	The object.
...	Unused parameters.

Value

A number of the number of parameters.

npars.bboufit_ml *Get Number of Parameters from bboufit_ml Object*

Description

Get Number of Parameters from bboufit_ml Object

Usage

```
## S3 method for class 'bboufit_ml'  
npars(x, ...)
```

Arguments

x	The object.
...	Unused parameters.

Value

A number of the number of parameters.

nterms.bboufit *Get Number of Terms from bboufit Object*

Description

Get Number of Terms from bboufit Object

Usage

```
## S3 method for class 'bboufit'  
nterms(x, ...)
```

Arguments

x	The object.
...	Unused parameters.

Value

A number of the number of terms.

nterms.bboufit_ml *Get Number of Terms from bboufit_ml Object*

Description

Get Number of Terms from bboufit_ml Object

Usage

```
## S3 method for class 'bboufit_ml'  
nterms(x, ...)
```

Arguments

x The object.
... Unused parameters.

Value

A number of the number of terms.

pars.bboufit *Get Parameters from bboufit Object*

Description

Get Parameters from bboufit Object

Usage

```
## S3 method for class 'bboufit'  
pars(x, ...)
```

Arguments

x The object.
... Unused parameters.

Value

A vector of the parameter names.

pars.bboufit_ml	<i>Get Parameters from bboufit_ml Object</i>
-----------------	--

Description

Get Parameters from bboufit_ml Object

Usage

```
## S3 method for class 'bboufit_ml'  
pars(x, ...)
```

Arguments

x	The object.
...	Unused parameters.

Value

A vector of the parameter names.

predict.bboufit_recruitment	<i>Predict Recruitment</i>
-----------------------------	----------------------------

Description

A wrapper on [bb_predict_recruitment\(\)](#).

Usage

```
## S3 method for class 'bboufit_recruitment'  
predict(  
  object,  
  year = TRUE,  
  sex_ratio = 0.5,  
  conf_level = 0.95,  
  estimate = median,  
  sig_fig = 3,  
  ...  
)
```

Arguments

object	The object.
year	A flag indicating whether to predict by year.
sex_ratio	A number between 0 and 1 of the proportion of females at birth.
conf_level	A number between 0 and 1 of the confidence level.
estimate	A function to calculate the estimate.
sig_fig	A whole number of the significant figures to round estimates by.
...	Unused parameters.

See Also

[bb_predict_recruitment\(\)](#)

predict.bboufit_survival

Predict Survival

Description

A wrapper on [bb_predict_survival\(\)](#).

Usage

```
## S3 method for class 'bboufit_survival'
predict(
  object,
  year = TRUE,
  month = FALSE,
  conf_level = 0.95,
  estimate = median,
  sig_fig = 3,
  ...
)
```

Arguments

object	The object.
year	A flag indicating whether to predict by year.
month	A flag indicating whether to predict by month.
conf_level	A number between 0 and 1 of the confidence level.
estimate	A function to calculate the estimate.
sig_fig	A whole number of the significant figures to round estimates by.
...	Unused parameters.

See Also

[bb_predict_survival\(\)](#)

rhat.bboufit	<i>Get Rhat of bboufit Object</i>
--------------	-----------------------------------

Description

Get Rhat of bboufit Object

Usage

```
## S3 method for class 'bboufit'
rhat(x, ...)
```

Arguments

x	The object.
...	Unused parameters.

Value

A number of rhat value.

samples	<i>Get MCMC samples</i>
---------	-------------------------

Description

Get MCMC samples from Nimble model.

Usage

```
samples(x)

## S3 method for class 'bboufit'
samples(x)

## S3 method for class 'bboufit_ml'
samples(x)
```

Arguments

x	The object.
---	-------------

Methods (by class)

- `samples(bboufit)`: Get MCMC samples from `bboufit` object.
- `samples(bboufit_ml)`: Create MCMC samples (1 iteration, 1 chain) from `bboufit_ml` object.

`tidy.bboufit`
Get Tidy Tibble from bboufit Object.

Description

Get a tidy tibble of the coefficient estimates and confidence intervals from Bayesian model fit.

Usage

```
## S3 method for class 'bboufit'
tidy(
  x,
  conf_level = 0.95,
  estimate = median,
  sig_fig = 3,
  include_random_effects = TRUE,
  ...
)
```

Arguments

<code>x</code>	The object.
<code>conf_level</code>	A number between 0 and 1 of the confidence level.
<code>estimate</code>	A function to calculate the estimate.
<code>sig_fig</code>	A whole number of the significant figures to round estimates by.
<code>include_random_effects</code>	A flag indicating whether to include random effects in coefficient table. Standard deviation estimates will always be included.
<code>...</code>	Unused parameters.

Value

A tibble of the tidy coefficient summary.

See Also

[coef.bboufit\(\)](#)

Other generics: [augment.bboufit\(\)](#), [augment.bboufit_ml\(\)](#), [glance.bboufit\(\)](#), [glance.bboufit_ml\(\)](#), [tidy.bboufit_ml\(\)](#)

Examples

```
if (interactive()) {
  fit <- bb_fit_survival(bboudata::bbousurv_a)
  tidy(fit)
}
```

tidy.bboufit_ml	<i>Get Tidy Tibble from bboufit_ml Object.</i>
-----------------	--

Description

Get a tidy tibble of the coefficient estimates and confidence intervals from Maximum Likelihood model fit.

Usage

```
## S3 method for class 'bboufit_ml'
tidy(x, conf_level = 0.95, sig_fig = 3, include_random_effects = TRUE, ...)
```

Arguments

x	The object.
conf_level	A number between 0 and 1 of the confidence level.
sig_fig	A whole number of the significant figures to round estimates by.
include_random_effects	A flag indicating whether to include random effects in coefficient table. Standard deviation estimates will always be included.
...	Unused parameters.

Value

A tibble of the tidy coefficient summary.

See Also

[coef.bboufit_ml\(\)](#)

Other generics: [augment.bboufit\(\)](#), [augment.bboufit_ml\(\)](#), [glance.bboufit\(\)](#), [glance.bboufit_ml\(\)](#), [tidy.bboufit\(\)](#)

Examples

```
if (interactive()) {
  fit <- bb_fit_survival_ml(bboudata::bbousurv_a)
  tidy(fit)
}
```


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